MODULE CONTENT

| Unit of Competency | **DIAGNOSE AND REPAIR BRAKE SYSTEM** |
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| Module Title | **DIAGNOSING AND REPAIRING BRAKE SYSTEM** |
| Module Descriptor | This unit identifies the competencies required to diagnose and repair the brake systems. |
| Nominal Duration | **hours** |
| Summary of the Learning Outcomes: | |
| Upon completion of this module the student must be able to: | |
| LO1. Prepare to diagnose and repair brake system | |
| LO2. Diagnose brake system | |
| LO3. Repair brake system | |
| LO4. Complete work processes | |

**LEARNING EXPERIENCES**

**LEARNING OUTCOMES NO. 1**

**PREPARE TO DIAGNOSE AND REPAIR BRAKE SYSTEM**

| **Learning Activities** | **Special Instructions** |
| --- | --- |
| Read Information Sheet 3.1-1 Prepare to diagnose and repair brake system | If you have some problem with the content of the information sheet don’t hesitate to approach your Trainer.  If you feel that you are now knowledgeable on the content of the information sheet, you can now answer the self-check provided in the module. |
| Answer Self-Check 3.1-1 on Prepare to diagnose and repair brake system | Try to answer the Self-check without looking at the Answer Key  Compare your answer to Answer Key 3.1-1 |
| Observe Trainer’s demonstration on Task Sheet 3.1-1 on Prepare to diagnose and repair brake system | Listen carefully and attentively so that you may be able to perform a task correctly  Ask questions if are in doubt for clarification |
| Perform the Task Sheet 3.1-1 on Prepare to diagnose and repair brake system | Remember the step-by-step procedure the Prepare to diagnose and repair brake system |
| Evaluate the performance using the Performance Criteria Checklist 3.1-1 | Repeat the task in case fail to meet the criteria |

**INFORMATION SHEET 1.1-1**

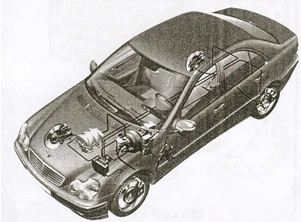
**PREPARE TO DIAGNOSE AND REPAIR BRAKE SYSTEM**

**Learning Objectives:**

After reading this **Information Sheet**, you must be able to:

1. Made final inspection.
2. Turned-over vehicle.
3. Restored work area.
4. Managed wastes.
5. Checked and stored tools and equipment.
6. Accomplished workplace documents.

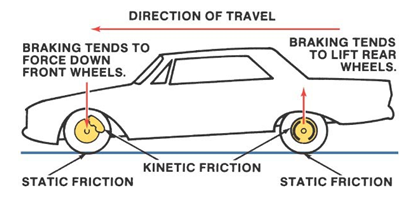
The brake system (Figure 46-1) is designed to slow and halt the motion of a vehicle. To do that, various components within a hydraulic brake system must convert the momentum of the vehicle into heat. They do so by using friction.



**Figure 46-1** A complex late-model brake system.

**FRICTION**

There are two basic types of friction that explain how brake systems work: **kinetic**, or moving, and **static**, or stationary **(Figure 46-2)**. The amount of friction, or resistance to movement, depends on the type of materials in contact, the smoothness of their rubbing surfaces, and the pressure holding them together (often gravity or weight). Friction always converts moving, or kinetic, energy into heat. The greater the friction between two moving surfaces, the greater the amount of heat produced.



**Figure 46-2** Braking action creates kinetic friction in the brakes and static friction between the tire and road to slow vehicle. When brakes are applied, the vehicle’s weight is transferred to the front wheels and is unloaded on the rear wheels.

As the brakes on a moving automobile are applied, rough-textured pads or shoes are pressed against rotating parts of the vehicle-either rotors (disc) or drums. The kinetic energy, or momentum, of the vehicle is then converted into heat energy by the kinetic friction of rubbing surfaces and the car or truck slows down.

When the vehicle comes to a stop, it is held in place by static friction. The friction between the surfaces of the brakes and between the tires and the road resists any movement.

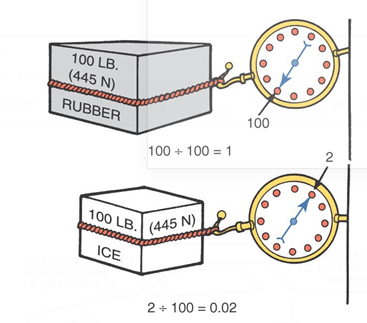
**Factors Governing Braking**

Four basic factors determine the braking power of a system. The first three factors govern the generation of friction: pressure, coefficient of friction, and frictional contact surface. The fourth factor is a result of friction. It is heat or, more precisely, heat dissipation.

