1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Hydraulic systems are used to actuate the brakes of all modern automobiles. The system transports the power required to force the frictional surfaces of the braking system together from the pedal to the individual brake units at each wheel. A hydraulic system is used for two reasons.

First, fluid under pressure can be carried to all parts of an automobile by small pipes and flexible hoses without taking up a significant amount of room or posing routing problems.

Second, a great mechanical advantage can be given to the brake pedal end of the system, and the foot pressure required to actuate the brakes can be reduced by making the surface area of the master cylinder pistons smaller than that of any of the pistons in the wheel cylinders or calipers.

The master cylinder consists of a fluid reservoir along with a double cylinder and piston assembly. Double type master cylinders are designed to separate the front and rear braking systems hydraulically in case of a leak. The master cylinder coverts mechanical motion from the pedal into hydraulic pressure within the lines. This pressure is translated back into mechanical motion at the wheels by either the wheel cylinder (drum brakes) or the caliper (disc brakes).

Steel lines carry the brake fluid to a point on the vehicle's frame near each of the vehicle's wheels. The fluid is then carried to the calipers and wheel cylinders by flexible tubes in order to allow for suspension and steering movements.

All Volvos are equipped with a four wheel power-assisted disc brake system. Disc brakes offer better stopping, ease of repair and simplified construction.

In disc brake systems, the cylinders are part of the calipers. At least one cylinder in each caliper is used to force the brake pads against the disc.

All pistons employ some type of seal, usually made of rubber, to minimize fluid leakage. A rubber dust boot seals the outer end of the cylinder against dust and dirt. The boot fits around the outer end of the piston on disc brake calipers, and around the brake actuating rod on wheel cylinders.

The hydraulic system operates as follows: When at rest, the entire system, from the piston(s) in the master cylinder to those in the wheel cylinders or calipers, is full of brake fluid. Upon application of the brake pedal, fluid trapped in front of the master cylinder piston(s) is forced through the lines to the wheel cylinders. Here, it forces the pistons outward, in the case of drum brakes, and inward toward the disc, in the case of disc brakes. The motion of the pistons is opposed by return springs mounted outside the cylinders in drum brakes, and by spring seals, in disc brakes.

Upon release of the brake pedal, a spring located inside the master cylinder immediately returns the master cylinder pistons to the normal position. The pistons contain check valves and the master cylinder has compensating ports drilled in it. These are uncovered as the pistons reach their normal position. The piston check valves allow fluid to flow toward the wheel cylinders or calipers as the pistons withdraw. Then, as the return springs force the brake pads or shoes into the released position, the excess fluid reservoir through the compensating ports. It is during the time the pedal is in the released position that any fluid that has leaked out of the system will be replaced through the compensating ports.

Dual circuit master cylinders employ two pistons, located one behind the other, in the same cylinder. The primary piston is actuated directly by mechanical linkage from the brake pedal through the power booster. The secondary piston is actuated by fluid trapped between the two pistons. If a leak develops in front of the secondary piston, it moves forward until it bottoms against the front of the master cylinder, and the fluid trapped between the pistons will operate the rear brakes. If the rear brakes develop a leak, the primary piston will move forward until direct contact with the secondary piston takes place, and it will force the secondary piston to actuate the front brakes. In either case, the brake pedal moves farther when the brakes are applied, and less braking power is available.

All dual circuit systems use a switch to warn the driver when only half of the brake system is operational. This switch is usually located in a valve body which is mounted on the firewall or the frame below the master cylinder. A hydraulic piston receives pressure from both circuits, each circuit's pressure being applied to one end of the piston. When the pressures are in balance, the piston remains stationary. When one circuit has a leak, however, the greater pressure in that circuit during application of the brakes will push the piston to one side, closing the switch and activating the brake warning light.

In disc brake systems, this valve body also contains a metering valve and, in some cases, a proportioning valve. The metering valve keeps pressure from traveling to the disc brakes on the front wheels until the brake shoes on the rear wheels have contacted the drums, ensuring that the front brakes will never be used alone. The proportioning valve controls the pressure to the rear brakes to lessen the chance of rear wheel lock-up during very hard braking.

Warning lights may be tested by depressing the brake pedal and holding it while opening one of the wheel cylinder bleeder screws. If this does not cause the light to go on, substitute a new lamp, make continuity checks, and, finally, replace the switch as necessary.

