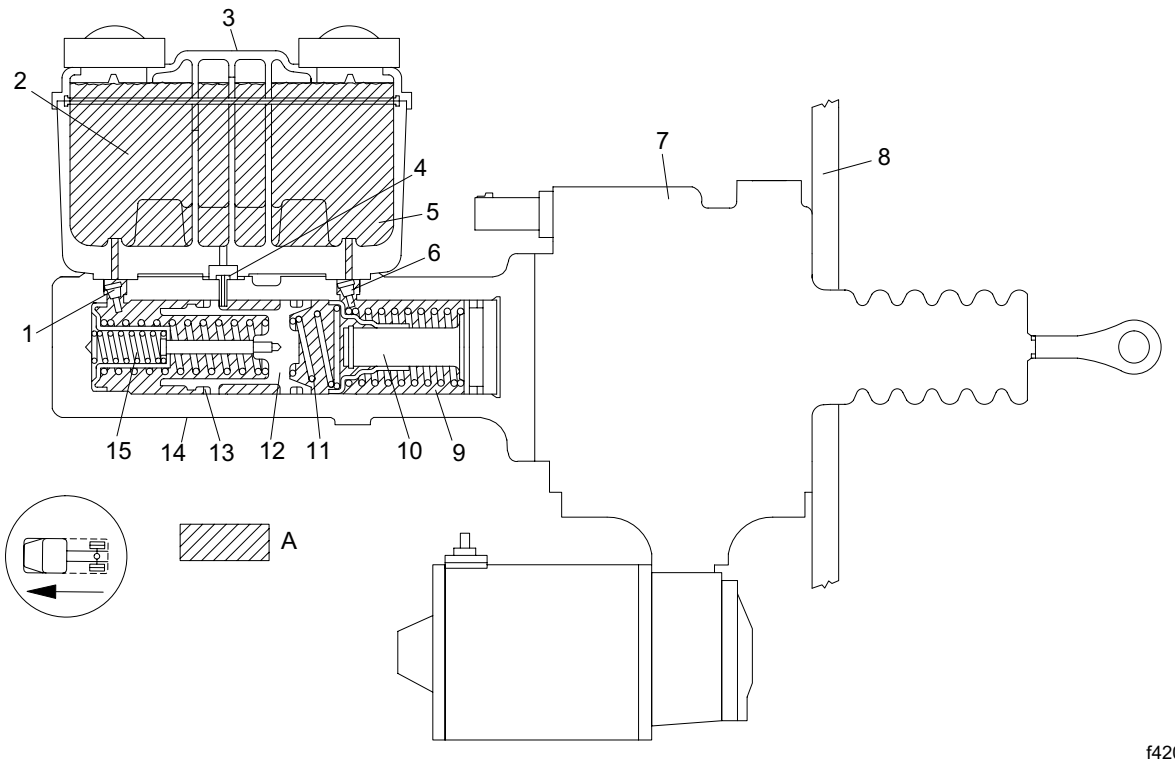


NOTE: Not all parts are shown.

A. DOT 3 Brake Fluid

1. Secondary Compensating Valve (open)
2. Secondary Reservoir Section
3. DOT 3 Brake Fluid Reservoir
4. Piston Stop
5. Primary Reservoir Section
6. Primary Compensating Valve (open)
7. Power Brake Booster Assembly
8. Frontwall
9. Primary Pressure Chamber
10. Primary Piston/Actuator Assembly
11. Primary Piston Return Spring
12. Secondary Piston/Actuator Assembly
13. Secondary Pressure Chamber
14. Housing
15. Secondary Piston Return Spring

Fig. 5, Master Cylinder

The "R" light (brake pressure) output—terminal 3—is activated when any of the following conditions exist:

- The flow switch on the power brake booster closes due to reduced or lost flow of ATF to the power brake booster;
- The pressure differential switch on the master cylinder closes due to a pressure difference between the front and rear brake subsystems;
- The DOT 3 brake fluid level switch on the master cylinder reservoir closes due to a drop in the fluid level;
- Too much electrical resistance in the backup pump motor. This is often caused by a bad ground.

Monitor Module Terminal Identification		
Terminal Number	**Function**	**Circuit Number**
1	Not Used	—
2	Not Used	—
3	Light "R" (Brake System Pressure) Output	388H

General Information

Monitor Module Terminal Identification		
Terminal Number	**Function**	**Circuit Number**
4	Ground	GND
7	Ignition Input	81C
8	Not Used	—
9	Relay Input	388F
10	Not Used	—
11	Pressure Differential Switch Input	388A
12	Brake Pedal Input	388L
13	Backup Pump Motor Input	388C
14	Fluid Level Input	388B
15	Flow Switch Input	388G

Table 1, Monitor Module Terminal Identification

- No power to the backup pump at startup.

See **Table 2** for information on when the input terminals are activated.

Applying the Brakes

Pushing the brake pedal moves the brake pedal rod against the actuator pin in the power brake booster, moving the reaction piston forward inside the power piston. See **Fig. 7**. This moves the throttle valve, restricting the flow of ATF through the power piston, which increases pressure. The increased ATF pressure pushes the power piston forward through the end-cap assembly and into the master cylinder.

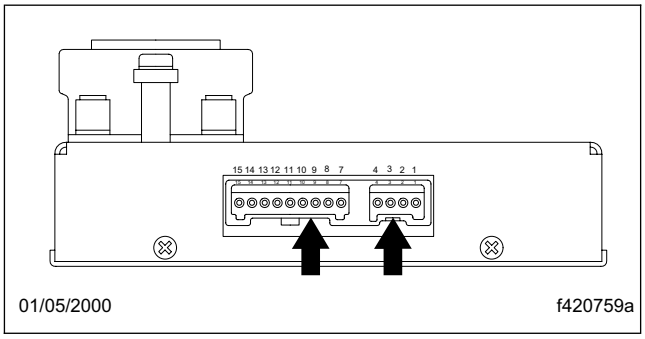


Fig. 6, Monitor Module Terminals

As the primary piston/actuator assembly is pushed forward in the master cylinder, the primary compensating valve closes. This shuts the outlet at the primary reservoir section and raises hydraulic pressure in the primary pressure chamber.

The primary piston/actuator assembly motion also moves the secondary piston/actuator assembly. This closes the secondary compensating valve, pressurizing the secondary pressure chamber.

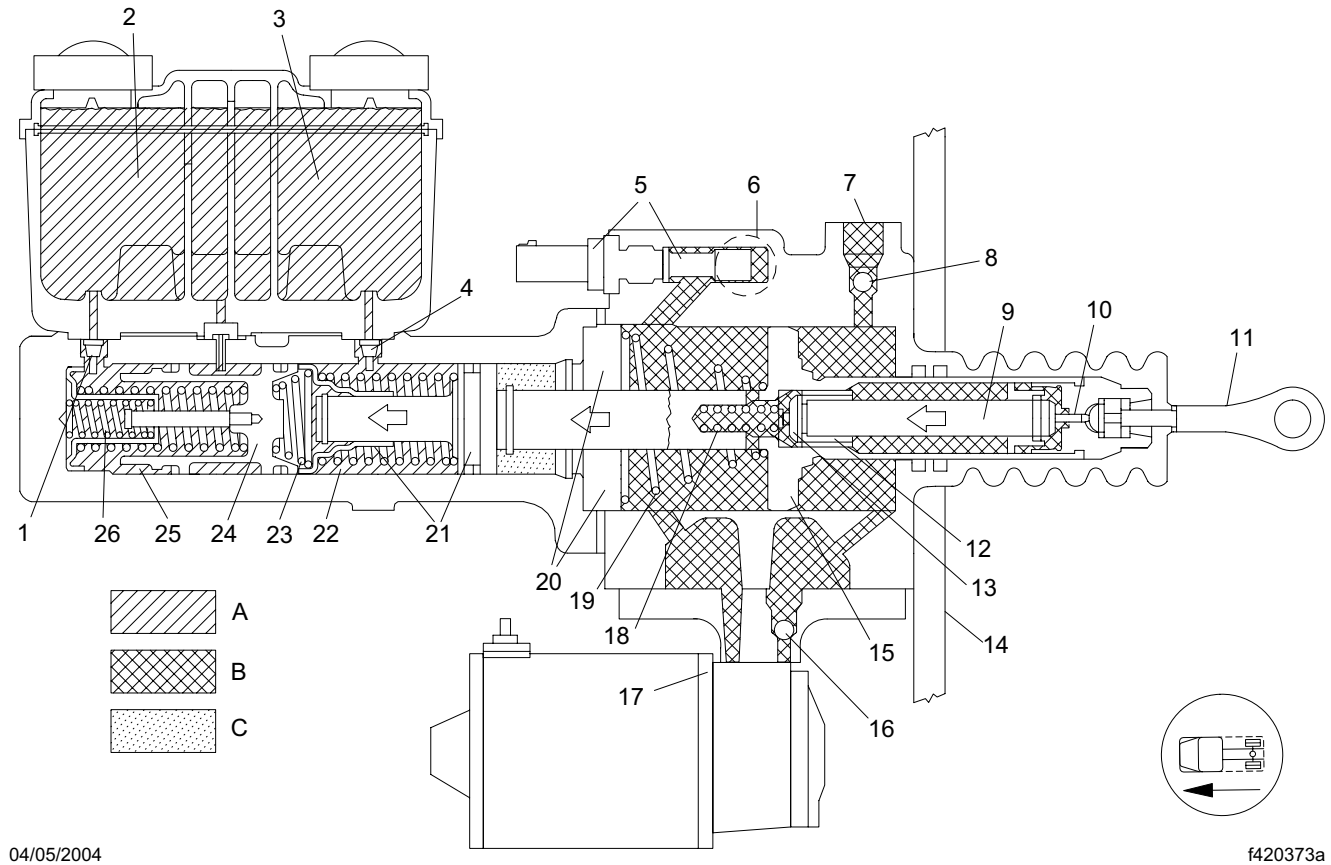
Both primary and secondary pressure chambers have outlet ports into individual brake lines leading to the brake calipers. The brake lines transmit the pressure through DOT 3 brake fluid to the calipers, moving the dual piston pads against the rotors. That pulls the caliper assemblies in, squeezing the rotors, slowing or stopping the wheels.

If the power brake booster loses pressure from the power steering pump, the flow switch turns on the backup pump, closing the main supply check valve and opening the backup pump check valve. The electric backup pump then takes over pressurizing the ATF in the power brake booster, providing enough pressure for the master cylinder to operate the brakes.

Releasing the Brakes

When the brake pedal is released, a return spring in the booster opens the throttle valve, reducing ATF pressure in the power brake booster. See **Fig. 7**. The reduced power brake booster pressure allows the master cylinder and piston return springs to move the booster power piston back toward the frontwall side of the power brake booster housing.

In the master cylinder, the return springs push back the primary and secondary pistons, opening their compensating valves. This lowers hydraulic pressure in the master cylinder and the brake lines, allowing the caliper pistons and their brake pads to back away from the brake rotors. With the brake pads no longer squeezing the rotors, the brakes let off and the rotors and wheel hubs can turn freely again.



NOTE: Not all parts are shown.

A. DOT 3 Brake Fluid B. ATF C. Air Space

1. Secondary Compensating Valve (closed)
2. Secondary Reservoir Section
3. Primary Reservoir Section
4. Primary Compensating Valve (closed)
5. Flow Switch Assembly
6. Return Port
7. Supply Port
8. Supply Check Valve (shown open)
9. Pressure Regulator Assembly
10. Actuator Pin
11. Brake Pedal Rod
12. Reaction Piston
13. Throttle Valve
14. Frontwall
15. Power Piston
16. Backup Pump Check Valve (shown closed)
17. Electric Backup Pump
18. Throttle Valve Return Spring
19. Piston Return Spring
20. End-Cap
21. Primary Piston/Actuator Assembly
22. Primary Pressure Chamber
23. Primary Piston Return Spring
24. Secondary Piston/Actuator Assembly
25. Secondary Pressure Chamber
26. Secondary Piston Return Spring

Fig. 7, Power Brake Booster and Master Cylinder

General Information

Input Terminal Activation			
Terminal Number	**Function**	**Circuit Number**	**Activated if**
7	Ignition Input	81C	The ignition is on.
8	Not Used	—	—
9	Relay Input	388F	The ignition is on or brake pedal is depressed.
10	Not Used	—	—
11	Pressure Differential Switch Input	388A	Pressure difference between front and rear systems becomes more than 483 kPa (70 psi).
12	Brake Pedal Input	388L	Brake pedal depressed.
13	Pump Motor Input	388C	Electrical resistance of backup pump motor too high.
14	Fluid Level Input	388B	Fluid level of master cylinder below 25 percent capacity.
15	Flow Switch Input	388G	No hydraulic flow through power brake booster.

Table 2, Input Terminal Activation

General Safety Precautions

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- Disconnect the batteries.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

⚠ WARNING

Hydraulic brake fluid is hazardous, and can cause blindness if it gets in your eyes. Always wear safety glasses when handling brake fluid or bleeding brake components. Brake fluid may also be a skin irritant. If you get it on your skin, wash it off as soon as possible.

Special care must be taken when disposing of used brake fluid. Put the fluid in a sealed plastic container and label it "Used Brake Fluid." Then dispose of it in an approved manner. Check with local and state regulations as to the correct disposal procedure.

IMPORTANT: During service procedures, keep grease and other foreign material away from caliper assemblies, disc brake pads, brake rotors and external surfaces of the hub. Handle parts carefully to avoid damage to the caliper, rotor, disc brake pads or brake lines.

Asbestos and Non-Asbestos Safety

⚠ WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through

Safety Precautions

sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

⚠ WARNING

Before working on or around hydraulic brake systems and components, see Safety Precautions 100. Failure to follow those safety precautions may result in personal injury.

Bleeding

⚠ WARNING

The hydraulic brake and power steering systems must be bled whenever any fitting has been loosened or disconnected. Failure to bleed the system will allow air to remain in it. That will decrease the vehicle's braking ability and can result in an accident, property damage, and serious personal injury.

Properly dispose of used hydraulic brake fluid. Used hydraulic brake fluid is often contaminated. Reusing it can cause brake system damage, loss of braking, property damage and serious personal injury.

Automatic transmission fluid (ATF) and brake fluid must not be mixed. Use only brake fluid for the master cylinder and brake lines. Use only ATF for the power brake booster. Mixing these two fluids will seriously damage the hydraulic system. ATF will damage the rubber parts of the ABS modulator, master cylinder, and brake calipers and can cause damage, loss of braking and serious personal injury.

Always use new clean DOT 3 brake fluid when bleeding the master cylinder and service brake system. Never reuse brake fluid, and do not use brake fluid containers for any other purpose. DOT 3 brake fluid exposed to the air absorbs water from it, so keep brake fluid containers tightly closed to keep new brake fluid clean and dry. Keeping the master cylinder reservoir properly filled to the bottom of the narrow filler neck helps reduce moisture absorption from the air.

IMPORTANT: Do not let DOT 3 brake fluid touch any painted surfaces. Brake fluid removes paint and may also damage other non-metallic surfaces. Do not let fluid get on brake pads or rotors.

Pressure Bleeding

Pressure bleeding is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These are available from a number of manufacturers and include instructions for use. See Fig. 1.

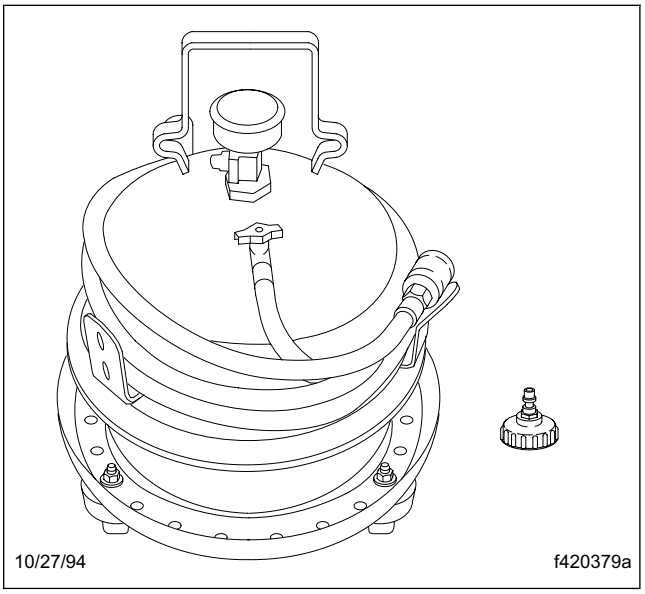


Fig. 1, Pressure Bleeder Kit

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Connect the pressure bleeder to the brake master cylinder reservoir following the manufacturer's instructions.