**Pressure** The amount of friction generated between moving surfaces contacting one another depends in part on the pressure exerted on the surfaces. For example, if you slowly increase the downward pressure on the palm of your hand as you move it across a tabletop, you feel a gradual increase in friction.

In automobiles, hydraulic systems provide application pressure. Hydraulic force is used to move brake pads or brake shoes against spinning rotors or drums mounted to the wheels.

**Coefficient of Friction** The amount of friction between two surfaces is expressed as a **coefficient of friction** **(COF)**. The coefficient of friction is determined by dividing the force required to pull an object across a surface by the weight of the object **(Figure 46-3)**. For example, if it requires 100 pounds (445 Newtons) of pull to slide a 100-pounds (445 N) block of rubber across a concrete floor, the coefficient of friction is 100 ÷ 100 or 1. To pull a 100-pound (445N) block of ice across the same floor might require only 2 pounds ( 9 N) of pull. The coefficient of friction then would be only 0.02. As it applies to automotive brakes, the COF expresses the frictional relationship between pads and rotors or shoes and drums and is carefully engineered to ensure optimum performance. Therefore, when replacing pads or shoes, it is important to use replacement parts with similar COF. If, for example, the COF is too high, the brakes are too sticky to stop the car smoothly. Premature wheel lockup or grabbing would result. If the coefficient is too low, the friction material tends to slide over the machined surface of the drum or rotor rather than slowing it down. Most automotive friction materials are thus engineered with a COF of between 0.25 and 0.55, depending on their intended application.



**Figure 46-3** Coefficient of friction is equal to the pounds of pull divided by the weight of the object.

**Frictional Contact Surface** The third factor is the amount of surface, or area, that is in contact. Simply put, bigger brakes stop a car more quickly than smaller brakes used on the same car. Similarly, brakes on all four wheels slow or stop a moving vehicle faster than brakes on only two wheels, assuming the vehicles are equal in size.

**Heat Dissipation**  Any braking system must be able to effectively handle the heat created by friction within the system. The tremendous heat created by the rubbing brake surfaces must be conducted away from the pad and rotor (or shoe and drum) and be absorbed by the air. The greater the surface areas of the brake components, the faster the heat can be dissipated. Thus, the weight and potential speed of the vehicle determine the size of the braking mechanism and the friction surface area of the pad or shoe. Brakes that do not effectively dissipate heat experience brake fade during hard, continuous braking. The linings of the pad and shoe become glazed, and the rotor and drum become hardened. Therefore, the coefficient of friction is reduced and excessive foot pressure must be applied to the brake pedal to produce the desired braking effect.

**Brake Lining Friction Materials**

The friction materials used on brake pads and shoes are called brake linings. Brake linings are either riveted or bonded to the backing of the pad or shoe. Some newer brake pads are integrally molded. These can be identified by looking at the backing of the pad. Integrally molded pad assemblies will have holes that are partially or totally filled with the lining material.

For many decades, asbestos was the standard brake lining material. It offers good friction qualities, long wear, and low noise. New materials, such as composite/organic, ceramics, and carbon fibers, are being used because of the health hazards of breathing asbestos dusty. In fact, the federal government has banned the use of asbestos in new vehicles in aftermarket replacement parts.

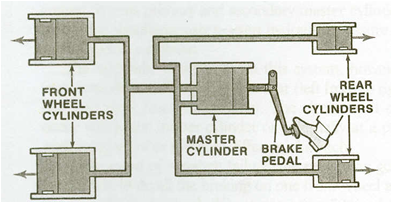
**Fully Metallic** Fully **metallic** linings of sintered iron have been used for years in heavy-duty and racing applications because they have great fade resistance. However, they require very high pedal pressure and tend to quickly wear out drums and rotors.

**Semimetallic** **Semimetallic** lining materials were developed to eliminate the disadvantages of fully metallic linings. Semimetallic linings are made of iron fibers molded with an adhesive matrix. Semimetallic material offers excellent fade resistance that meets the needs of today’s vehicles. It has good frictional characteristics so only a moderate amount of application pressure is needed. Finally, semimetallic padsand shoes do not cause excessive wear on rotor or drum surfaces.

**Nonasbestos** Other **nonasbestos** lining materials made of synthetic substances are now available. The major brake lining manufactures are constantly experimenting with new materials that meet all established criteria for long life, friction characteristics, drum and rotor wear and heat dissipation.