The hydraulic system may be checked for leaks by applying pressure to the pedal gradually and steadily. If the pedal sinks very slowly to the floor, the system has a leak. This is not to be confused with a springy or spongy feel due to the compression of air within the lines. If the system leaks, there will be a gradual change in the position of the pedal with a constant pressure.

Check for leaks along all lines and at wheel cylinders. If no external leaks are apparent, the problem is inside the master cylinder.

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Instead of the traditional expanding brakes that press outward against a circular drum, disc brake systems utilize a disc (rotor) with brake pads positioned on either side of it. An easily-seen analogy is the hand brake arrangement on a bicycle. The pads squeeze onto the rim of the bike wheel, slowing its motion. Automobile disc brakes use the identical principle but apply the braking effort to a separate disc instead of the wheel.

The disc (rotor) is a casting, usually equipped with cooling fins between the two braking surfaces. This enables air to circulate between the braking surfaces making them less sensitive to heat build-up and more resistant to fade. Dirt and water do not drastically affect braking action since contaminants are thrown off by the centrifugal action of the rotor or scraped off the by the pads. Also, the equal clamping action of the two brake pads tends to ensure uniform, straight line stops. Disc brakes are inherently self-adjusting. There are three general types of disc brake:

- Fixed caliper
- Floating caliper
- Sliding caliper

The fixed caliper design uses two pistons mounted on either side of the rotor (in each side of the caliper). The caliper is mounted rigidly and does not move.

The sliding and floating designs are quite similar. In fact, these two types are often lumped together. In both designs, the pad on the inside of the rotor is moved into contact with the rotor by hydraulic force. The caliper, which is not held in a fixed position, moves slightly, bringing the outside pad into contact with the rotor. There are various methods of attaching floating calipers. Some pivot at the bottom or top, and some slide on mounting bolts. In any event, the end result is the same.

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Virtually all modern vehicles use a vacuum assisted power brake system to multiply the braking force and reduce pedal effort. Since vacuum is always available when the engine is operating, the system is simple and efficient. A vacuum diaphragm is located on the front of the master cylinder and assists the driver in applying the brakes, reducing both the effort and travel he must put into moving the brake pedal.

The vacuum diaphragm housing is normally connected to the intake manifold by a vacuum hose. A check valve is placed at the point where the hose enters the diaphragm housing, so that during periods of low manifold vacuum brakes assist will not be lost.

Depressing the brake pedal closes off the vacuum source and allows atmospheric pressure to enter on one side of the diaphragm. This causes the master cylinder pistons to move and apply the brakes. When the brake pedal is released, vacuum is applied to both sides of the diaphragm and springs return the diaphragm and master cylinder pistons to the released position.

If the vacuum supply fails, the brake pedal rod will contact the end of the master cylinder actuator rod and the system will apply the brakes without any power assistance. The driver will notice that much higher pedal effort is needed to stop the car and that the pedal feels harder than usual.

Vacuum Leak Test

1. Operate the engine at idle without touching the brake pedal for at least one minute.
2. Turn off the engine and wait one minute.
3. Test for the presence of assist vacuum by depressing the brake pedal and releasing it several times. If vacuum is present in the system, light application will produce less and less pedal travel. If there is no vacuum, air is leaking into the system.

System Operation Test

1. With the engine **OFF**, pump the brake pedal until the supply vacuum is entirely gone.
2. Put light, steady pressure on the brake pedal.
3. Start the engine and let it idle. If the system is operating correctly, the brake pedal should fall toward the floor if the constant pressure is maintained.

Power brake systems may be tested for hydraulic leaks just as ordinary systems are tested.

WARNING
Clean, high quality brake fluid is essential to the safe and proper operation of the brake system. You should always buy the highest quality brake fluid that is available. If the brake fluid becomes contaminated, drain and flush the system, then refill the master cylinder with new fluid. Never reuse any brake fluid. Any brake fluid that is removed from the system should be discarded.

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Whenever a spongy brake pedal indicates that there is air in the system, or when any part of the hydraulic system has been removed for service, the system must be bled. In addition, if the level in the master cylinder reservoir is allowed to drop below the minimum mark for too long a period of time, air may enter the system, necessitating bleeding.

If only one caliper is removed for servicing, it is usually necessary to bleed only that unit. If, however, the master cylinder, warning valve, or any of the main system lines are removed, the entire system must be bled.

Be careful not to spill any brake fluid onto the brake surfaces or the paint. When bleeding the entire system, the rear of the car should be raised higher than the front. Only use brake fluid bearing the designation DOT 3.

The following procedure is acceptable for use on vehicles with and without ABS.