⚠ WARNING

Do not exceed 35 psi (241 kPa) at the master cylinder inlet. Exceeding this pressure could rupture the master cylinder assembly, spraying brake fluid around the area. This will almost certainly result in vehicle paint damage and may cause other damage or personal injury.

3.1 Fill the pressure bleeder with new DOT 3 approved brake fluid. Pressurize it according to the manufacturer's instructions.

Hydraulic System Bleeding

3.2 Using the supplied adapter, connect the pressure bleeder to either one of the fill ports on the master cylinder reservoir.

4. Bleed the hydraulic connections at the rear wheel calipers, starting on the right side.

4.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tubing fits snugly. Submerge the other end of the tubing in a container of clean brake fluid. See **Fig. 2**.

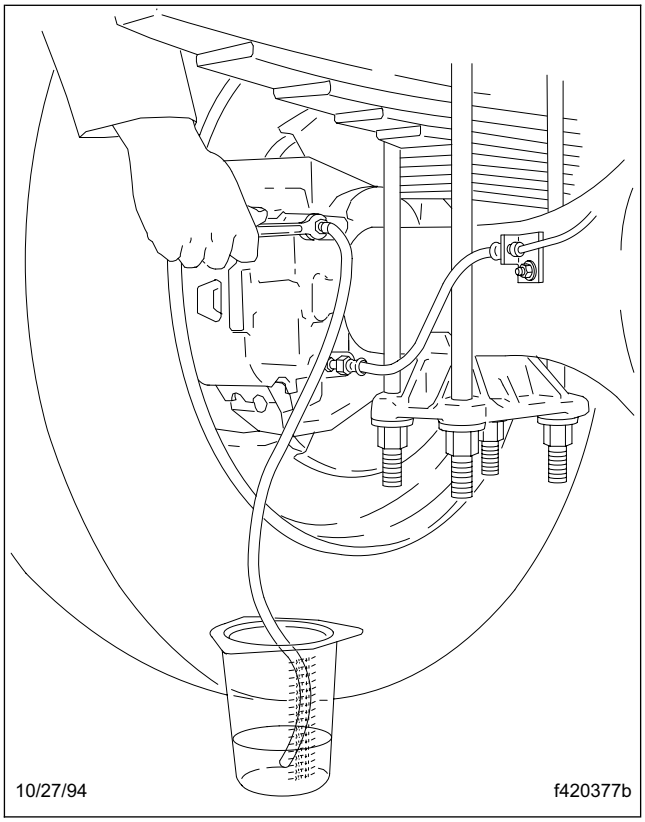


Fig. 2, Bleed the Connections at the Rear Wheel Calipers

4.2 Loosen the bleeder fitting about 3/4-turn and let the brake fluid flow out of the fitting until it is free of air bubbles. Tighten the fitting firmly.

4.3 Move to the left rear caliper and repeat steps for bleeding the caliper.

5. Add DOT 3 brake fluid to the master cylinder reservoir, if it is needed.

6. Bleed the front wheel brake calipers, right side first.

6.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the other end of the tubing in a container of clean brake fluid. See **Fig. 2**.

6.2 Loosen the bleeder fitting by about 3/4-turn and let the brake fluid flow out of the fitting until it is free of air bubbles. Tighten the fitting firmly.

6.3 Move to the left front wheel caliper and repeat steps for bleeding the caliper.

7. Check the brake fluid level in both compartments of the reservoir. Add new DOT 3 approved brake fluid if needed.

8. Check the operation of the brakes by pumping the brake pedal several times until it feels firm. The brake pedal should not go all the way down to the floor. If it does, see **Troubleshooting 300**.

9. Close and latch the hood.

10. Connect the batteries.

11. Remove the chocks from the rear tires.

12. Repeat step 8. Check for operation of the brakes.

Manual Bleeding

If you do not have pressure bleeding equipment, you can use the manual bleeding procedure.

IMPORTANT: Do not let the brake master cylinder fluid level get too low during manual bleeding operations. Keep the master cylinder reservoir filled with new DOT 3 approved brake fluid. Allowing the brake fluid reservoir to empty will force air into the system, the opposite of the desired result.

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

2. Open the hood.

3. Disconnect the batteries. The ignition must remain off for the entire bleed procedure.
4. Bleed the master cylinder.

   NOTE: It will not usually be necessary to bleed the master cylinder unless the brake fluid reservoir has run dry or master cylinder components have been replaced.

   4.1 Using a wrench and holding a rag underneath to absorb leaking brake fluid, loosen the fitting at the rear outlet port on the master cylinder about one turn. See Fig. 3.

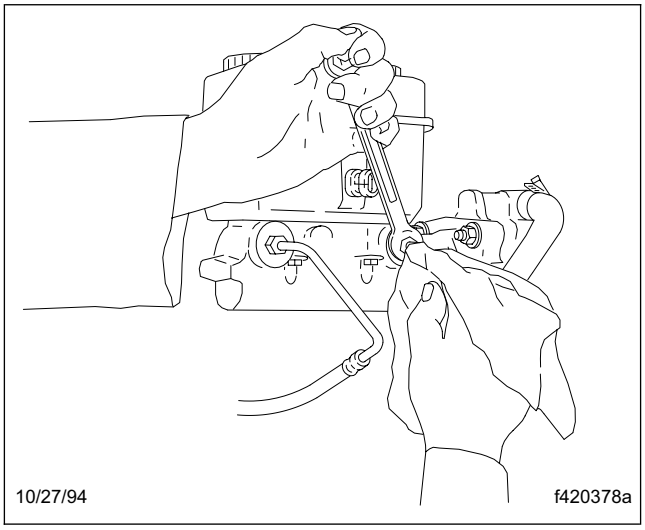


Fig. 3, Loosen the Fitting at the Rear Outlet Port

   4.2 Have someone push the brake pedal down slowly to the floor and hold it there. Brake fluid and any air in the master cylinder will squirt from the fitting.

   4.3 *With the brake pedal held down*, tighten the rear hydraulic line fitting firmly.

   IMPORTANT: Do not release the brake pedal until the fitting is tightened, or more air will get into the system.

   4.4 Release the brake pedal.

   4.5 Loosen the fitting again and bleed the line until no air escapes from the fitting and the brake pedal feels firm.

   4.6 Check the fluid level in the master cylinder reservoir. Add new DOT 3 approved brake fluid as needed to raise the level to the bottoms of the narrow filler necks.

   4.7 Using a wrench and holding a rag under it to absorb leaking brake fluid, loosen the fitting at the front outlet port on the master cylinder. See Fig. 4. Loosen the fitting about one turn.

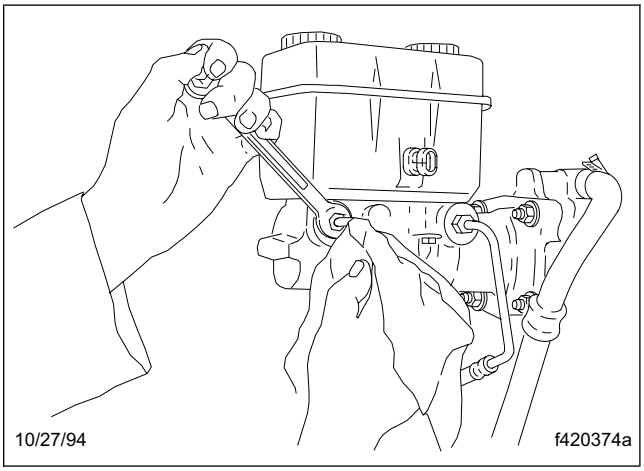


Fig. 4, Loosen the Fitting at the Front Outlet Port

   4.8 Repeat steps as required for the front outlet port.

   4.9 Check the brake fluid level in the master cylinder reservoir. Add new DOT 3 heavy duty brake fluid as needed.

5. Bleed the brake lines at the wheel calipers, starting at the right rear wheel caliper.

   5.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tubing fits snugly. Submerge the other end of the tubing in a container of clean brake fluid. See Fig. 2.

   5.2 Loosen the bleeder fitting by about 3/4-turn.

   5.3 Have an assistant slowly push the brake pedal to the floor and hold it down. *Hold the brake pedal down* as you tighten the bleeder fitting.

   IMPORTANT: Do not let off the brake pedal until the caliper fitting is tightened. Releasing

Hydraulic System Bleeding

the pedal before the fitting is tightened will suck air back into the system.

5.4 Release the brake pedal. Check the fluid in the tube. If there are air bubbles present, repeat bleeding as required until the fluid in the tube is completely free of air bubbles.

5.5 Check the brake fluid level in the reservoir. Add new DOT 3 heavy duty brake fluid as needed.

5.6 Repeat the steps for bleeding the left rear caliper, the right front caliper and the left front caliper. When finished, fill the reservoir to the bottoms of the narrow filler necks.

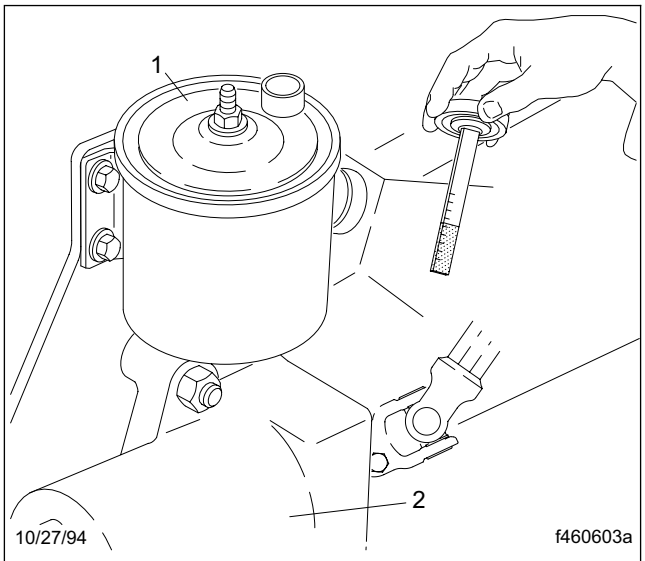
6. Close and latch the hood.
7. Connect the batteries.
8. Remove the chocks from the rear tires.
9. **Check the operation of the brakes by pumping the brake pedal several times until it feels firm.** The brake pedal should not go all the way down to the floor. If it does, see **Troubleshooting 300**.

Power Brake Booster Bleeding

⚠ WARNING

Use only clean, approved automatic transmission fluid (ATF) for the procedure below. Do not use DOT 3 brake fluid. Putting DOT 3 brake fluid in the power brake booster system will damage the seals and O-rings in the power brake booster, the power steering pump and the power steering gear. This could result in a loss of power steering and/or braking, which could possibly cause an accident resulting in property damage or serious personal injury.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Check the level of fluid in the power steering reservoir. See **Fig. 1**. Fill it with approved ATF as needed. See **Specifications 400** for approved ATF.



1. Power Steering Reservoir
2. Steering Gear

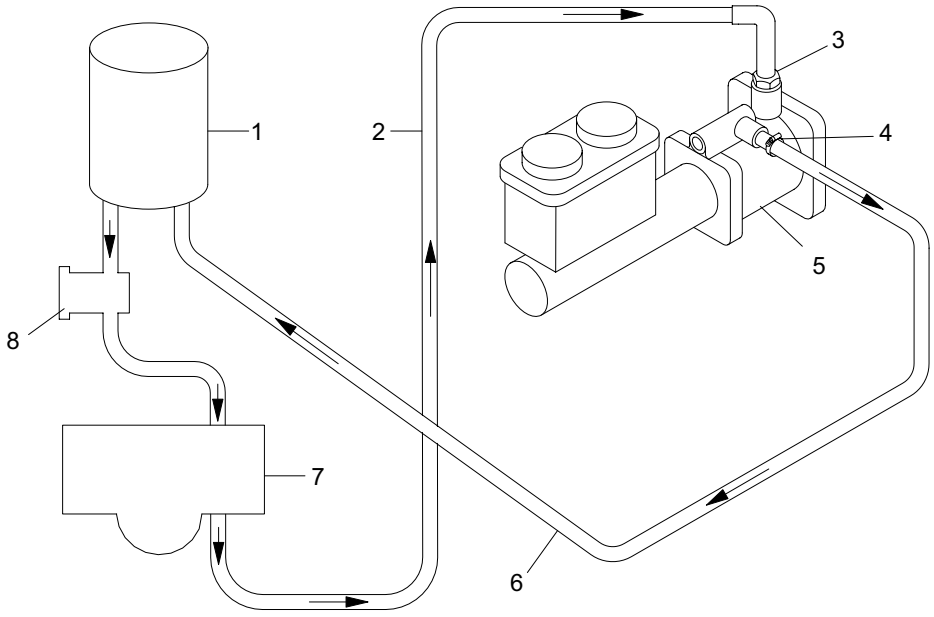
Fig. 1, ATF Level Check

4. Place the transmission in neutral and crank the starter several times, but do not start the engine.
5. Check the ATF level in the power steering reservoir. Fill, if needed.
6. Crank the starter and check the fluid level again.
7. Check the operation of the brakes.
   - 7.1 With the key off, push the brake pedal. The dash warning light and buzzer should come on and the backup pump should come on.
   - 7.2 Turn the key to the ON position, but do not start the engine. The dash warning light and buzzer should come on, and the backup pump should start to run.
   - 7.3 Start the engine. Depress the brake pedal. The dash warning light, buzzer and backup pump should stay off. If they come on, see **Troubleshooting 300** and find the problem.
   - 7.4 Shut down the engine. Check the ATF level in the power steering reservoir. Fill it as needed.
8. Close and latch the hood.
9. Remove the chocks from the rear tires.

Replacing Hydraulic Lines

Power Brake Booster System

The power brake booster gets pressurized ATF through its connection to the power steering gear and returns the ATF to the steering system into the power steering reservoir. See **Fig. 1**.



1. Power Steering Reservoir
2. Hydraulic Supply Line
3. Steel Fitting with O-Ring Seal
4. Hose Clamp
5. Power Brake Booster
6. Hydraulic Return Line
7. Power Steering Gear
8. Power Steering Pump

Fig. 1, Power Brake Booster System

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Replace all power steering hoses that are leaking or show signs of cracking, softening or bulging. Replace the entire hose; do not attempt to repair it.

   3.1 Remove all hose clamps and tie straps used for routing the hose.

   3.2 Using a shop towel over the fittings to catch dripping ATF power steering fluid, disconnect both ends of the hose being replaced.

   3.3 Install the new hose.

   If replacing the power brake booster supply hose, tighten the supply port connection to 21 ±5 lbf·ft (28 ±6 N·m), and the outlet connection on the power steering gear 41 lbf·ft (56 N·m).

   If replacing the power brake booster return hose, tighten the hose clamps firmly at the booster return fitting and the power steering reservoir.

   3.4 Install the hose clamps and replace any tie straps removed earlier.

   Check the routing of the hose. Make sure it is away from heat sources and moving parts such as the steering and driveline. Make sure there are no kinks or sharp

Replacing Hydraulic Lines

bends in the hose, and that it can not be rubbed or pinched by other parts as they move.

4. Bleed the power brake booster system following the instructions in **Subject 120**.
5. Close and latch the hood.
6. Remove the chocks from the tires.

Service Brake System

The service brake system has two types of hydraulic brake lines, rigid steel tubing and flexible rubber hose.

The steel brake lines are 1/4-inch o.d. double-walled tubing, and run from the master cylinder to points on the chassis near each wheel. The rubber brake hoses are 1/8-inch i.d. low-expansion rubber; they connect the end of each rigid line to the caliper assembly at each wheel.

IMPORTANT: Use only lines or hoses approved for use in high pressure brake fluid applications.