**PRINCIPLES OF HYDRAULIC BRAKE SYSTEMS**

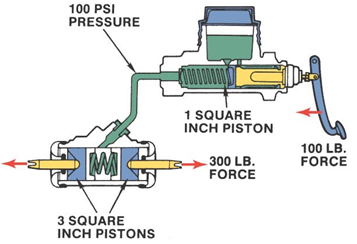
A hydraulic system **(Figure 46-4)** uses a brake fluid to transfer pressure from the brake pedal to the pads or shoes. This transfer of pressure is reliable and consistent because liquids are not compressible. That is, pressure applied to a liquid in a closed system is transmitted by that liquid equally to every other part of that system. Apply a force of a5 pounds (35 kPa) per square inch (psi) through the master cylinder and you can measure 5 psi (35 kPa) anywhere in the lines and at each wheel where the brakes operate.



**Figure 46-4**  A schematic of a basic automotive hydraulic brake system

The force can be increased at output (that is, at the wheel) by increasing the size of the wheel’s piston, though piston travel decreases. The force at output can be decreased by decreasing the size of the wheel piston, but the piston travel increases.

Thus, to double the output force of the 5 psi (35 kPa) at the master cylinder to 10 psi (69 kPa) at the wheels, simply use a wheel cylinder piston with a surface area of 2 square inches (13 sq. cm). To triple the force of 100 psi (690 kPa), use a piston with 3 square inches (20 sq. cm) and 300 pounds (2086 kPa) of output result **(Figure 46-5)**. No matter what the fluid pressure is, the output force can be increased with a larger piston, though piston travel decreases proportionately. In actual practice, however, fluid movement in an automotive hydraulic brake system is very slight. In emergency, when the pedal goes all the way to the floor, the volume of fluid displaced amounts to only about 20 cubic centimetres. About 15 cubic centimetres goes to the front discs and 5 cubic centimetres goes to the rear drums. Even under these conditions, the wheel cylinder and calliper pistons move only slightly.



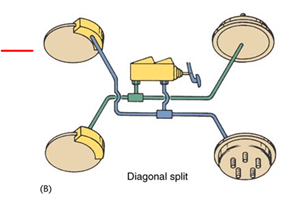
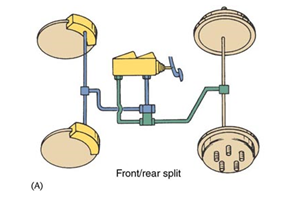
**Figure 46-5** Output force increases with piston size.

Of course, the hydraulic system does not stop the car all by itself. In fact, it really just transmits the action of the driver’s foot on the brake pedal out to the wheels. In the wheels, sets of friction pads are forced against rotors or drums to slow their turning and bring the car to a stop. Mechanical force (the driver stepping on the brake pedal0 is changed into hydraulic pressure, which is changed back into mechanical force (brake shoes and disc pads contacting the drums and rotors). The amount of force acting on the friction pads and shoes is equivalent to the psi applied to the pedal multiplied by the area of the piston affected. A force of 25 psi applied to the pedal times 4 square inches of piston area equals 100 pounds of pressure in the system.

**Dual Braking Systems**

Since 1967, federal law has required that all cars be equipped with two separate brake systems. If one circuit fails, the other provides enough braking power to safely stop the car.

The dual system differs from the single system by employing a tandem master cylinder, which is essentially two master cylinders formed by installing two separate pistons and fluid reservoirs into one cylinder bore. Each piston applies hydraulic pressure to two wheels **(Figure 46-6).**



**Figure 46-6** (A) A front/rear split of the braking system. (B) A diagonal split. The master cylinder is also split to allow pressure only to its designated wheel units.

**Front/Rear Split System** In early dual systems, the hydraulic circuits were separated front and rear. Both front wheels were on one hydraulic circuit and both rear wheels on another. If a failure occurred in one system, the other system was still available to stop the vehicle. However, the front brakes do approximately 70% of the braking work. A failure in the front system would only leave 20 to 40% braking power. This problem was somewhat reduced with the development of diagonally split systems.

**Diagonally Split System** The **diagonally split system** operates on the same principles as the front rear split system. It uses primary and secondary master cylinders that move simultaneously to exert hydraulic pressure on their respective systems.

The hydraulic brake lines on this system, however, have been diagonally split front to rear (left front to right rear and right to left rear). The circuit split can occur within the master cylinder or externally at a proportioning valve or pressure differential switch.

In the event of a system failure, the remaining good system would do all the braking on one front wheel and the opposite rear wheel, thus maintaining 50% of the total braking force.

**HYDRAULIC BRAKE SYSTEM COMPONENTS**

The following sections describe the major components of a hydraulic brake system, including power-assisted systems and antilock braking systems.

**Brake Fluid**

Brake fluid **(Figure 46-7)** is the lifeblood of any hydraulic brake system and is what makes the system operate properly.