1. Check to make sure that floor mats are not obstructing pedal travel. Full pedal travel should be 6 inches (15cm).
2. Clean the cap and top of the master cylinder reservoir, and make sure that the vent hole in the cap is open. Fill the reservoir to the maximum mark.

   NOTE: Never allow the level to drop below the minimum mark during bleeding.
3. If only one brake caliper or line was removed, it will usually suffice to bleed only that wheel. Otherwise, prepare to bleed the entire system beginning at the passenger side rear wheel.
4. Raise the vehicle and support it safely.
5. Remove the protective cap for the bleeder and fit a suitable line wrench on the nipple.

   NOTE: The calipers, on some models, are equipped with 2 bleeder screws. Attach one hose to each screw and submerge in brake fluid.
6. Install a tight plastic hose onto the nipple and insert the other end of the hose into a glass bottle containing clean brake fluid. The hose must hang down below the surface of the fluid, or air will be sucked into the system when the brake pedal is released.
7. Open the bleeder nipple and pump the brake pedal 5 times. Keep the brake pedal depressed and close the nipple. Release the brake pedal and check the brake fluid. This should be repeated until the fluid flowing into the bottle is completely free of air bubbles. Continue to bleed the system in the following manner.
   - driver's side rear wheel
   - passenger side front wheel
   - driver's side front wheel

   NOTE: During this procedure, check the master cylinder reservoir frequently.
8. When completed, press the pedal to the bottom of its stroke and tighten the bleeder screw.
9. Install the protective cap. If the pedal still feels spongy after bleeding the entire system, repeat the bleeding sequence.
10. Fill the reservoir to the maximum line.
11. Turn the ignition **ON** but do not start the engine. Apply moderate force to the brake pedal. The pedal must travel no more than 2.4 inches (61mm) without ABS; 2.17 inches (55mm) with ABS. The brake warning light (and ABS warning light) must not be on.

    NOTE: After bleeding the brake system, pressure test the brake system, by depressing the brake pedal with a force corresponding to an abrupt halt, almost sufficient to lock the wheels, for 30 seconds. Then check whether there has been any leakage of brake fluid from the master cylinder.
12. Lower the vehicle.

Fig. 5: Remove the nipple exposing the bleeder valve

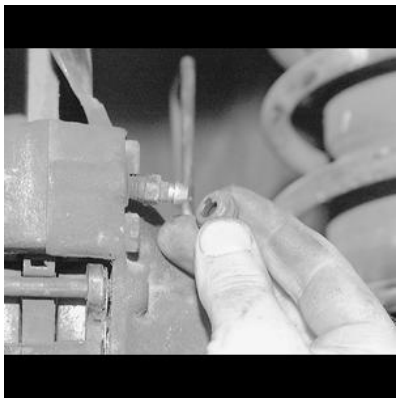

Fig. 6: Install a clear tube on the bleeder valve to visually inspect for air bubbles

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Metal lines and rubber brake hoses should be checked frequently for leaks and external damage. Metal lines are particularly prone to crushing and kinking under the vehicle. Any such deformation can restrict the proper flow of fluid and therefore impair braking at the wheels. Rubber hoses should be checked for cracking or scraping; such damage can create a weak spot in the hose and it could fail under pressure.

Any time the lines are removed or disconnected, extreme cleanliness must be observed. Clean all joints and connections before disassembly (use a stiff bristle brush and clean brake fluid); be sure to plug the lines and ports as soon as they are opened. New lines and hoses should be flushed clean with brake fluid before installation to remove any contamination.

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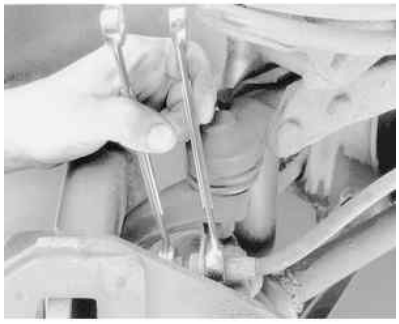
1. Disconnect the negative battery cable.
2. Raise and safely support the vehicle on jackstands.
3. Remove any wheel and tire assemblies necessary for access to the particular line you are removing.
4. Thoroughly clean the surrounding area at the joints to be disconnected.

Fig. 1: Use a brush to clean the fittings of any debris

5. Place a suitable catch pan under the joint to be disconnected.
6. Using two wrenches (one to hold the joint and one to turn the fitting), disconnect the hose or line to be replaced.