Do not attempt to repair brake lines or hoses. Faulty lines or hoses must be replaced.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Locate the leak in the brake line. Determine the length and configuration (if a steel line) of the section involved.
4. If necessary, loosen and remove any brackets holding the brake line to the frame or axle so that you can remove the damaged section.
5. Put a container under the connection on one end of the leaking brake line. Disconnect the line. Plug both ends of the connection.

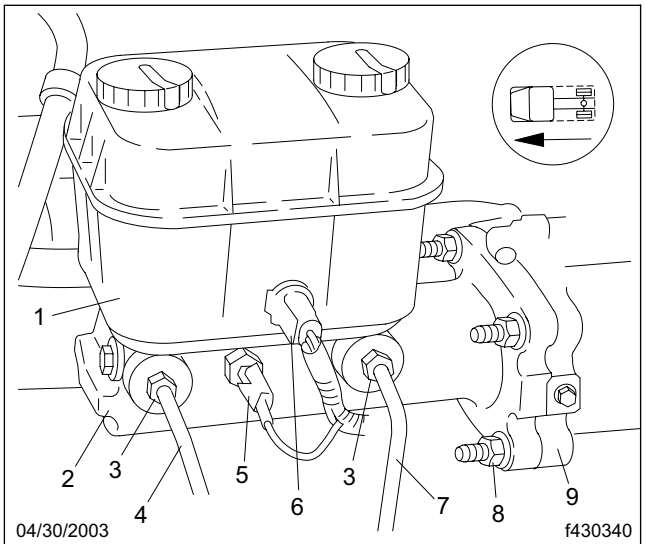
   Repeat at the connection on the other end of the leaking brake line, and remove it from the vehicle.
6. Remove the plugs installed earlier. Install the new section of brake line and tighten the connections.
7. Install any brackets that were removed.
8. Bleed the brake system following the procedure in **Subject 110**.
9. Close and latch the hood.
10. Remove the chocks from the rear tires.

Removal

⚠ WARNING

Before starting the procedure below, read the information in Safety Precautions 100. Exposure to brake fluid could cause serious, permanent health damage. Take precautions against exposing yourself to it.

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Disconnect the wires from the pressure differential switch on the master cylinder body and the fluid level sensor on the reservoir. See Fig. 1.



1. Reservoir
2. Master Cylinder Housing
3. Brake Line Tube Nuts
4. Secondary Subsystem Brake Line
5. Pressure Differential Switch
6. Fluid Level Sensor
7. Primary Subsystem Brake Line
8. Flanged Hexnut
9. Power Brake Booster Mounting Flange

Fig. 1, Master Cylinder Assembly

⚠ CAUTION

Do not let the brake fluid get on any painted surface; it will quickly damage the paint. Wrap a rag around the fitting you are working on, or put a container underneath it to catch any fluid leaking as it is disconnected.

4. Disconnect the brake lines from the outlet ports of the master cylinder. See Fig. 2. Plug the brake lines to prevent contamination and leakage.
5. Remove the four flanged hexnuts that attach the master cylinder to the power brake booster unit. See Fig. 3.

   Remove the master cylinder from the vehicle. See Fig. 4. Keep it upright with a rag wrapped around it so you do not drip any brake fluid.

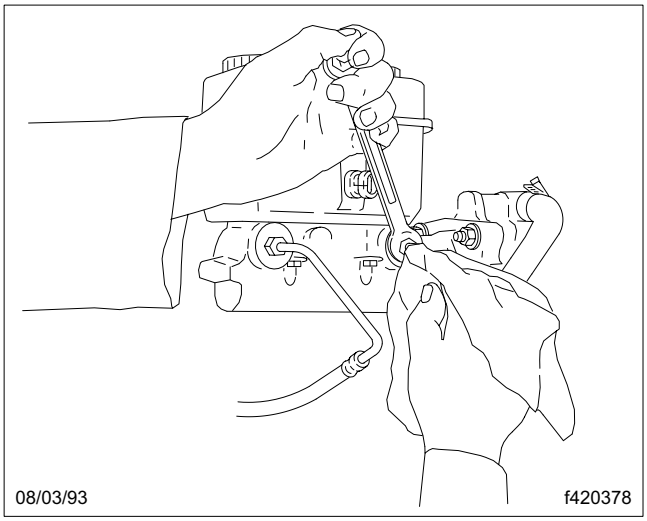


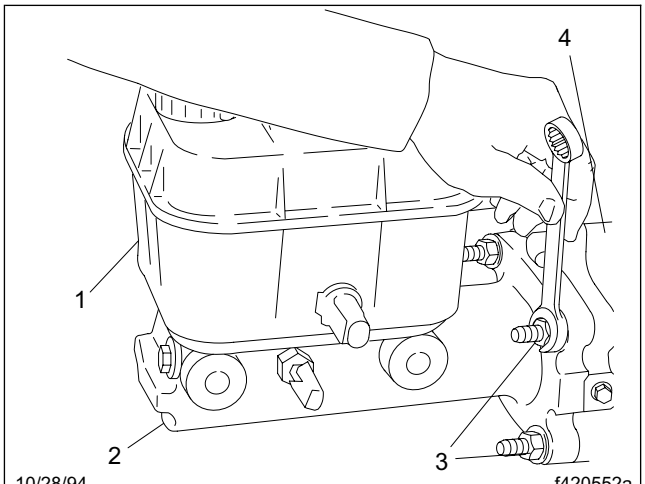
Fig. 2, Brake Lines

6. Remove the caps from the master cylinder reservoir, then carefully turn it over and dump the brake fluid into a container. Dispose of used brake fluid in a responsible and approved manner.

Installation

1. Bench bleed the master cylinder.
   - 1.1 Put the master cylinder and reservoir assembly in a vise.
   - 1.2 Install the plastic adapter and clear tubing on the master cylinder outlet ports, as shown in Fig. 5.

Master Cylinder Removal and Installation



1. Reservoir
2. Master Cylinder
3. Flanged Hexnut
4. Power Brake Booster

Fig. 3, Remove Hexnuts

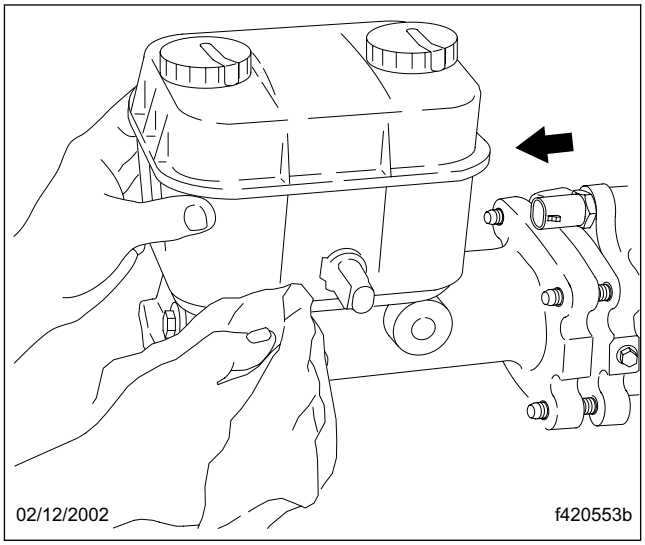


Fig. 4, Remove the Master Cylinder

Put the other end of each tube up into the reservoir, as shown in **Fig. 6**.

1.3 Fill the reservoir about half-full with new DOT 3 heavy duty brake fluid.

1.4 Using a metal rod with a rounded end, push and release the primary piston several times. This purges air bubbles

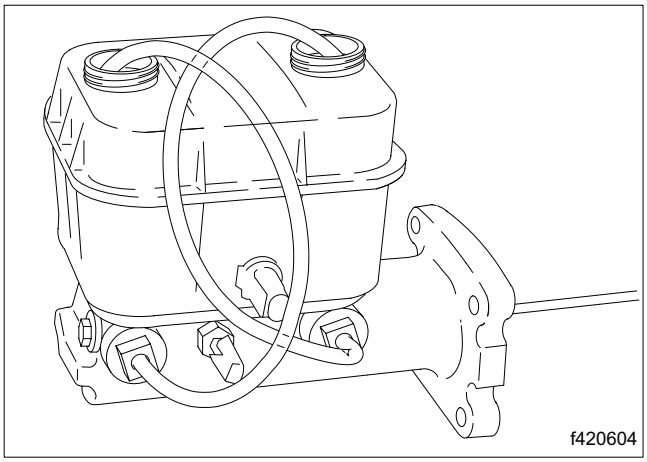
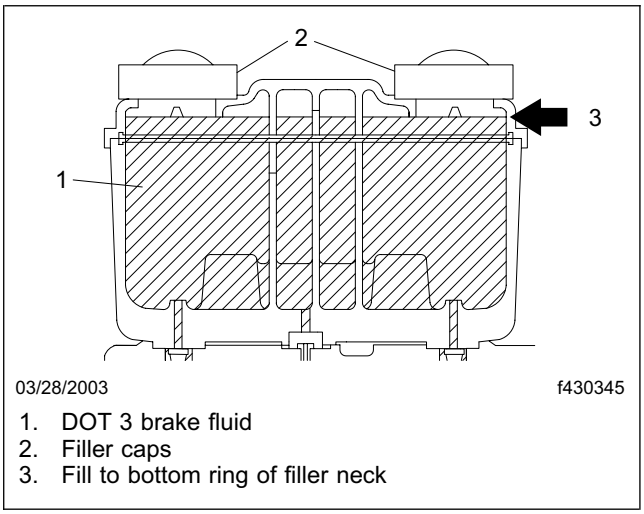


Fig. 5, Outlet Ports With Master Cylinder Bleeder Tubes



1. DOT 3 brake fluid
2. Filler caps
3. Fill to bottom ring of filler neck

Fig. 6, Master cylinder fill level

trapped in the master cylinder while returning fluid to the master cylinder reservoir.

The brake bleeder plastic adapters and tubing may be left in place to retain fluid until the master cylinder is in place and the vehicle brake lines are installed.

2. Slip the master cylinder onto its studs on the front of the power brake booster, install the four flanged nuts on the studs of the power brake booster and tighten to 27 lbf·ft (37 N·m).
3. Remove the plastic bleeder tubes if they were left on after bench bleeding. Connect the secondary circuit line to the front outlet port on the

master cylinder, and the primary circuit line to the rear outlet port. Tighten the fittings to maximum 16 lbf·ft (22 N·m).

4. Connect the wires to the pressure differential switch and the fluid level sensor. See **Fig. 1**.
5. Fill the reservoir to the bottom of the narrow throat formed by the fill opening with new DOT 3 heavy duty brake fluid. See **Fig. 6**.
6. Bleed the entire brake system following the instructions in **Subject 110**.
7. Close and latch the hood.
8. Remove the chocks from the tires.

Hydro-Max® II Power Brake Booster Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Disconnect the batteries at the negative cable.
4. If the brake master cylinder is still mounted on the power booster, remove it following the instructions in **Subject 140**.
5. Inside the cab, disconnect the brake pedal rod from the brake pedal.

   5.1 Below the dash, find the clevis pin, washer, and cotter key that connect the power booster push rod to the brake pedal. See **Fig. 1**.

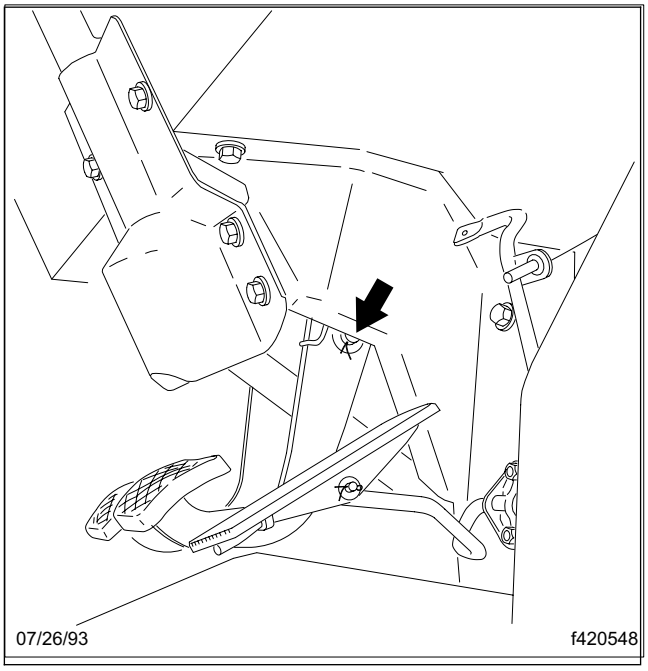
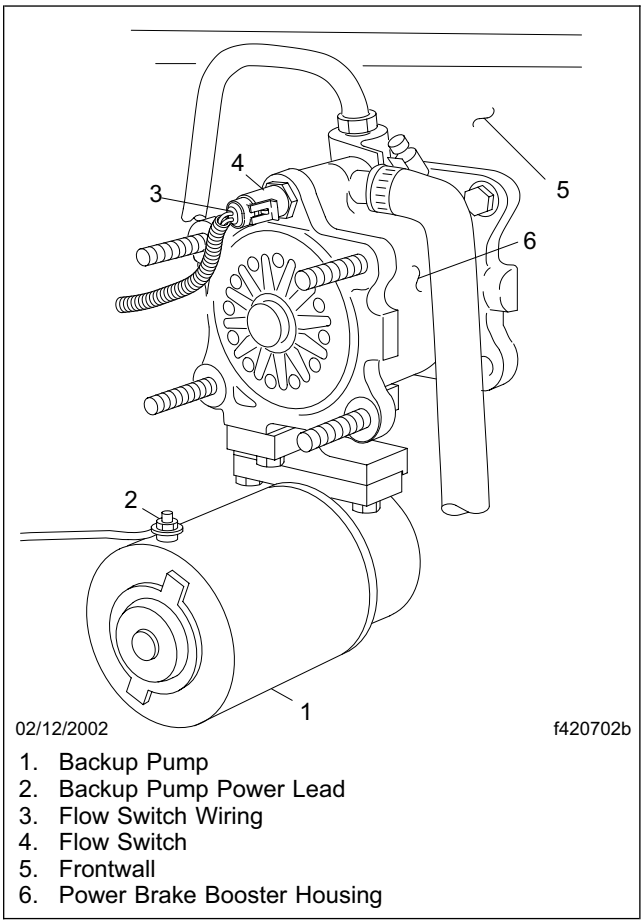


Fig. 1, Brake Pedal

   5.2 Remove the cotter key, washer and clevis pin.

6. Disconnect the wiring from the backup pump assembly. See **Fig. 2**.
7. Disconnect the wiring from the flow switch at the front of the power brake booster. See **Fig. 2**.



1. Backup Pump
2. Backup Pump Power Lead
3. Flow Switch Wiring
4. Flow Switch
5. Frontwall
6. Power Brake Booster Housing

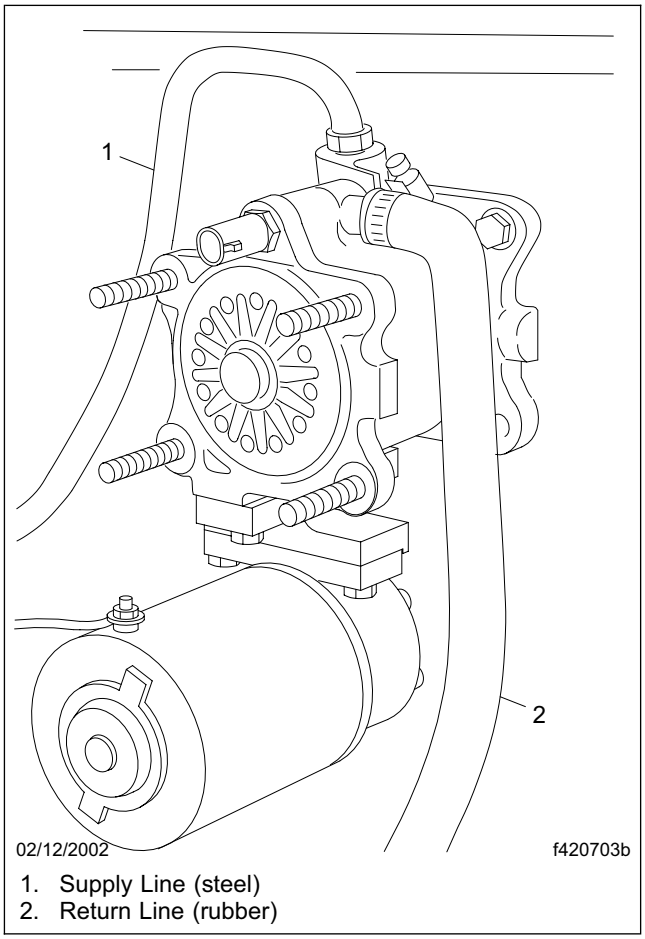
Fig. 2, Backup Pump Assembly (actual appearance may vary)

8. Using a shop towel or a container to catch any leaking automatic transmission fluid (ATF), disconnect the hydraulic supply and return lines from the power brake booster. See **Fig. 3**. Plug the lines.
9. Remove the four hexbolts and washers holding the power brake booster to the frontwall. See **Fig. 4**. Pull the power brake booster straight out from the frontwall. See **Fig. 5**.