**Figure 46-7** A container brake fluid.

Modern brake fluid is specially blended to enable it to perform a variety of functions. Brake fluid must be able to flow freely at extremely high temperatures (500 ̊F, 260 ̊C) and at very low temperatures (-104 ̊F, -75 ̊C). Brake fluid must also serve as a lubricant to the many parts with which it comes into contact to ensure smooth and even operation. In addition, brake fluid must fight corrosion and rust in the brake lines and various assemblies and components in services. Another important property of brake fluid is that it must resist evaporation. All brake fluids are hydroscopic; that is, they readily absorb water. This is why brake fluid should always be kept in a sealed container and should only be exposed to outside air for limited periods of time.

Some of the earliest brake fluids had chemicals in them that ate away at the rubber components in the brake system (that is, cups and seals). Modern brake fluid must be compatible with rubber to avoid damage to the cups and seals in the system. Brake fluid must provide a controlled amount of swell to the brake system cups and seals. There must be just enough swell to form a good seal. However, the swell cannot be too great. If it is, drag and poor brake response occur. Every can of brake fluid carries the identification letters of SAE and **DOT.** These letters (and corresponding numbers) indicate the nature, blend, and performance characteristics of that particular brand of brake fluid.

There are three basic types of classifications of hydraulic brake fluids. DOT 3 is a conventional brake fluid with a minimum dry **equilibrium reflux boiling point (ERBP)** of 401 ̊F (205 ̊C) and a minimum wet ERBP of 284 ̊F (140 ̊C). It is generally recommended for the most ABS systems and some power brake setups. DOT 4 is a conventional brake fluid with a minimum dry ERBP of 446 ̊F (230 ̊C) and a minimum wet ERBP of 356 ̊F (180 ̊C). It is the most commonly used brake fluid for conventional brake systems. DOT 5 is a unique silicone-based brake fluid with a minimum dry ERBP of 500 ̊F (260 ̊C) and a minimum wet ERBP of 356 ̊F (180 ̊C). In the last few years, DOT 5 has lost its demand by brake servicing experts. DOT 5.1 is a nonsilicone-based polyg-lycol fluid and is amber in color. This is a severe duty fluid that has the same boiling point as DOT 5. However, remember that it is best to follow the vehicle manufacturer’s recommendations.

| ***W A R N I N G !*** |
| --- |
| *Use only approved brake fluid in a brake system. Any other lubricant, such as power steering fluid, automatic transmission fluid, or engine oil, which has a petroleum base, must never be used in the brake system. Petroleum-based fluids attack the rubber components in the brake system, like the piston cups and seals, and cause them to swell and disintegrate.* |

Some vehicles have brake fluid level sensors that provide the driver with an early warning message that the brake fluid in the master cylinder reservoir has dropped below the normal level.

As the brake fluid in the master cylinder reservoir drops below the designated level, the sensor closes the warning message circuit. About fifteen seconds later; the message “brake fluid low” appears on the instrument panel. At this time, the master cylinder reservoir should be checked and filled to the correct level with the specified brake fluid.

**Brake Pedal**

The brake pedal is where the brake’s hydraulic system gets its start. When brake pedal is depressed, force is applied to the master cylinder. On a basic hydraulic brake system (where there is no power assist), the force applied is transmitted mechanically. As the pedal pivots, the force applied to it is multiplied mechanically. The force that the pushrod applies to the master cylinder piston is, therefore, much greater than the force applied to the brake pedal.

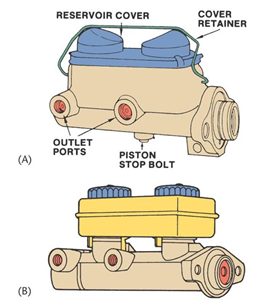
**Master Cylinders**

The heart of the hydraulic brake system is the master cylinder **(Figure 46-8)**. It converts the mechanical force of the driver’s foot on the brake pedal to hydraulic pressure. The master cylinder has a bore that contains an assembly of two pistons and a return spring. One piston pressurizes one-half of the brake system and one takes care of the other half. Although master cylinders differ in the size of the pistons, reservoir design, and integrated hydraulic components, the operation of all master cylinders is basically the same.



**Figure 46-8** A brake master cylinder.

Master cylinders are generally constructed of cast iron **(Figure 46-9A)** with an integral fluid reservoir, or they are made of aluminium with a separate molded nylon of fiberglass-reinforced plastic reservoir. Aluminum body master cylinders feature an anodized body **(Figure 46-9B**) to protect against corrosion to extend bore life.