Fig. 2: Use two wrenches to loosen the fitting. If available, use flare nut type wrenches



7. Disconnect the other end of the line or hose, moving the drain pan if necessary. Always use a back-up wrench to avoid damaging the fitting.
8. Disconnect any retaining clips or brackets holding the line and remove the line from the vehicle.

NOTE: If the brake system is to remain open for more time than it takes to swap lines, tape or plug each remaining clip and port to keep contaminants out and fluid in.

Fig. 4: Tape or plug the line to prevent contamination

To install:

9. Install the new line or hose, starting with the end farthest from the master cylinder. Connect the other end, then confirm that both fittings are correctly threaded and turn smoothly using finger pressure. Make sure the new line will not rub against any other part. Brake lines must be at least $^{1}/_{2}$ in. (13mm) from the steering column and other moving parts. Any protective shielding or insulators must be reinstalled in the original location.

WARNING
Make sure the hose is NOT kinked or touching any part of the frame or suspension after installation. These conditions may cause the hose to fail prematurely.

10. Using two wrenches as before, tighten each fitting.
11. Install any retaining clips or brackets on the lines.
12. If removed, install the wheel and tire assemblies, then carefully lower the vehicle to the ground.
13. Refill the brake master cylinder reservoir with clean, fresh brake fluid, meeting DOT 3 specifications. Properly bleed the brake system.
14. Connect the negative battery cable.

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The switch controlling the brake lights is located at the brake pedal. As the pedal moves from its rest position, the switch engages and turns on the brake lights.

1. Remove the soundproofing.
2. Detach the electrical connectors at the switch
3. Unscrew the locknut and remove the switch.

To install:

4. Place the new switch into position.
5. Install the locknut and electrical connectors.
6. After installing the new switch, it must be adjusted so that the brake lights comes ON when the brake pedal is depressed approximately $^{3}/_{8}$ – $^{1}/_{2}$ inches (8–14mm).

Fig. 1: Older style brake light switch

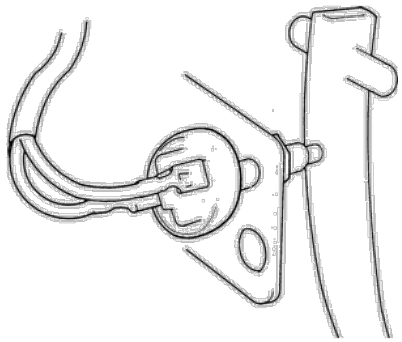
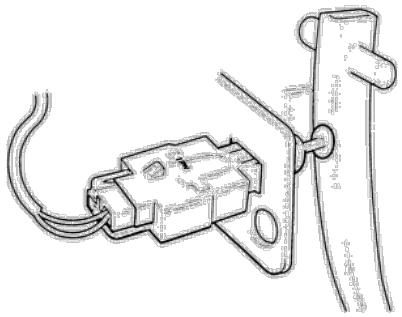


Fig. 2: Newer style brake light switch



1. Disconnect the negative battery cable.
2. To prevent brake fluid from spilling onto and damaging the paint, place a protective cover over the fender apron, and rags beneath the master cylinder.
3. Unplug the electrical connector for the brake fluid level sensor.
4. Empty out and discard the brake fluid.
5. Label and disconnect the brake lines from the master cylinder and plug them immediately.
6. Label and remove any hoses from the master cylinder.

NOTE: It may be easier to remove the hoses when the master cylinder is loosened and partially removed.

7. If the vehicle has a hydraulic clutch, disconnect its line from the fluid reservoir. Plug it and secure the line out of the way.
8. Remove the two nuts which retain the master cylinder and reservoir assembly to the vacuum booster, and lift the assembly forward, being careful not to spill any fluid on the fender.

WARNING
Do not depress the brake pedal while the master cylinder is removed!

To install:

9. Place a new sealing rim (if equipped) onto the sealing flange of the master cylinder.
10. Position the master cylinder and reservoir assembly onto the booster studs, and install the washer and nuts.
11. Tighten the nuts to 103–130 inch lbs. (12–15 Nm).
12. Remove the plugs and loosely connect the brake lines. Have a helper depress the brake pedal to remove air from the cylinder. Tighten the nuts for the lines when the brake fluid (free of air bubbles) is forced out.
13. Reconnect the lines for the hydraulic clutch (if so equipped) and any hoses which were removed.
14. Fasten the electrical connector for the brake fluid level sensor.
15. Bleed the entire brake system and, where applicable, the clutch system. Refer to the bleeding procedure later in this section.
16. Connect the negative battery cable.