Installation

1. Position the power brake booster on the frontwall so the brake pedal rod fits through the large hole and into the cab and the four holes in the power brake booster line up with those on the frontwall. See **Fig. 5**.

Hydro-Max® II Power Brake Booster Removal and Installation



1. Supply Line (steel)
2. Return Line (rubber)

Fig. 3, Power Brake Booster Lines (actual appearance may vary)

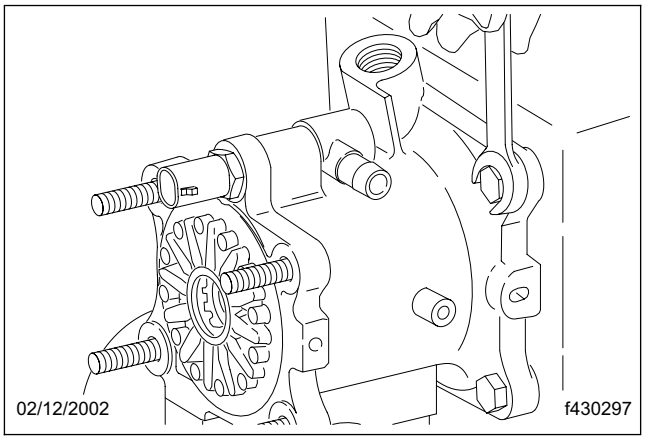


Fig. 4, Power Brake Booster Mounting (actual appearance may vary)

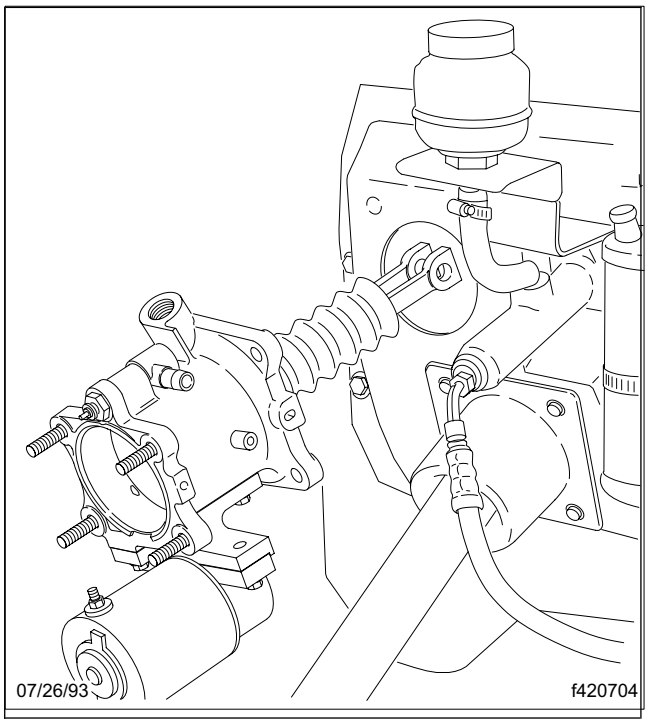
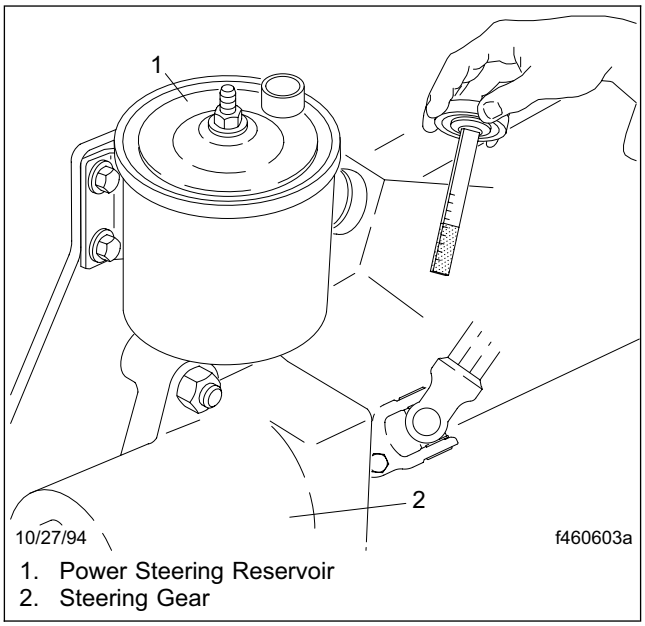


Fig. 5, Power Brake Booster Removal

2. Install the four mounting hexbolts and washers. See **Fig. 4**. Tighten to 27 lbf·ft (37 N·m).
3. Install the master cylinder on the power brake booster, following the instructions in **Subject 140**.
4. Connect the hydraulic supply and return lines See **Fig. 3**. Tighten the supply line to 21 lbf·ft (28 N·m). Tighten the hose clamp on the return line firmly.
5. Connect the wiring to the backup pump assembly and to the flow switch assembly. See **Fig. 2**.
6. Check the ATF level in the power steering reservoir See **Fig. 6**. Add approved ATF if needed. See **Specifications 400** for the approved ATF.
7. Connect the batteries.
8. Bleed the power brake booster following the instructions in **Subject 110**.
9. Close and latch the hood.
10. Remove the chocks from the rear tires.

Hydro-Max® II Power Brake Booster Removal and Installation



1. Power Steering Reservoir
2. Steering Gear

Fig. 6, Fluid Level Check

Hydraulic Brake Electronic Monitor Module Removal and Installation

NOTE: The monitor module is located on the driver side of the dash behind the instrument control unit (ICU).

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries at the negative terminals.
3. Inside the cab, remove the dash trim panel. See **Fig. 1**.

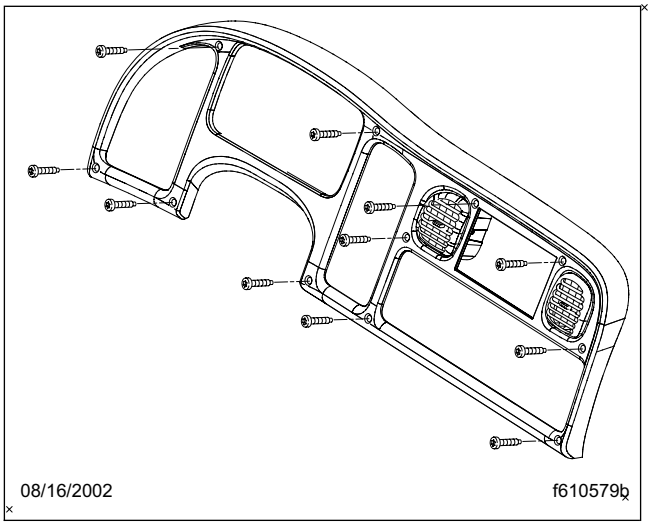


Fig. 1, Dash Trim Panel

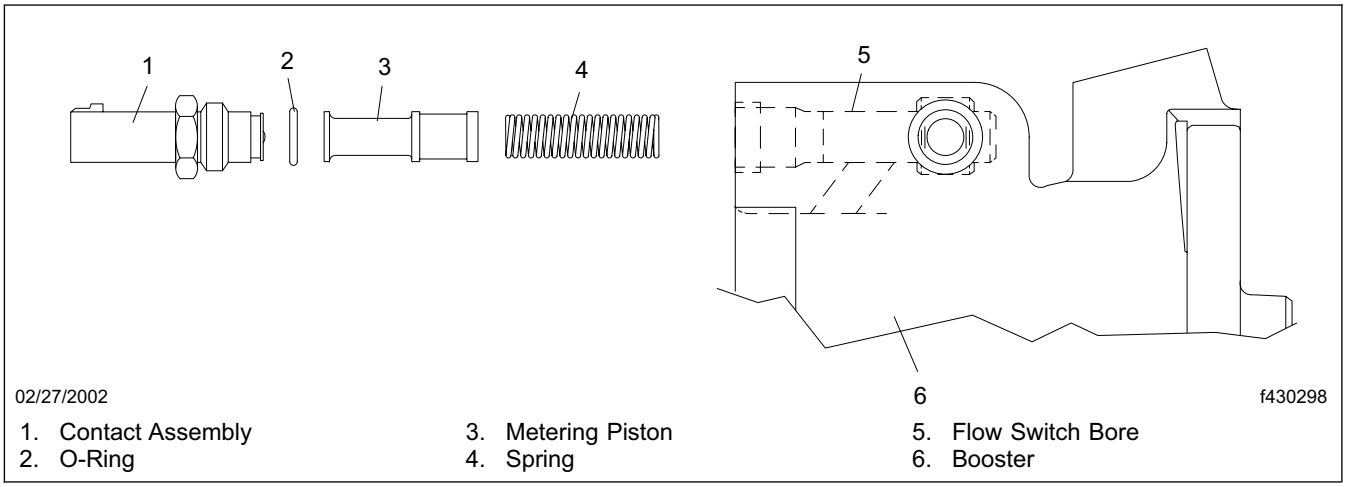
4. Locate the monitor module behind the instrumentation control unit (ICU-M2). Disconnect the 9-pin connector and the 4-pin connector from the module.
5. If necessary in order to remove the monitor module, remove the U-M2. For instructions, see **Section 54.04**, Subject 100.
6. Remove the monitor module.

Installation

1. Connect the 9-pin and the 4-pin connectors to the monitor module.
2. Install the monitor module on the mounting bracket.
3. If it was removed, install the ICU-M2. For instructions, see **Section 54.04**, Subject 100.
4. Install the dash trim panel. See **Fig. 1**.
5. Connect the batteries.
6. Remove the chocks from the rear tires.
7. Verify proper operation of the monitor module. See **Subject 120**.

Flow Switch Removal, Inspection and Installation

NOTE: Refer to **Fig. 1** when performing the following procedures.



1. Contact Assembly
2. O-Ring
3. Metering Piston
4. Spring
5. Flow Switch Bore
6. Booster

Fig. 1, Flow Switch Assembly (exploded view)

The most likely conditions requiring service of the flow switch are:

- Contamination of the metering piston.
- Damaged contact assembly.
- Leaking at the contact assembly.
- The backup pump running continuously when the engine is running.
- The backup pump not running when it should be.

Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Place a suitable container under the booster to catch any automatic transmission fluid (ATF) that may drain out while removing the flow switch contact assembly.
4. Disconnect the wiring harness flow switch connector from the flow switch contact assembly.
5. Remove the contact assembly from the booster. Be prepared to catch the metering piston; it may be pushed out of the booster housing by the spring.
6. If the metering piston did not come out by itself, use a small magnet to extract the metering piston and spring from the bore.

Inspection

1. If the contact assembly is damaged, replace it.
2. If the O-ring seal is damaged, replace it.
3. Inspect the opening into the booster and inspect the flow switch bore. These surfaces must be clean and free of particles, chips or any other form of contaminant. Remove any contaminant.
4. Inspect the metering piston and spring for cleanliness. Remove any contaminants.

Installation

1. If a new contact assembly or O-ring is being used, install the O-ring onto the contact assembly.
2. Install the spring and metering piston into the flow switch bore.
3. Install the contact assembly and O-ring into the booster. Tighten 20 to 40 lbf·in (2 to 4 N·m).
4. Connect the wiring harness flow switch connector to the flow switch contact assembly.

Flow Switch Removal, Inspection and Installation

5. Fill the power steering pump reservoir to the proper level with ATF. Do not reuse old ATF from the booster.
6. Connect the battery ground cable.
7. Confirm proper installation of the switch.
   - 7.1 Start the engine. With the engine running, the power steering pump circulates ATF through the system. This automatically purges air from the booster.
   - 7.2 While the engine is running, press on the brake pedal several times to make sure the pedal feels normal.
8. Shut the engine off. Press on the brake pedal several times to make sure the pedal feels normal in the backup pump mode.
9. Check for leakage at the flow switch contact assembly.
10. Confirm that the backup pump does not run when the engine is running.
11. Confirm that the backup pump runs both when the engine is off and the ignition key is on, and when the ignition key and engine are off but the brake pedal is depressed.
12. Recheck the ATF level in the power steering pump reservoir. If necessary, add ATF.
13. Road test the vehicle to ensure proper steering and braking operation.

Hydraulic Brake Troubleshooting Index		
Common Categories	**Subject**	**Figure/Table**
Warning light and buzzer related to parking brake	Subject 300	Fig. 1
Warning light and buzzer related to service brake	Subject 300	Fig. 2
Backup pump runs continuously	Subject 300	Fig. 3, Fig. 4
Backup pump does not run	Subject 300	Fig. 5, Fig. 4
Abnormal brake pedal conditions	Subject 300	Fig. 6, Fig. 8
Hydraulic system leakage	Subject 300	Fig. 9, Fig. 10, Fig. 11, Fig. 12
Brakes are dragging	Subject 300	Fig. 13, Fig. 14
Short pad life, uneven pad wear, or overheated brakes	Subject 300	Fig. 13
Brake system pressure test	Subject 310	Fig. 1
Hydraulic brake system plumbing diagram	Subject 400	Fig. 2
Hydraulic system fluid specification	Subject 400	Table 2 and Table 3
Fastener torque table	Subject 400	Table 1

Table 1, Hydraulic Brake Troubleshooting Index

Troubleshooting

This subject is designed to help service technicians do their own troubleshooting and to help them troubleshoot customer complaints. This guide covers most common problems encountered in the field, but some unusual problems may require approaches and remedies not covered here.

NOTE: This subject does not deal with pressure tests, they are covered in Subject 310.

Warning Light and Buzzer Related to Parking Brake

There may be two lights generally relating to brakes: the parking/service brake light, and an ABS light if the vehicle has ABS. This section refers only to the parking/service brake light, not ABS. There is one buzzer for all brake signals.

The brake light and buzzer come on together when triggered by one or more of the following:

- the parking brake switch
- the flow switch
- the fluid level indicator switch
- the differential pressure switch
- the electric backup pump

See Fig. 1 for troubleshooting if the problem seems to be with the parking brake, or Fig. 2 if the service brakes seem to be the problem.

Brake Warning Light and Buzzer Related to Service Brake

See Fig. 2 for troubleshooting.

Backup Pump Runs Continuously

Normally, the backup pump will run only if the flow switch has activated its relay.

A good relay will run the backup pump only if it is triggered by the flow switch and there is power to the relay's coil. A bad relay can be stuck ON, making the backup pump run even though the relay coil is not triggered. A bad relay can also make the backup pump run although the flow switch has not triggered it.

See Fig. 3 for troubleshooting and Fig. 4 for electrical circuits of the master cylinder and power brake booster.