**Figure 46-9** (A) A typical cast-iron dual master cylinder and (B) a typical aluminum/composite dual master cylinder.

| ***C A U T I O N !*** |
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| *It is recommended that aluminum master cylinders not be rebuilt if pitting or scoring of the cylinder bore is evident. A new unit should be installed.* |
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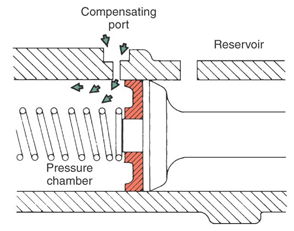
**MASTER CYLINDER OPERATION**

It is important that you understand how a master cylinder works. This understanding will be help when diagnosing a brake system. The basic principle of operation is a simple one. The brake pedal, connected to the master cylinder’s piston assembly by a pushrod, controls the movement of the pistons. As the pedal is depressed, the piston assembly moves. The piston exerts pressure on the fluid, which flows out under pressure on the fluid, which flows out under pressure through the fluid outlet ports into the rest of the hydraulic system. When the brake pedal is released, the return spring in the cylinder forces the piston assembly back to its original position.

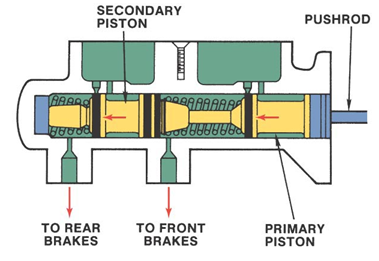
Because the master cylinder is a hydraulic device, the system must remain sealed and full of fluid. To do this, each piston has a primary and a secondary cup. The primary cup compresses the fluid when the pedal is depressed and keeps the brake fluid ahead of the pistons when they are put under pressure. The movement of the piston and cup shut off the fluid supply from the reservoir and create a sealed system from the primary cup forward. To prevent the fluid in the reservoir from leaking out of the cylinder when the primary cup has moved forward, each piston has a secondary cup. The secondary cup seals nonpressurized fluid.

When the brake pedal is not depressed, fluid from the reservoir keeps the cylinder filled. The fluid enters the cylinder through vent (intake) ports and compensating or replenishing ports that connect the reservoir to the piston chamber.

Each piston has a return spring in front of it. This holds the primary piston cup slightly behind the compensating or replenishing port **(Figure 46-10)** for the reservoir allowing gravity to keep the cylinder filled with fluid. In addition to keeping the replenishing ports uncovered, the return springs also help to return the brake pedal when the force has been removed from it. As the brakes are applied **(Figure 46-11)**, the stiffer primary piston spring pushes the secondary piston and spring slightly. Then the cup at the front end of the secondary piston passes and closes off the primary replenishing port on the secondary side of the master cylinder.



**Figure 46-10** Fluid from the reservoir fills the cylinder through the compensating port.



**Figure 46-11** The position of the pistons in a master cylinder when the brakes are applied.

When the piston moves quickly back to its resting place, the brake fluid cannot return through the lines fast enough to avoid creating a low-pressure condition ahead of it. The fluid must reach the low-pressure area in time for another stroke of the cylinder. To keep the system filled with fluid and to maintain a sealed system, fluid from the reservoir then enters the cylinder through a vent port to fill the void. Fluid also enters the system by flowing past the primary cups. During the return stroke, the edges of the cup pull away from the bore enough to allow fluid to pass around the piston assembly to the area of low pressure.

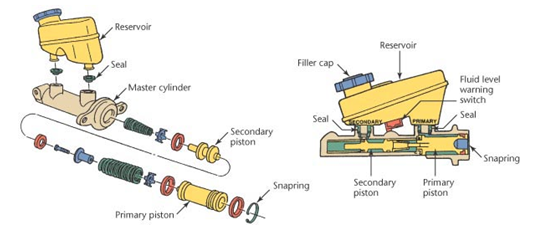
Finally, the pads and shoes return to position. That is, once the brake pedal is released and the master cylinder piston has returned to the rest position, shoe return springs (in the drum brakes) and piston seals (in the disc brakes) cause these pistons to retract. When all of the brakes are fully released, any excess fluid is returned to the reservoir through the compensating port to relieve pressure in the system.

**Master Cylinder Components**

The two pistons in the cylinder are not rigidly connected. Each piston has a return spring with the primary spring between the two pistons. Stepping on the brake pedal moves a pushrod, causing the first or primary piston to move forward. The fluid ahead of it cannot be compressed, so the secondary piston moves. As the pistons progress deeper into the cylinder bore, the brake fluid that is put under pressure transmits this force through both systems to friction pads at the wheels. A retaining ring fits into a groove near the end of the bore and holds the piston inside the cylinder.

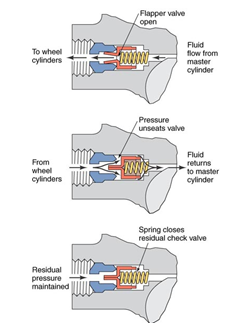
Extra brake fluid is stored in two separate reservoirs. The reservoirs are made of either cast iron or specially blended plastic and are designed to function independently as a protection against lost brake fluid **(Figure 46-12)**. The cap or cover for the reservoir keeps an air-tight seal on the master cylinder while letting it breathe. It also keeps moisture from entering the system.