Fig. 1: The brake fluid level sensor is located on the reservoir cap

Fig. 2: A vacuum pump is useful to draw brake fluid out of the master cylinder reservoir

Fig. 3: A flare nut or "line" wrench should be used to detach the brake lines

Fig. 4: Label and disconnect the brake lines

Fig. 5: Remove the two master cylinder retaining nuts

Fig. 6: Slowly rotate and remove the master cylinder from the booster assembly

Fig. 7: The hoses are usually more accessible after the master cylinder is moved

Fig. 8: The pushrod end should be inspected after the master cylinder is removed

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Remove the vacuum by depressing the brake pedal approximately 5 times. Depress the brake pedal and start the engine. The pedal position should drop slightly if the power brake is functioning properly.

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Apply moderate pressure on the brake pedal for approximately 20 seconds. Then, repeat with high pedal pressure for 5 seconds. The pedal position must not drop. A drop indicates brake fluid leakage or booster vacuum leak.

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1. Disconnect the negative battery cable.
2. Remove the master cylinder.
3. Disconnect the vacuum hose and check valve from the booster.
4. If required, disconnect the fuel filter and vacuum pump. Position them aside.
5. From inside the vehicle, remove the soundproofing and disconnect the brake pedal rod.
6. Remove the power booster retaining nuts.
7. Remove the power booster from the vehicle.

To install:

8. Before installing the booster, check the valve seal. Replace it if necessary. When installing the new check valve seal, ensure that the flange of the seal is in the correct position.
9. On the 2 x 8 inch booster, install the sealing washer and seal onto the booster.
10. Install the booster to the vehicle.
11. Reconnect the brake pedal to the booster rod.
12. Refit the soundproofing.
13. Install the master cylinder, check valve and vacuum hose.
14. Bleed the brakes and clutch, if so equipped.
15. Connect the negative battery cable.

Fig. 1: Remove the four pedal-to-booster retaining nuts

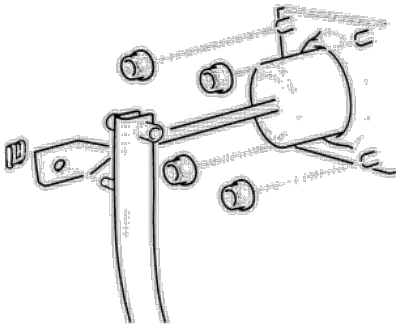
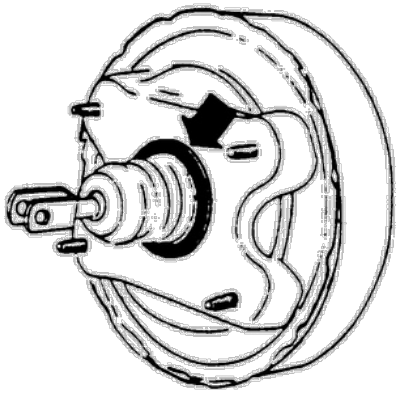


Fig. 2: Remember to install the check valve seal when replacing the booster



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NOTE: The proportioning valve is also known as a pressure differential warning valve.

Each of the brake circuits has a proportioning (relief) valve located inline between the rear wheels. The purpose of this valve is to ensure that brake pressure on all four wheels compensates for the change in weight distribution under varied braking conditions.

The harder the brakes are applied, the more weight there is on the front wheels. The valve regulates hydraulic pressure to the rear wheels, so that under hard braking conditions they receive a smaller percentage of the total braking effort. This prevents premature rear wheel lockup and possible skidding or loss of control.

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1. Place a rag under the valve to catch the brake fluid.
2. Detach the electrical connector from the switch and slacken the brake pipe connections.
3. Unfasten the bolt(s) which retain the valve to the underbody and unscrew the brake pipe connections.
4. Remove the differential warning valve.

To install:

5. Place a new seal on it, then screw the valve onto the rear brake hose and hand-tighten.
6. Secure the valve to the underbody with the retaining bolt(s).
7. Connect the brake pipe and tighten both connections, making sure there is no tension on the flexible rear hose.
8. Bleed the brake system.

1. Disconnect the plug contact and screw out the warning switch so the pistons inside the valve may return to their normal position.
2. Repair and bleed the faulty hydraulic circuit.
3. Screw in the warning switch and tighten it to 10–14 ft. lbs. (14–19 Nm).
4. Connect the plug contact.