Backup Pump Does Not Run

The backup pump will not run if there is no voltage to the motor or if the motor is damaged — burnt out or

Troubleshooting

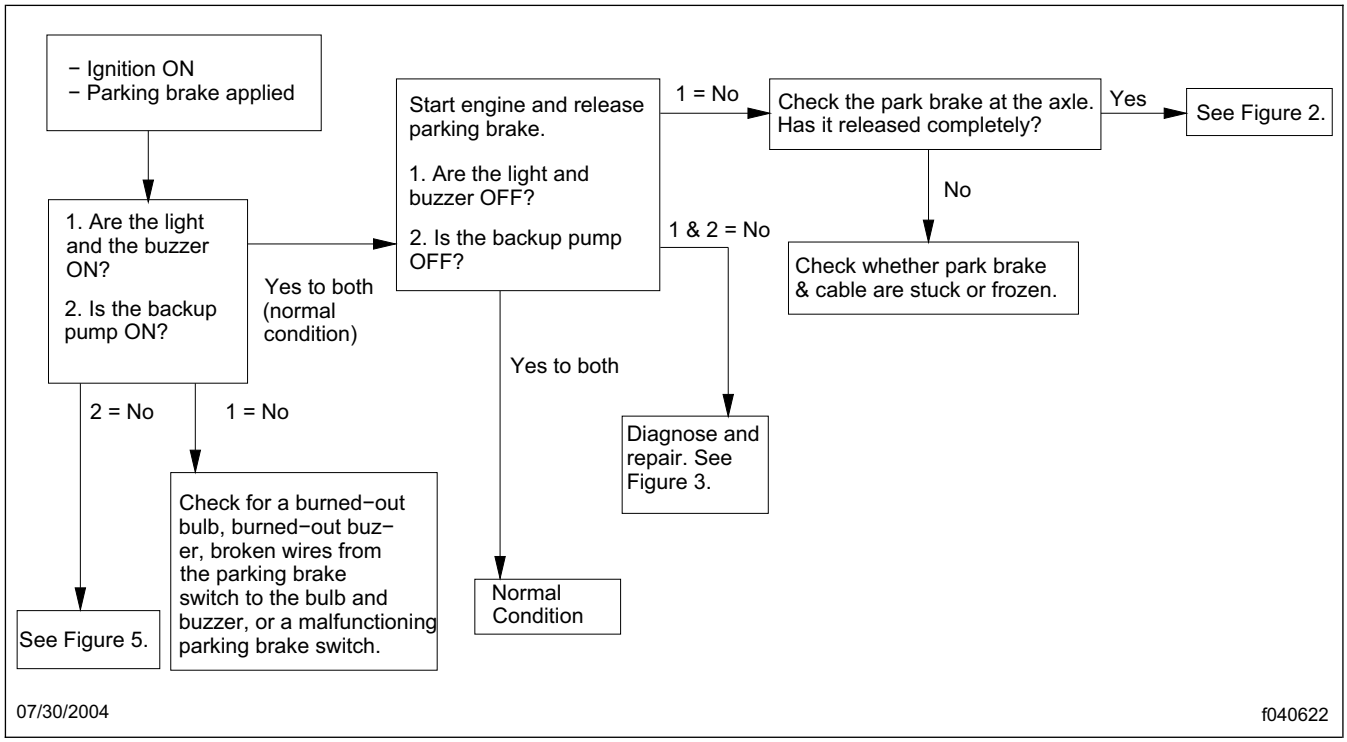


Fig. 1, Flow Chart: Brake Warning Light and Buzzer Relating to Parking Brake

jammed, for instance. Following are some of the possible reasons for the backup pump not running:

- a dead battery
- a broken relay
- a broken wire between the battery and pump motor
- a break in the circuit between the ignition switch/brake light switch and the flow switch
- a bad ground to the flow switch

See **Fig. 5** for troubleshooting and **Fig. 4** for electrical components of the master cylinder and power brake booster.

Abnormal Brake Pedal Conditions

Abnormal pedal conditions defined in this section include the following. See **Fig. 6** for flow chart diagnosis.

- Brake pedal dropping 1/2-inch when the engine is started.
- The brake pedal feels spongy, springy or soft.
- The brake pedal continues to fall with steady foot force.
- The brake pedal feels very hard.

Most common reasons for a very hard pedal—

- Insufficient flow or pressure from the power steering pump;
- ABS is blocking flow of brake fluid to the calipers.

Less likely causes include:

- contaminated power brake booster
- contaminated master cylinder
- binding pedal linkage
- binding power brake booster
- binding master cylinder
- blocked or kinked brake fluid tubes or hoses

With the engine OFF other causes are—

- Backup pump does not run;

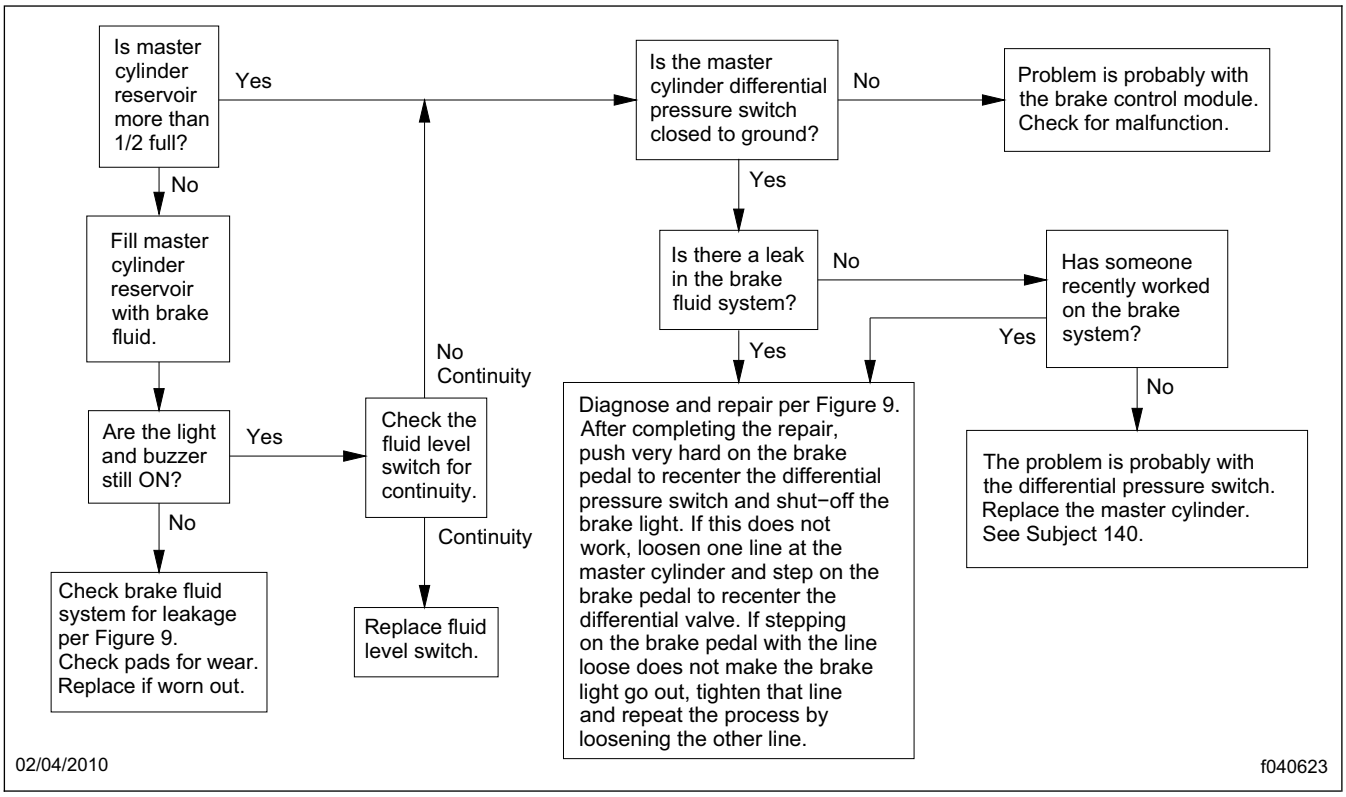


Fig. 2, Flow Chart: Brake Warning Light and Buzzer for Service Brake Problems

- The backup pump does not provide sufficient pressure.

See **Fig. 6** for abnormal brake conditions flow chart. **Fig. 7** illustrates how the rubber seals swell if ATF is put into the master cylinder.

See **Fig. 8** for flow chart regarding very hard brake pedal feel.

Hydraulic System Leakage

See **Fig. 9** and **Fig. 10** if hydraulic fluid leakage is detected.

See **Fig. 11** for the most frequent leak points at the power brake booster.

If fluid is leaking from any of the points listed in **Fig. 11**, see **Fig. 12**.

Brakes are Dragging

The following are possible causes for brake drag:

- The power brake booster does not return to the released position.
- The brake pedal linkage does not return to the released position.
- The master cylinder does not return to the released position.
- The ABS system is trapping hydraulic pressure.
- The brake calipers don't release.
- The brake lines or hoses are plugged, kinked, or collapsed.

NOTE: Some tests require doing things in the cab while at the same time, or within a few seconds, watching what happens elsewhere on the vehicle. These tests require two people.

See **Fig. 13** and **Fig. 14** for complete brake drag diagnostics.

Troubleshooting

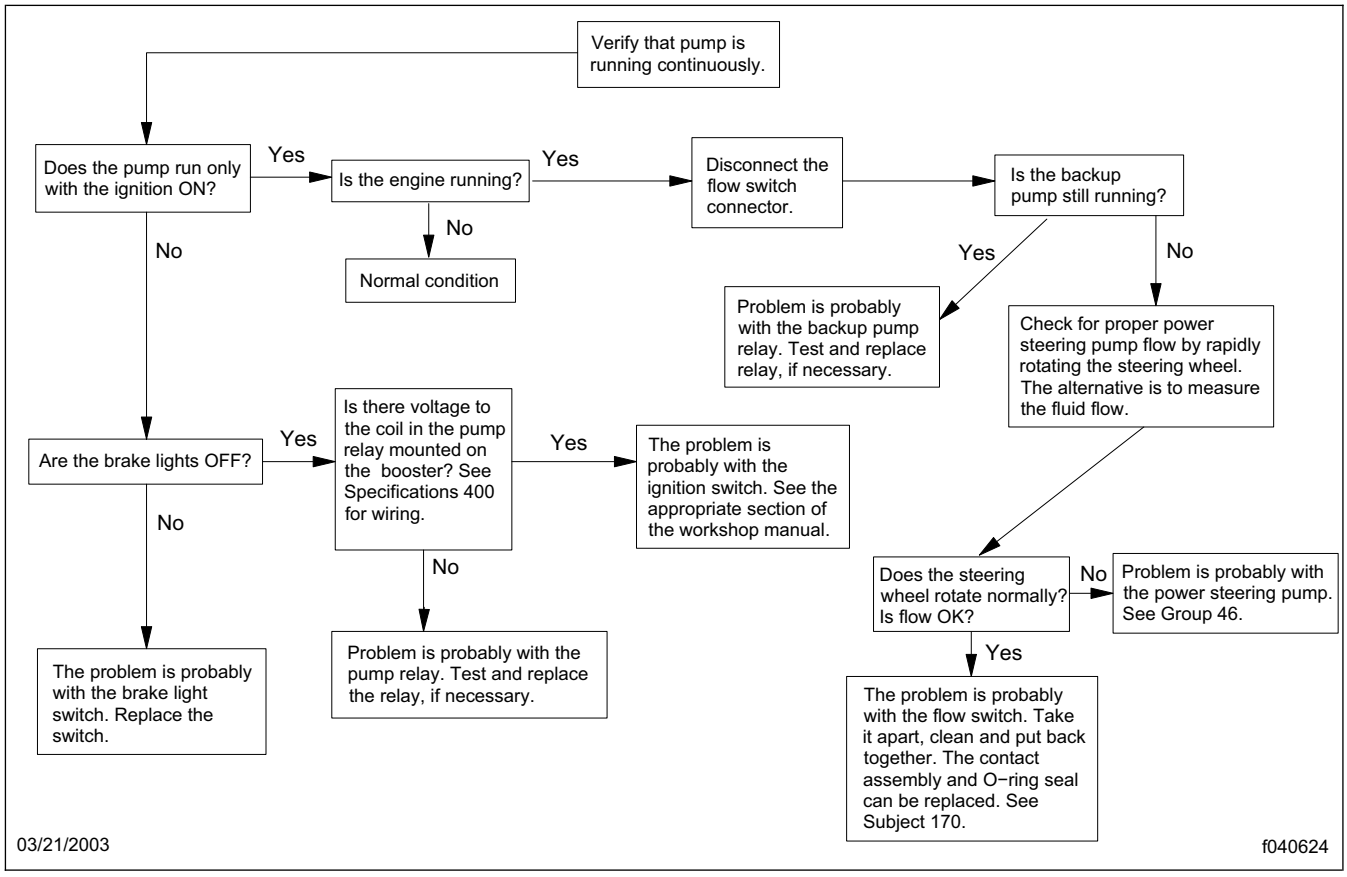


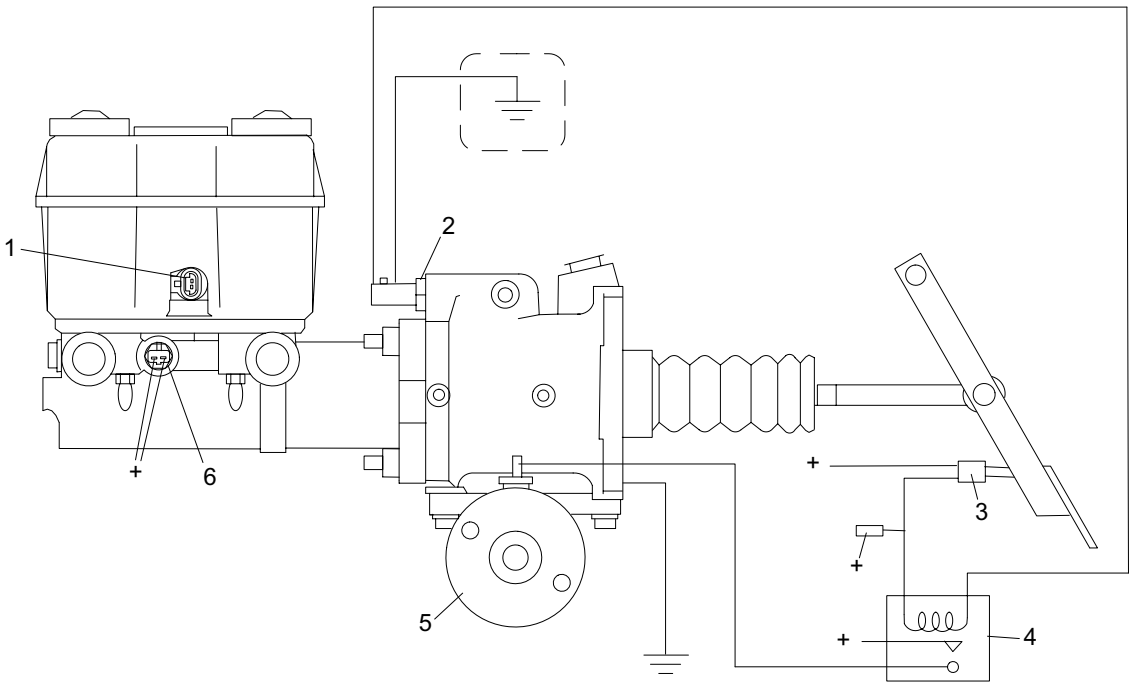
Fig. 3, Flow Chart: Backup Pump Runs Continuously

Short Pad Life, Uneven Pad Wear, or Overheated Brakes

NOTE: Because of vast differences in vehicle types, usage, terrain, driving style and many other factors, it is not possible to make a general prediction of brake lining life. In some cases of severe usage, short lining life is to be expected and does not indicate a problem in the brake system.

1. Check whether the brake pads are wearing abnormally. For instance, check whether the inner and outer pads are wearing unevenly.
2. If the brakes are dragging, smoking, overheating, smelling, pulling, or if there is poor acceleration, see **Fig. 13**.

   If the brake wear is not caused by one of these conditions, the problem is probably related to vehicle usage or the driver's braking habits. For low temperature or low duty conditions, consult the brake manufacturer for appropriate replacement linings.