Most master cylinders are equipped with a fluid level warning switch. The switch assembly is normally an integral part of the reservoir and consists of a float containing a magnet and a reed mounted in the bottom of the reservoir. When the brake fluid level gets to a predetermined level, the floating magnet will activate the reed switch, which causes the red brake warning lamp on the dash to turn on. The switch itself is not serviceable. If there is a problem with the switch or float assembly, the entire reservoir needs to be replaced.

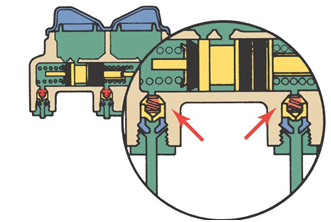


**Figure 46-12** Although the fluid reservoir looks like it is one reservoir, it is actually two separate reservoirs, one for each half of the hydraulic system.

The purpose of the **residual check valve, (Figure 46-13)** found only on vehicle with rear drum brakes, is to keep light (or residual) pressure in the brake lines and also at the wheel cylinders. Without residual pressure, air can be sucked past the wheel cylinder cups and into the wheel cylinders. This could when the brake pedal is released quickly. Residual check valves are designed to permit hydraulic fluid and pressure to flow from the master cylinder into the hydraulic lines when the pressure in the master cylinder becomes great enough to open the valve. After allowing the fluid to flow back into the master cylinder when the pedal is released, the outlet check valve spring **(Figure 46-14)** takes over and keeps the hydraulic lines and wheel cylinders full of fluid, ready for the next application of the brakes.



**Figure 46-13** The operation of a master cylinder’s residual valve.



**Figure 46-14** Outlet check valve spring.

On the most of the car models, automobile manufacturers have eliminated residual pressure check valves from the brake system. Instead, the wheel cylinders are equipped with cup expanders. The cup expanders keep the cup seals tightly against the cylinder walls to prevent air from entering the system.

Light residual pressure is needed for operating the drum brakes. However, when the brakes are used repeatedly, too much residual pressure can build up. Through heavy use the brake drums and wheel cylinders can get very hot. This in turn will cause the brake to heat up and expand. This pressure buildup can become so strong that it keeps the brake shoes from returning after releasing the brake pedal. If the brake shoes do not return properly, they can drag against the drums, which causes more heat to build up and pressure is further increased. The replenishing or compensating port takes care of this problem by allowing the excess pressure to leave the closed system.

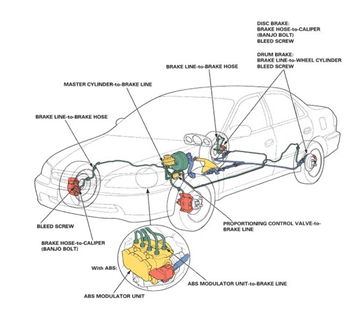
Vent ports in the matter cylinder help to pump up a low brake pedal by allowing more fluid in the lines. There are several reasons for a brake pedal to be lower than normal. One is that the clearance between the brake lining and the drum is too large. This can happen when the automatic brake adjusters are not working properly. Another reason could be the result of air leaking into the brake system. Vent ports help with this problem because the replenishing ports are not large enough to handle the extra flow of fluid needed when the pedal is pumped.

The design of the master cylinder used on a particular model car depends on the capacity of the reservoir and the displacement of the pistons at the wheel. Disc brakes require larger reservoirs than drum brakes because the calliper cylinder is much larger than that of a wheel cylinder. Some internal parts of the master cylinder may also change with application. For example, some General Motor’s products are fitted with wheel caliper pistons that have a low drag. These were designed to retract farther into the caliper’s cylinder when the brake pedal was released. This reduction of drag increased fuel economy. However since the piston had to move farther to push the pads against the rotor, more fluid had to be moved by the master cylinder. This caused a delay in pedal response and the feeling of a low pedal. To correct this problem, General Motors uses a **quick-take-up** master cylinder, with a larger rear piston to move fluid. A quick-take-up valve in the master cylinder controls the flow of fluid from the reservoir to the master cylinder’s rear piston.

**HYDRAULIC TUBES AND HOSES**

Steel tubing and flexible synthetic rubber hosing serve as the arteries and veins of the hydraulic brake system. These brake lines transmit brake fluid pressure (the blood) from the master cylinder (the heart) to the wheel cylinders and callipers (the muscles and working parts) of the drum and disc brakes.

Fluid transfer from the driver-actuated master cylinder is usually routed through one or more valves and then into the steel tubing and hoses **(Figure 46-15)**. The design of the brake lines offers quick fluid transfer response with very little friction loss. Engineering and installing the brake lines so they do not wrap around sharp curves is very important in maintaining this good fluid transfer.



**Figure 46-15** The typical layout of the hoses and tubes for the brake system.

**Brake Line Tubing**

Most brake line tubing consists of copper-fused double-wall steel tubing in diameters ranging from ⅛ to ⅜ inch (3 mm to 9 mm). Some OEM brake tubing is manufactured with soft steel strips, sheathed with copper. The strips are rolled into a double-wall assembly and then bonded in a furnace at extremely high temperatures. Corrosion protection is often added by tin-planting the tubing.

**Fittings**

Assorted fittings are used to connect steel tubing to junction blocks or other tubing sections. The most common fitting is the double or inverted flare style. Double flaring is important to maintain the strength and safety of the system. Single flare or sleeve compression fittings may not hold up in the rigorous operating environment of a standard vehicle brake system.

Fittings are constructed of steel or brass. The 37-degree inverted flare or standard flare fitting is the most commonly used coupling. Newer vehicles may use the **ISO** or metric bubble flare fitting.

Never change the style of fitting being used on the vehicle. Replace ISO fittings only with ISO fitting. Replace standard fittings with standard fittings.

The metal composition of the fittings must also match exactly. Using an aluminum-alloy fitting with steel tubing may provide a good initial seal, but the dissimilar metals create a corrosion cell that eats away the metal and reduces the connection’s service life.

**Brake Line Hoses**

Brake line hoses offer flexible connections to wheel units so steering and suspension members can operate without damaging the brake system. Typical brake hoses range from 10 to 30 inches (25 to 76 mm) in length and are constructed of multiple layers of fabric impregnated with a synthetic rubber. B rake hose material must offer high heat resistance and withstand harsh operating conditions.

| **S H O P T A L K**  Many brake hose failures can be traced to errors made in the original installation or repair of the hose. Hoses twisted into place become stressed and are prime candidates for leaks and bursting. Most manufacturers now print a natural lay indicator or line on the hose. By making sure this line is not spiralled after fittings are tightened, you can ensure the hose is not overly stressed. Also, always use a hose of the same length and diameter as the original during servicing to maintain brake balance at all wheels. |
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**HYDRAULIC SYSTEM SAFETY SWITCHES AND VALVES**

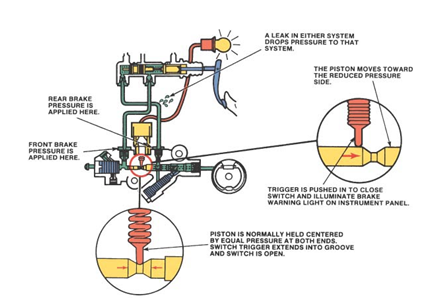
Switches and valves are installed in the brake system hydraulic lines to act as warning devices to pressure control devices.

**Pressure Differential (Warning Light) Switches**

A pressure differential valve is used to operate a warning light switch. Its main purpose is to tell the driver if pressure is lost in either of the two hydraulic systems. Since each brake hydraulic system functions independently, it is possible the driver might not notice immediately that pressure and braking are lost. When a pressure loss occurs, brake pedal travel increases and a more-than-unusual effort is needed for braking. Should the driver not notice the extra effort needed, the warning light is actuated by the hydraulic system safety switch.

Under normal conditions, the hydraulic pressure on each side of the pressure differential valve piston is balanced. The piston is located at its center point, so the spring-loaded warning switch plunger fits into the tapered groove of the piston. This leaves the contacts of the warning switch open.

If there is a leak in the front or rear braking system, the hydraulic pressure in the two systems is unequal. For example, if there is a leak in the system supplying the front brakes, there is lower pressure in the front system when the brake pedal is applied. The hydraulic pressure in the rear system then pushes the piston toward the front side, where the pressure is lower. As the piston moves, the plunger is pushed out **(Figure 46-16)**. This closes the switch and illuminates the brake warning light.



**Figure 46-16** A pressure differential valve under normal conditions.

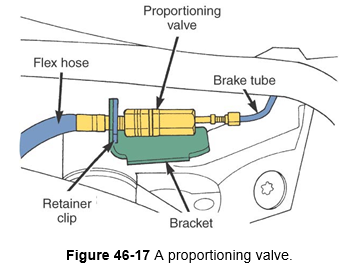
While all brake warning light switches serve the same function, there are three common variations in the design of these switches. These variations include switches with centering springs, without centering springs, and with centering springs and two pistons.

**Metering and Proportioning Valves**

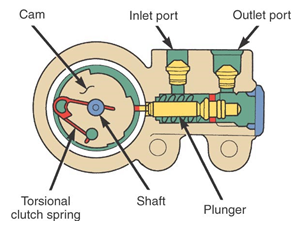
Metering and proportioning valves are used to balance the braking characteristics of disc and drum brakes.