1. Fluid Level Indicator Switch
2. Flow Switch
3. Brake Light Switch
4. Relay
5. Backup Pump
6. Differential Pressure Switch

Fig. 4, Electrical Components of the Master Cylinder and Power Brake Booster

Troubleshooting

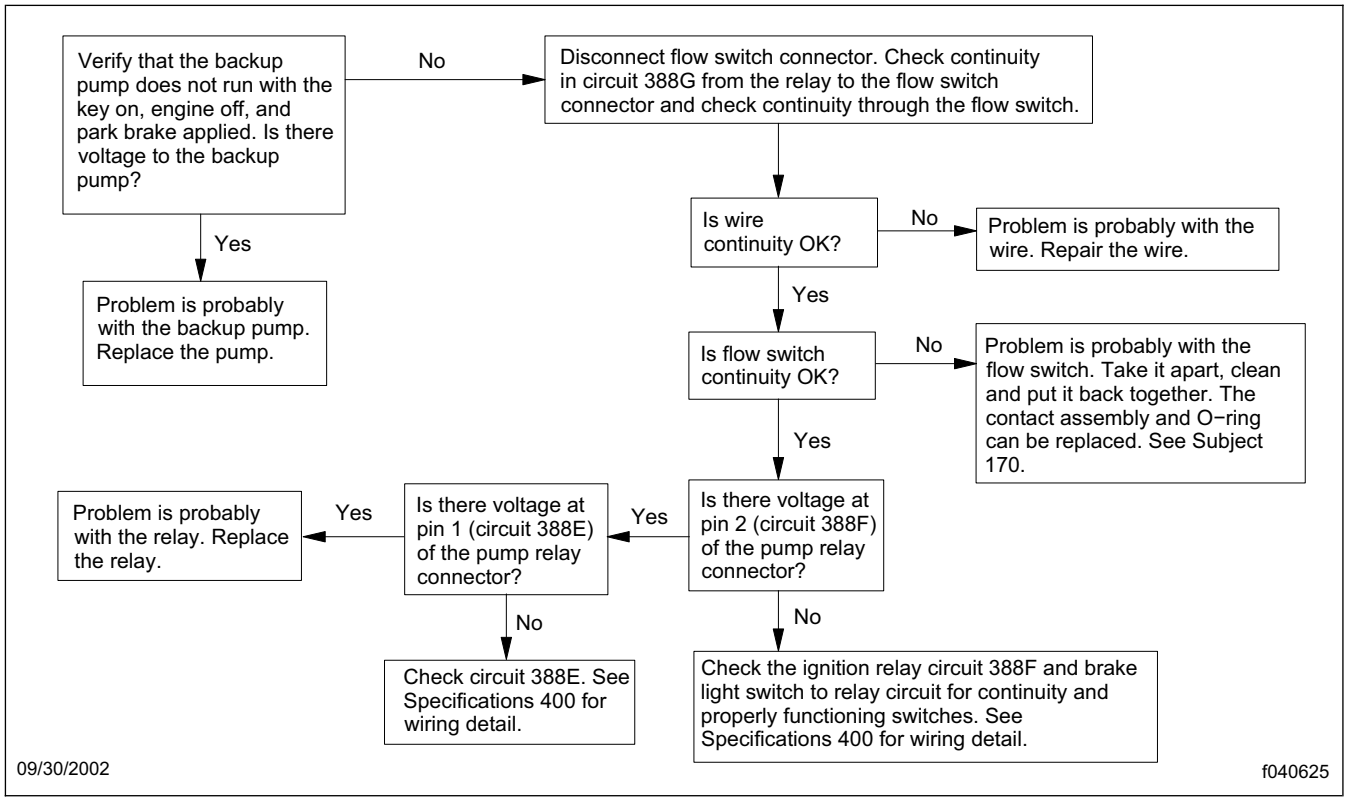


Fig. 5, Flow Chart: Backup Pump Does Not Run

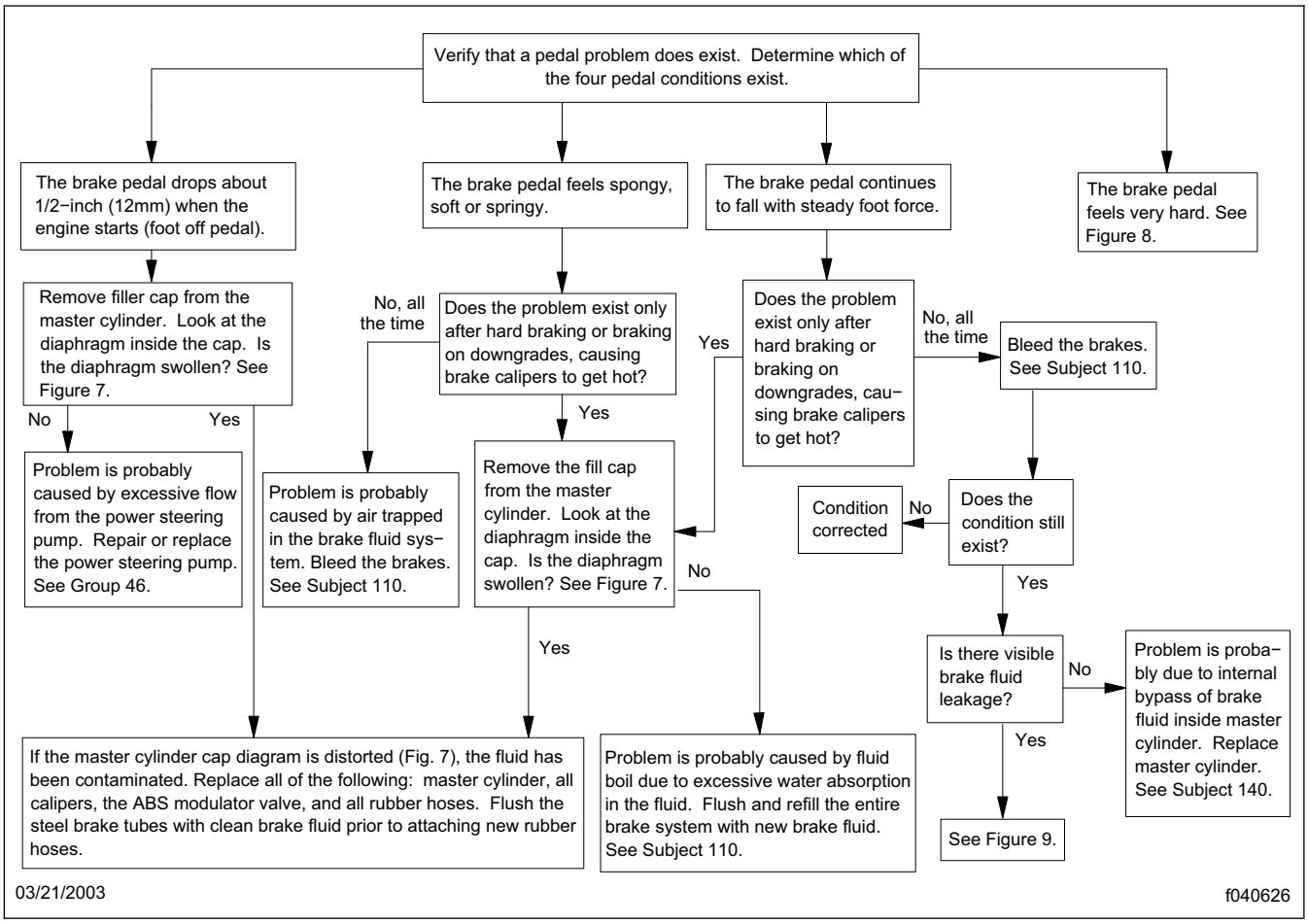
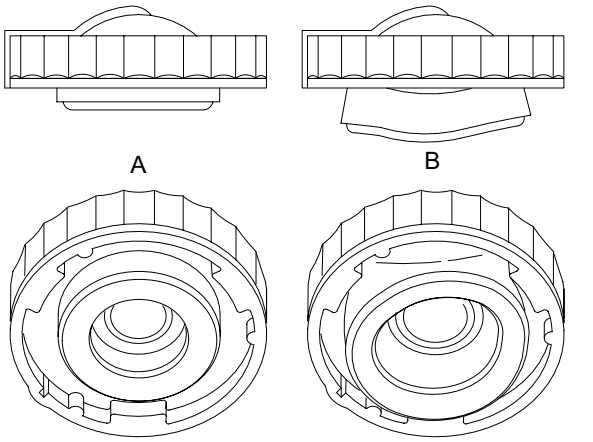


Fig. 6, Flow Chart: Abnormal Brake Pedal Conditions

Troubleshooting



A. Reservoir cap and diaphragm from uncontaminated system.
B. Reservoir cap and diaphragm from a system contaminated with power steering fluid, motor oil or ATF.