The braking response of the disc brakes is immediate when the brake pedal is applied. It is directly proportionate to the effort applied at the pedal. Drum brake response is delayed while rear brake hydraulic pressure moves the wheel cylinder pistons to overcome the force of their return springs and force the brake shoes to contact the drum. Their actions are self-energizing and tend to multiply the pedal effort.

**Metering Valve** A **metering valve** in the front brake line holds off pressure going from the master cylinder to the front disc calipers. This delay allows the pressure to build up in the rear drums first. When the rear brakes begin to take hold, the hydraulic pressure builds to the level needed to open the metering valve. When the metering valve opens, line pressure is high enough to operate the front disc. This process provides for better balance of the front and rear brakes. It also prevents lockup of the front brakes by keeping pressure from them until the rear brakes have started to operate. The metering valve has the most effect at the start of each brake operation and all during light braking conditions.

**Proportioning Valve** The self-energizing action of the delayed response rear drum can cause them to lock the rear wheels at a lower hydraulic pressure than the front brakes. The **proportioning valve (Figure 46-17)** is used to control rear brake pressures, particularly during hard stops. When the pressure to the rear brakes reaches a specified level, the proportioning valve overcomes the force of its spring-loaded piston, stopping the flow of fluid to the rear brakes. By doing so, it regulates rear brake system pressure and adjust for the difference in pressure between front and rear brake systems. This keeps front and rear braking forces in balance.

**Height-Sensing Proportional Valve** The height-sensing proportional valve provides two different brake balance modes to the rear brakes based on vehicle load. This is accomplished by turning the valve on or off. When the vehicle is not loaded, hydraulic pressure is reduced to the rear brakes. When the vehicle is carrying a full load, the actuator lever moves up to change the valve’s setting. The valve now allows full hydraulic pressure to the rear brakes. The valve contains a plunger, cam, torsional clutch spring, and an actuator shaft **(Figure 46-18).**



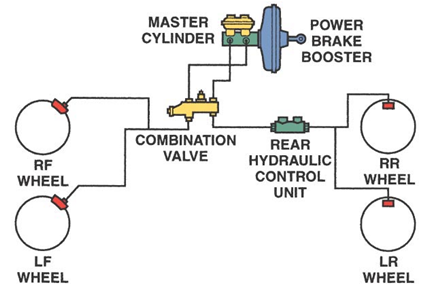
**Figure 46-18** A height-sensing proportional valve.

The valve is mounted to the frame above the rear axle and has an actuator lever connected by a link to the lower shock absorber bracket. The valve is turned on and off as the axle-to-frame height changes due to load in the vehicle. The torsional clutch spring attached to the valve shaft is used as an override. Once the valve is positioned during braking the spring prevents the valve from changing position if the vehicle goes over a bump or moves off the road.

Height-sensing proportional valves are replaced when defective and are not adjustable.

| **S H O P T A L K**  Distribution and weight on some vehicles, such as station wagons, is such that a rear-to-front weight transfer does not present a similar problem. For this reason, standard proportioning valves are not required on all station wagon models. |
| --- |

**Combination Valves** Most newer cars have a **combination valve (Figure 46-19)** in their hydraulic system. This valve is simply a single unit that combines the metering and proportioning valves with the pressure differential valve. Combination valves are described as three-function or two-function valves, depending on the number of functions they perform in the hydraulic system.



**Figure 46-19** The hydraulic circuit for a pickup with rear wheel antilock brakes and a combination valve.

*Three-Function Valve.* This type of valve performs the functions of the metering valve, brake warning light switch, and proportioning valve.

*Two-Function Valves.* There are two variations of the two-function combination valve. One variation does the proportioningvalve and brake warning light switch functions. The other performs the metering valve and brake warning light switch functions.

If any one of its several operations fail, the entire combination valve must be replaced, because these units are not repairable.

**Stop Light Switches**

The stop light (stop light/speed control) switch and mounting bracket assembly **(Figure 46-20)** is attached to the brake pedal bracket and is activated by pressing the brake pedal.

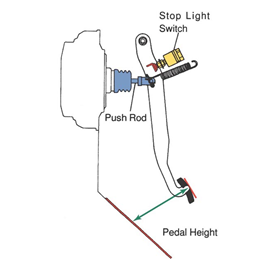


Figure 46-20 A mechanically activated stop light switch.

The mechanical stop light switch is operated by contact with the brake pedal or with a bracket attached to the pedal. The hydraulic switch is operated by hydraulic pressure developed in the master cylinder. In both types, the circuit through the switch is open when the brake pedal is released. When the brakes are applied, the circuit through the switch closes and causes the stop lights to come on. Hydraulic brake light switches are not commonly used today because they provided one more area for possible fluid leaks.