Fig. 7, Good and Bad Master Cylinder Fluid Reservoir Caps and Diaphragms

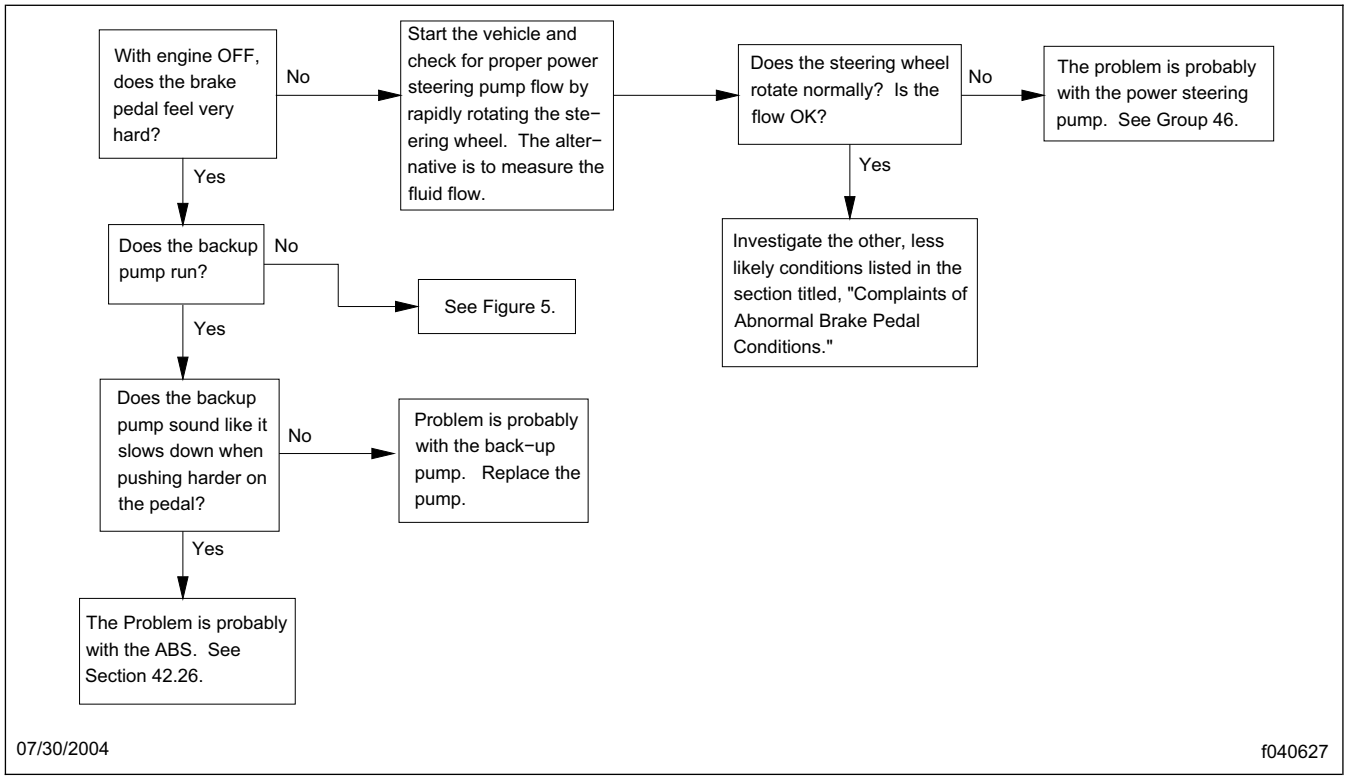


Fig. 8, Flow Chart: Brake Pedal Feels Very Hard

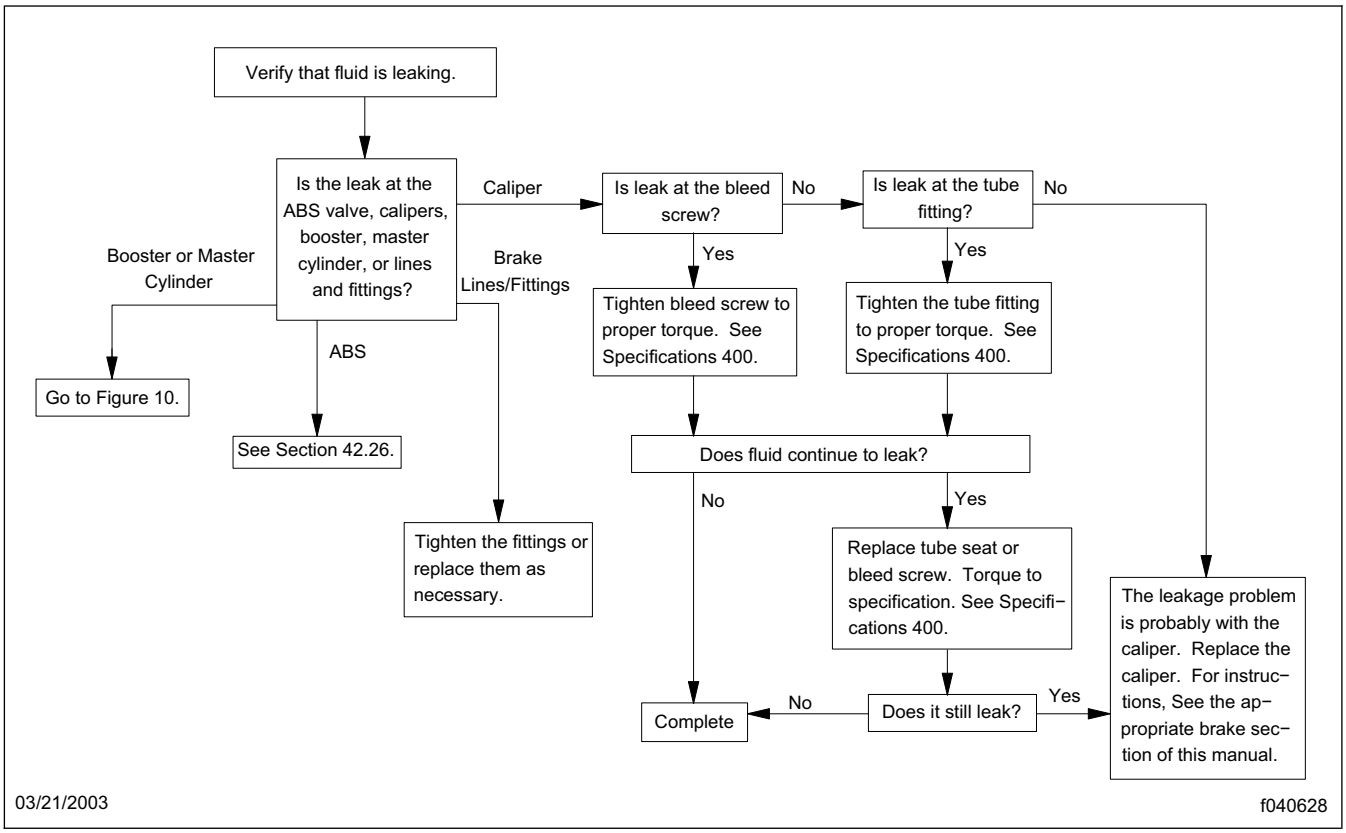


Fig. 9, Flow Chart: Hydraulic System Leakage

Troubleshooting

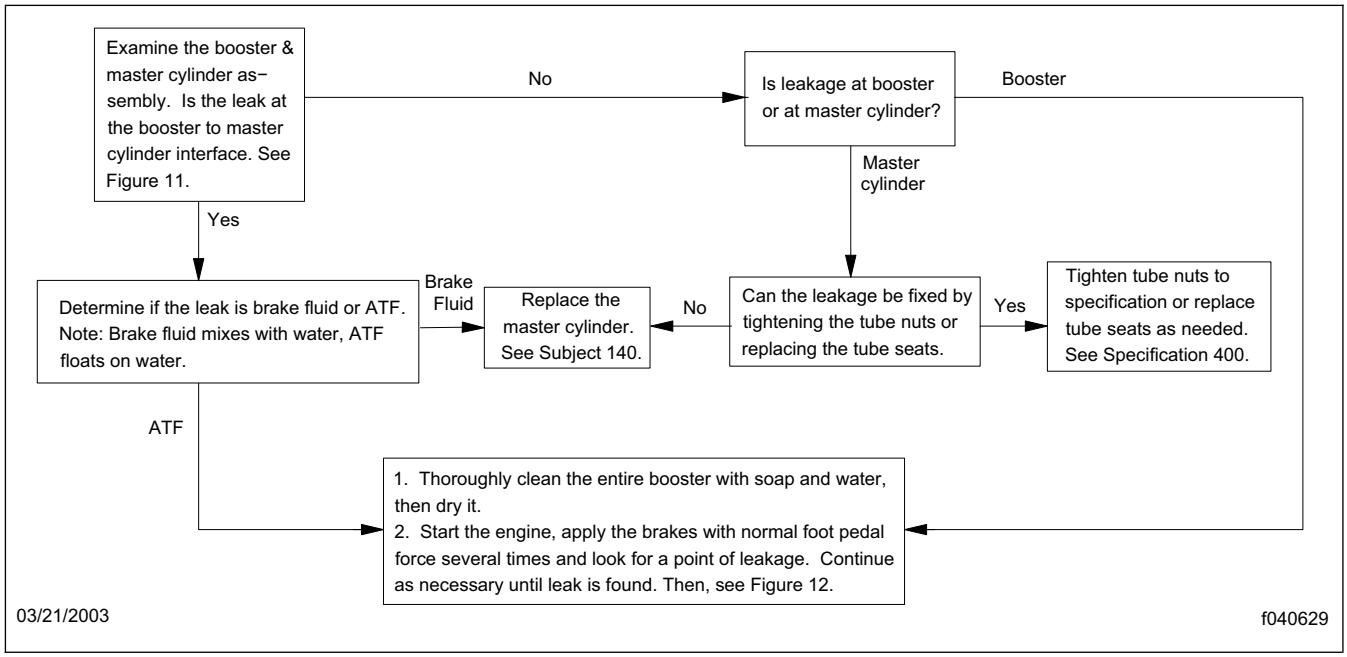
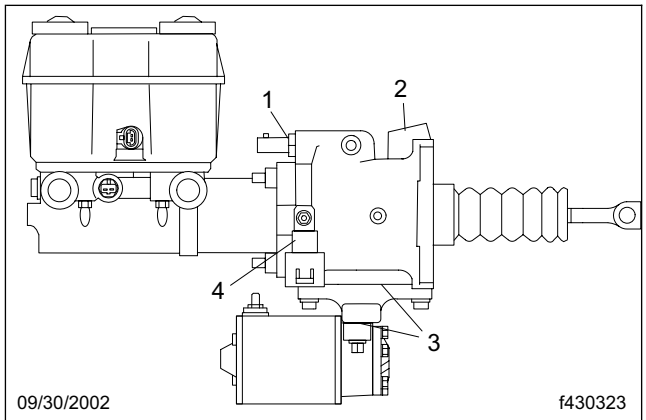


Fig. 10, Flow Chart: Hydraulic System Leakage (cont.)



1. Flow Switch and Power Brake Booster Interface
2. Inlet Port
3. Booster, Adapter and Pump Interface
4. Power Brake Booster and Master Cylinder Interface

Fig. 11, Potential Hydraulic Fluid Leak Points

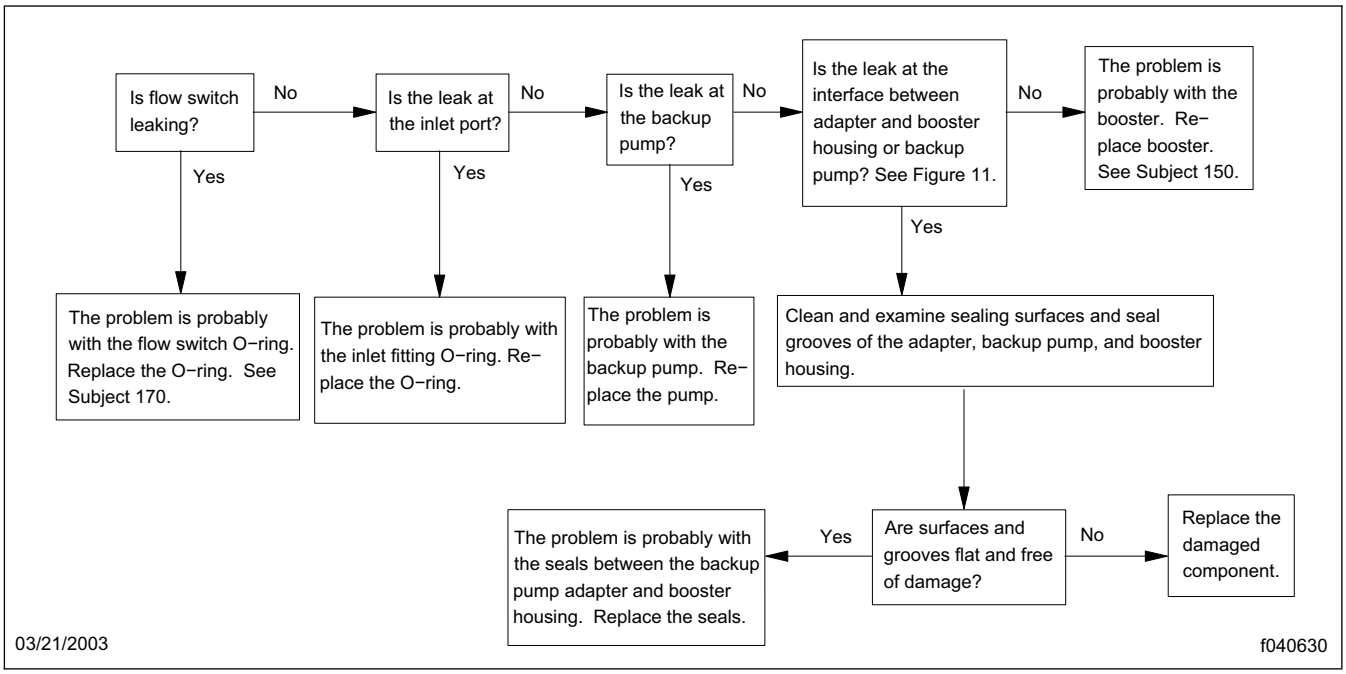


Fig. 12, Flow Chart: Hydraulic System Leakage (cont.)

Troubleshooting

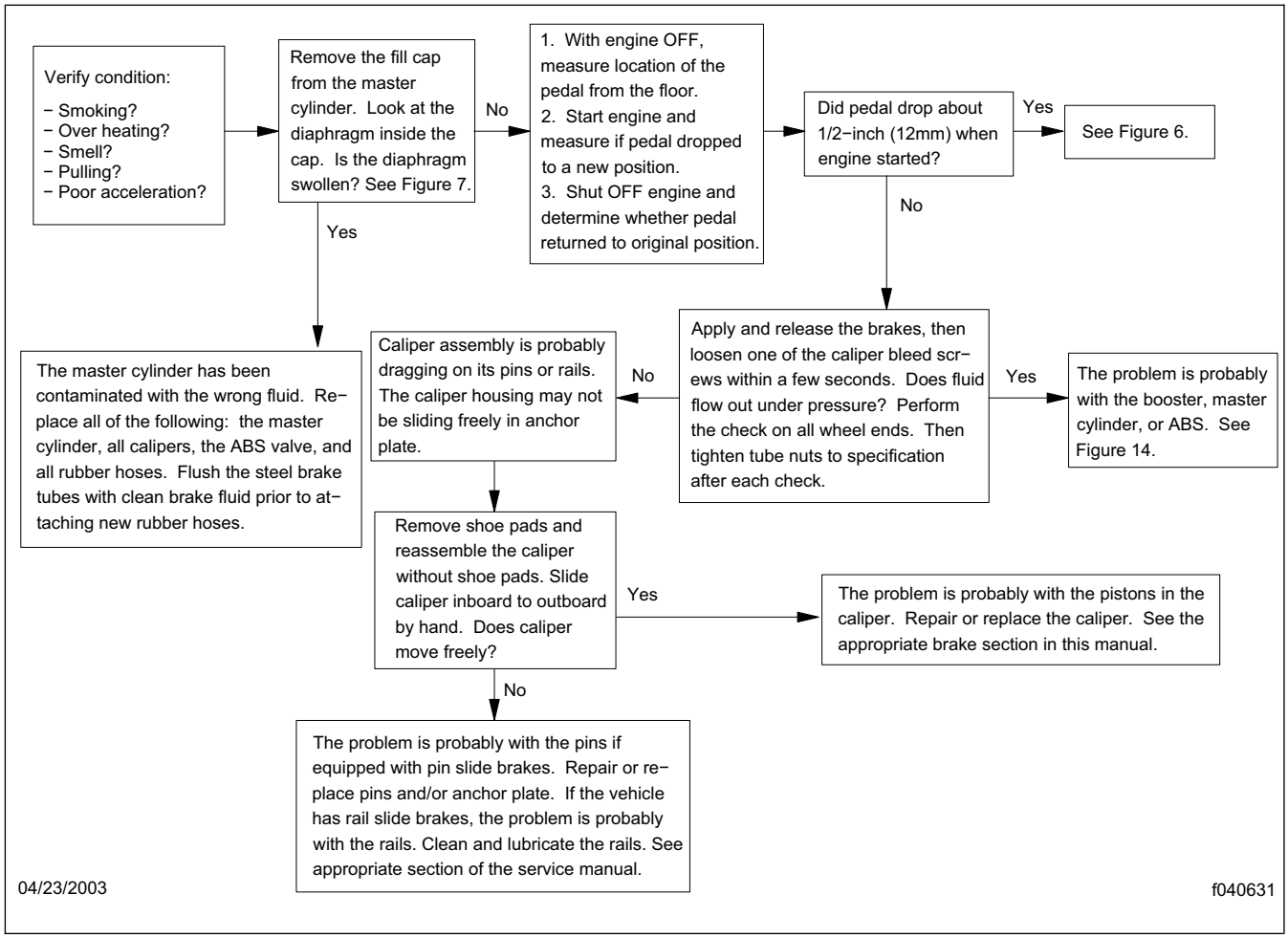


Fig. 13, Flow Chart: Brakes are Dragging

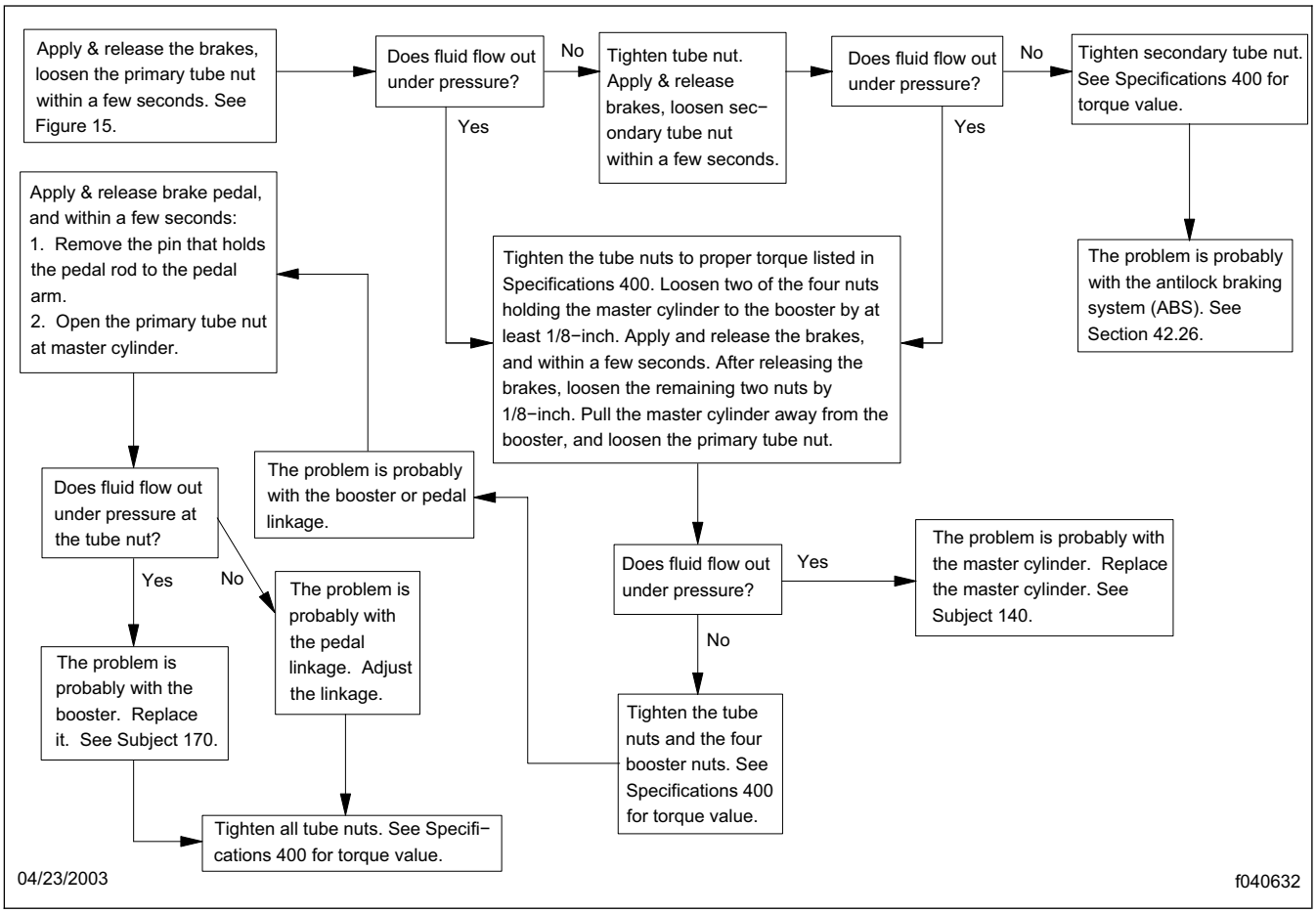
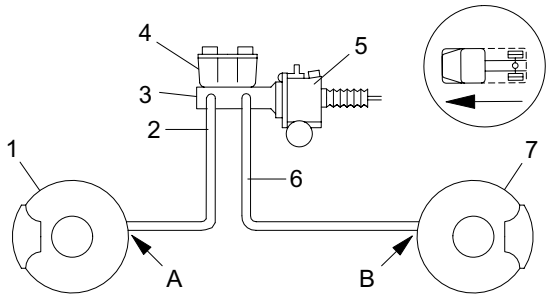


Fig. 14, Flow Chart: Brakes are Dragging (cont.)

Brake System Pressure Tests

NOTE: On most vehicles in the field, the primary master cylinder piston controls the rear brakes, the secondary piston, the front brakes. But on some vehicles the primary master cylinder piston controls the front brakes, the secondary master cylinder piston controls the rear brakes. Either configuration is considered normal and they are functionally identical. Technicians should check vehicle configuration for appropriate diagnosis and repair.

1. Install two low-pressure gauges with a range of 0 to 50 psi (345 kPa) — one at the rear wheels, and one at the front wheels. See Fig. 1.



04/16/2003 f430339

A. Install gauge #2 here.
B. Install gauge #1 here.
1. Front Brake
2. Front Brake Lines
3. Master Cylinder
4. Reservoir
5. Power Brake Booster
6. Rear Brake Lines
7. Rear Brake

Fig. 1, Gauge Installation

2. Bleed the brakes following the procedure in Subject 110.
3. With the ignition off, lightly apply the brakes several times. Do not push hard on the brake pedal or you may damage the low-pressure gauges.
4. Release the brakes. Read the residual pressure on both gauges. Record the information.
5. If the residual pressure on either gauge is less than 2 psi (14 kPa), go to "System Pressure Test" below.

   If the residual pressure on one or both gauges is more than 2 psi (14 kPa), check the linkage between the brake pedal and the booster. Repair the linkage if needed. Repeat steps 3 and 4. If the problem is solved, go to "System Pressure Test" below. If the problem is not solved, continue these steps.
6. Check the hydraulic lines for internal blockage or kinking and replace them as needed. Repeat steps 3 and 4. If the problem is solved, go to "System Pressure Test" below. If the problem is not solved, continue with these steps.
7. Check for residual pressure at the master cylinder. Replace as needed. Go to "System Pressure Test" below.

System Pressure Test

1. Install two pressure gauges with a range of 0 to 2500 psi (17,250 kPa) — one at the rear wheels, and one at the front wheels. See Fig. 1.
2. Bleed the brakes following the procedure under Subject 110.
3. Make a copy of Table 1. Use this copy to record the results from the next step.

Test Results				
Pressure Test	Gauge 1 (installed at rear wheel)		Gauge 2 (installed at front wheel)	
Rapid Pressure Rise	Yes	No	Yes	No
Slow Pressure Rise	Yes	No	Yes	No
Highest Reading (psi)		psi		psi
Pressure Constant	Yes	No	Yes	No

Table 1, Test Results

4. Start the engine. Quickly apply the brakes using full pedal force. Hold the pedal down for 15 to 20 seconds. Record the speed of the pressure rise, the highest pressure registered on each gauge and whether the pressure stayed constant while the pedal was held down. Use a copy of Table 1 to record your observations.
5. If the pressure reading on both gauges is not within 10 percent, the ABS may be affecting readings (Section 42.26). Replace the master cylinder if needed. Remove the pressure gauges.

Pressure Testing

Bleed the system following the instructions in **Subject 110**.

6. If the pressure reading on both gauges is within 10 percent but the gauges show less than 1770 psi (12 200 kPa), turn off the engine but leave the ignition on. Apply the brakes hard and hold the pedal down 15 to 20 seconds to test pressure from the backup pump.

   If both gauges show at least 860 psi (5930 kPa), replace the power steering pump. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

   If both gauges do not show at least 860 psi (5930 kPa), replace the power brake booster. Bleed the system following the instructions in **Subject 110**.

7. If the pressure reading on both gauges is within 10 percent and the gauges show at least 1770 psi (12 200 kPa), but the pressure came up slowly on both gauges, turn off the engine leaving the ignition on. Apply the brakes hard, hold down the pedal 15 to 20 seconds. If there was a rapid pressure rise on both gauges, repair or replace the power steering pump. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

   If the pressure rose slowly on both gauges, repair or replace the power brake booster. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

8. If the pressure reading on both gauges is within 10 percent and the gauges show at least 1770 psi (12 200 kPa), but the pressure comes up rapidly on one gauge and slowly on the other, there is probably a restriction in the brake system with the slow gauge. Remove the gauge and install it closer to the master cylinder until the pressure rises rapidly. The restriction is between that point and the point of previous installation. Repair or replace the brake line as needed. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

9. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1770 psi (12 200 kPa) and the pressure came up rapidly on both gauges but the gauges do not hold constant pressure while the pedal is held down, turn off the engine. Leave the ignition on. Push hard on the brake pedal and hold it down for 15 to 20 seconds. If both gauges hold constant pressure while the pedal is down, repair or replace the power steering pump. Bleed the system following the instructions in **Subject 110**.

   If either gauge does not show constant pressure with the pedal held down, there is probably leakage between the master cylinder and the calipers.

10. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1770 psi (12 200 kPa), the pressure comes up rapidly on both gauges and there is constant gauge pressure while the pedal is depressed but the brake pedal did not stay firm, there is probably leakage in the lines between the master cylinder and calipers.

11. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1770 psi (12 200 kPa), the pressure comes up rapidly on both gauges, there is constant gauge pressure while the pedal is depressed and the brake pedal stays firm, the system is good. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**. If the problem still exists, check the foundation brakes.

See **Fig. 1** for a full view of the hydraulic brake system wiring.

See **Fig. 2** and **Fig. 3** for partial views of the hydraulic brake system wiring.

See **Fig. 4** for a full view of the monitor module wiring.

See **Fig. 5** and **Fig. 6** for partial views of the control module wiring.

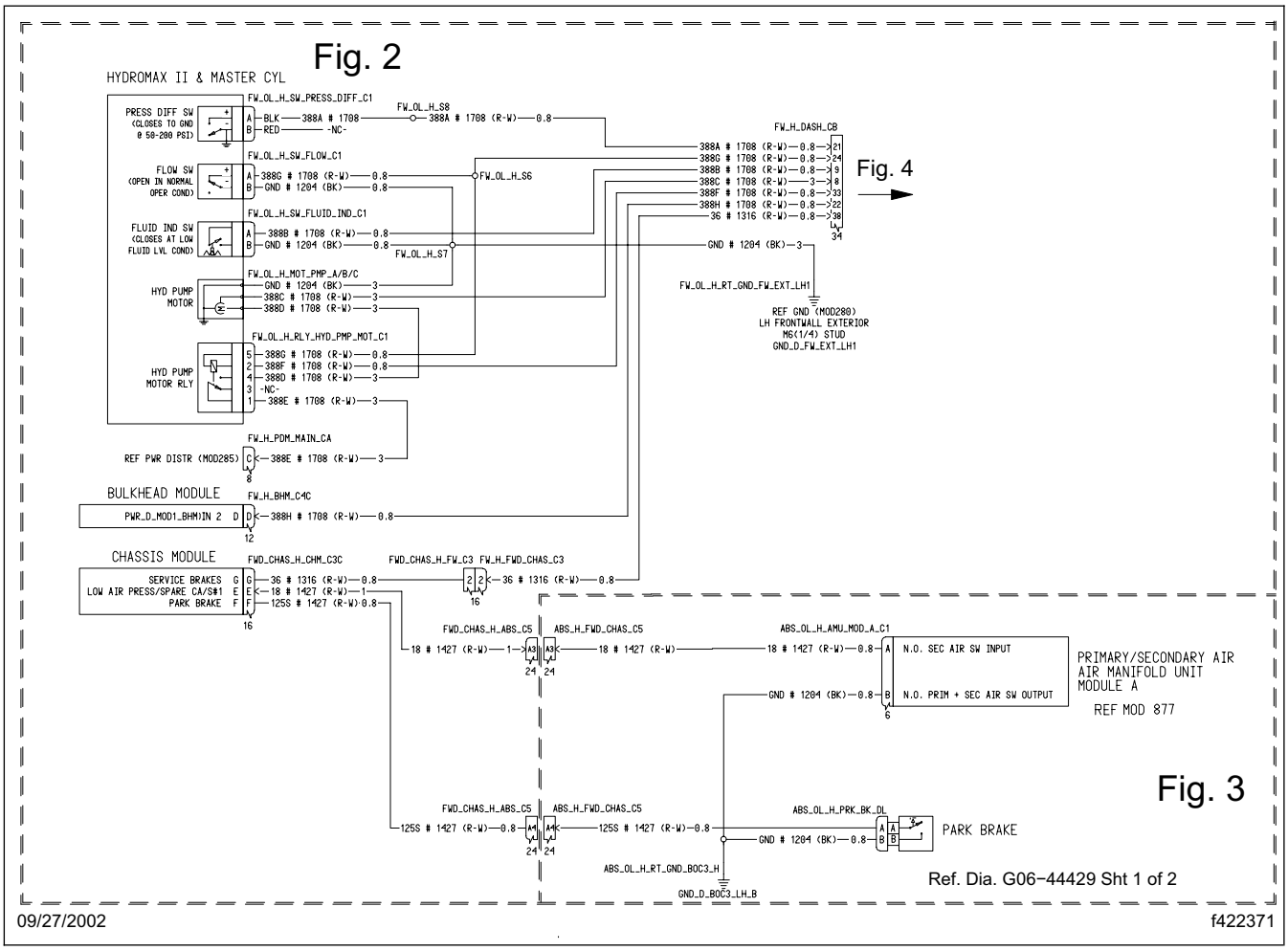


Fig. 1, Power Brake Booster and Master Cylinder Wiring (full view)

Specifications

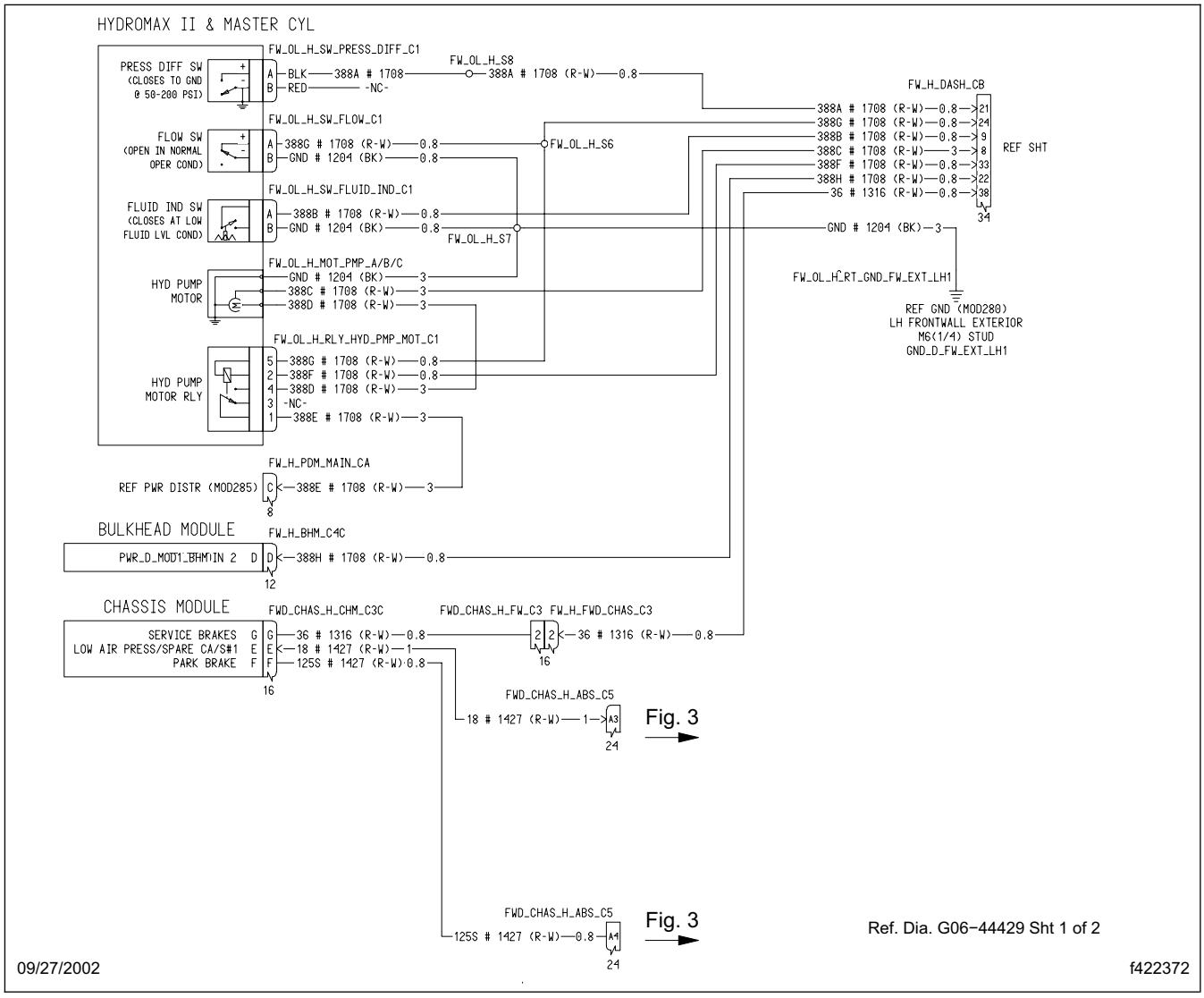


Fig. 2, Power Brake Booster and Master Cylinder Wiring (partial view)

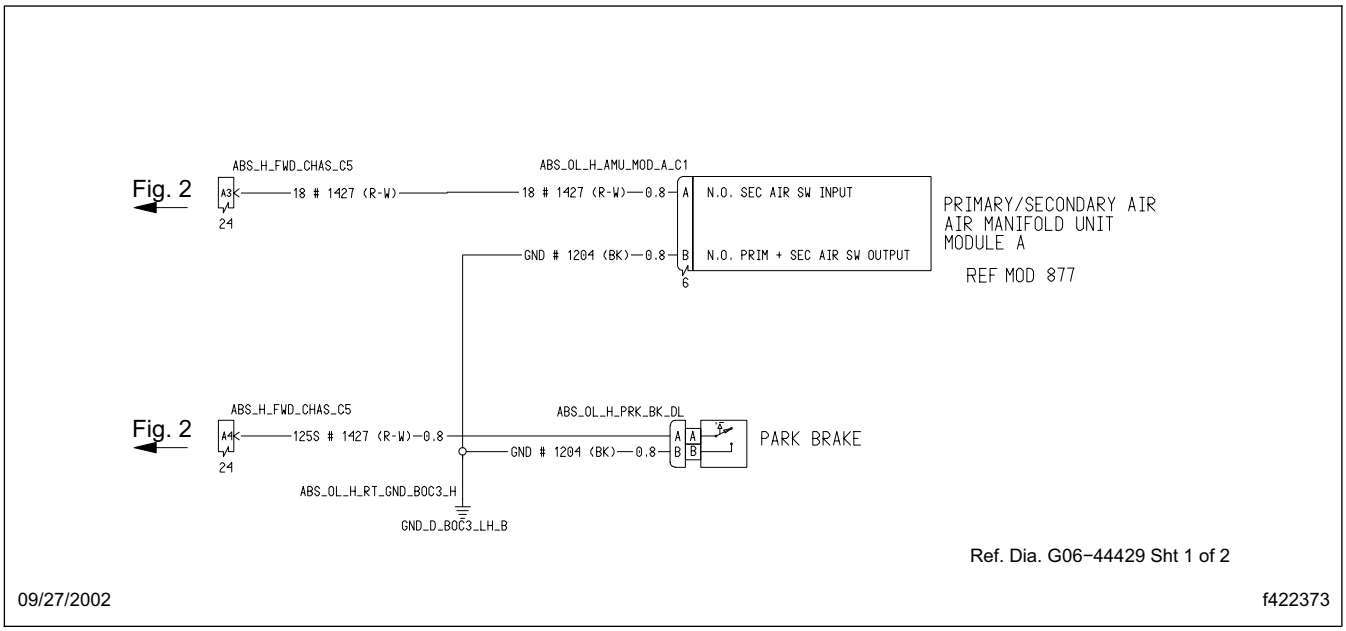


Fig. 3, Power Brake Booster and Master Cylinder Wiring (partial view)

Fastener Torques		
Description	**Torque: lbf·in (N·cm)**	**Torque: lbf·ft (N·m)**
Power Brake Booster Mounting Bolts	—	20 ±4 (28 ±6)
Master Cylinder Tube Nuts	–	Max.16.5 (22.6)
Master Cylinder Mounting Nuts	—	27 ±2 (37 ±3)
Power Brake Booster Supply Line Fitting	—	21 ±5 (27 ±7)
Backup Pump Mounting Screws	—	21.5 ±3.5 (29.2 ±4.7)
Relay Mount Screw	78 ±3 (77 ±7)	6.5 ±0.5 (8.75 ±0.85)
Flow Switch Contact Assembly	30 ±3 (30 ±0.10)	2.5 ±0.8 (3.4 ±1.1)
Differential Pressure Switch Contact Assembly	12 ±3(12 ±0.3)	1 ±0.25 (1.4 ±0.3)
Backup Pump Terminal Nut	17 ±4 (17 ±0.7)	1.4 ±0.5 (1.92 ±0.8)

Table 1, Fastener Torques

Approved Fluid for Power Brake Booster	
Fluid Type	**Recommended Fluid**
Automatic Transmission Fluid (ATF)	Dexron II®

Table 2, Approved Fluid for Power Brake Booster