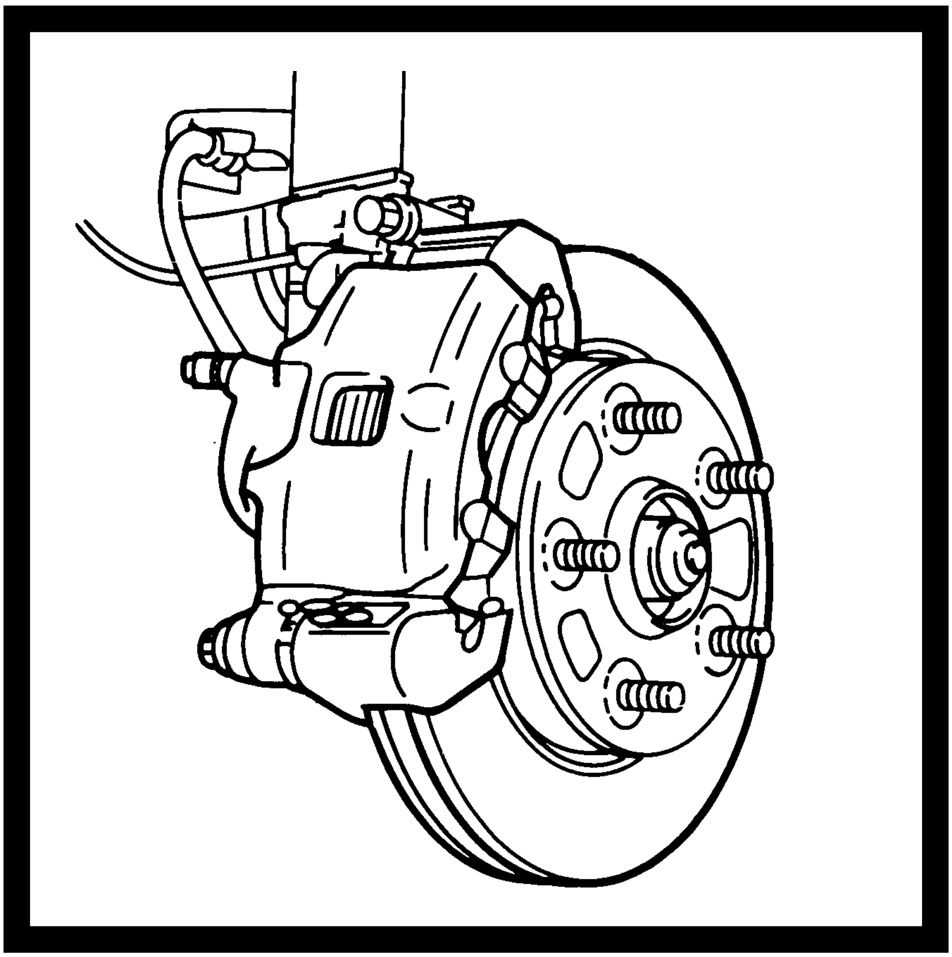
Technical Service Training

Global Fundamentals

Curriculum Training – TF1010015S

Brake Systems



Student Information

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FCS-13201-REF CG7971/S 04/2001

Global fundamentals training overview

The goal of the Global Fundamentals Training is to provide students with a common knowledge base of the theory and operation of automotive systems and components. The Global Fundamentals Training Curriculum (FCS-13203-REF) consists of nine self-study books. A brief listing of the topics covered in each of the self-study books appears below.

- Shop Practices (FCS-13202-REF) explains how to prepare for work and describes procedures for lifting materials and vehicles, handling substances safely, and performing potentially hazardous activities (such as welding). Understanding hazard labels, using protective equipment, the importance of environmental policy, and using technical resources are also covered.
- Brake Systems (FCS-13201-REF) describes the function and operation of drum brakes, disc brakes, master cylinder and brake lines, power-assist brakes, and anti-lock braking systems.
- Steering and Suspension Systems (FCS-13196-REF) describes the function and operation of the power-assisted steering system, tires and wheels, the suspension system, and steering alignment.
- Climate Control (FCS-13198-REF) explains the theories behind climate control systems, such as heat transfer and the relationship of temperature to pressure. The self-study also describes the function and operation of the refrigeration systems, the air distribution system, the ventilation system, and the electrical control system.
- Electrical Systems (FCS-13197-REF) explains the theories related to electricity, including the characteristics of electricity and basic circuits. The self-study also describes the function and operation of common automotive electrical and electronic devices.
- Manual Transmission and Drivetrain (FCS-13199-REF) explains the theory and operation of gears. The self-study also describes the function and operation of the drivetrain, the clutch, manual transmissions and transaxles, the driveshaft, the rear axle and differential, the transfer case, and the 4x4 system.
- Automatic Transmissions (FCS-13200-REF) explains the function and operation of the transmission and transaxle, the mechanical system, the hydraulic control system, the electronic control system, and the transaxle final drive. The self-study also describes the theory behind automatic transmissions including mechanical powerflow and electro-hydraulic operation.
- Engine Operation (FCS-13195-REF) explains the four-stroke process and the function and operation of the engine block assembly and the valve train. Also described are the lubrication system, the intake air system, the exhaust system, and the cooling system. Diesel engine function and operation are covered also.
- Engine Performance (FCS-13194-REF) explains the combustion process and the resulting emissions. The self-study book also describes the function and operation of the powertrain control system, the fuel injection system, the ignition system, emissions control devices, the forced induction systems, and diesel engine fuel injection. Read Engine Operation before completing Engine Performance.

To order curriculum or individual self-study books, contact Helm Inc.

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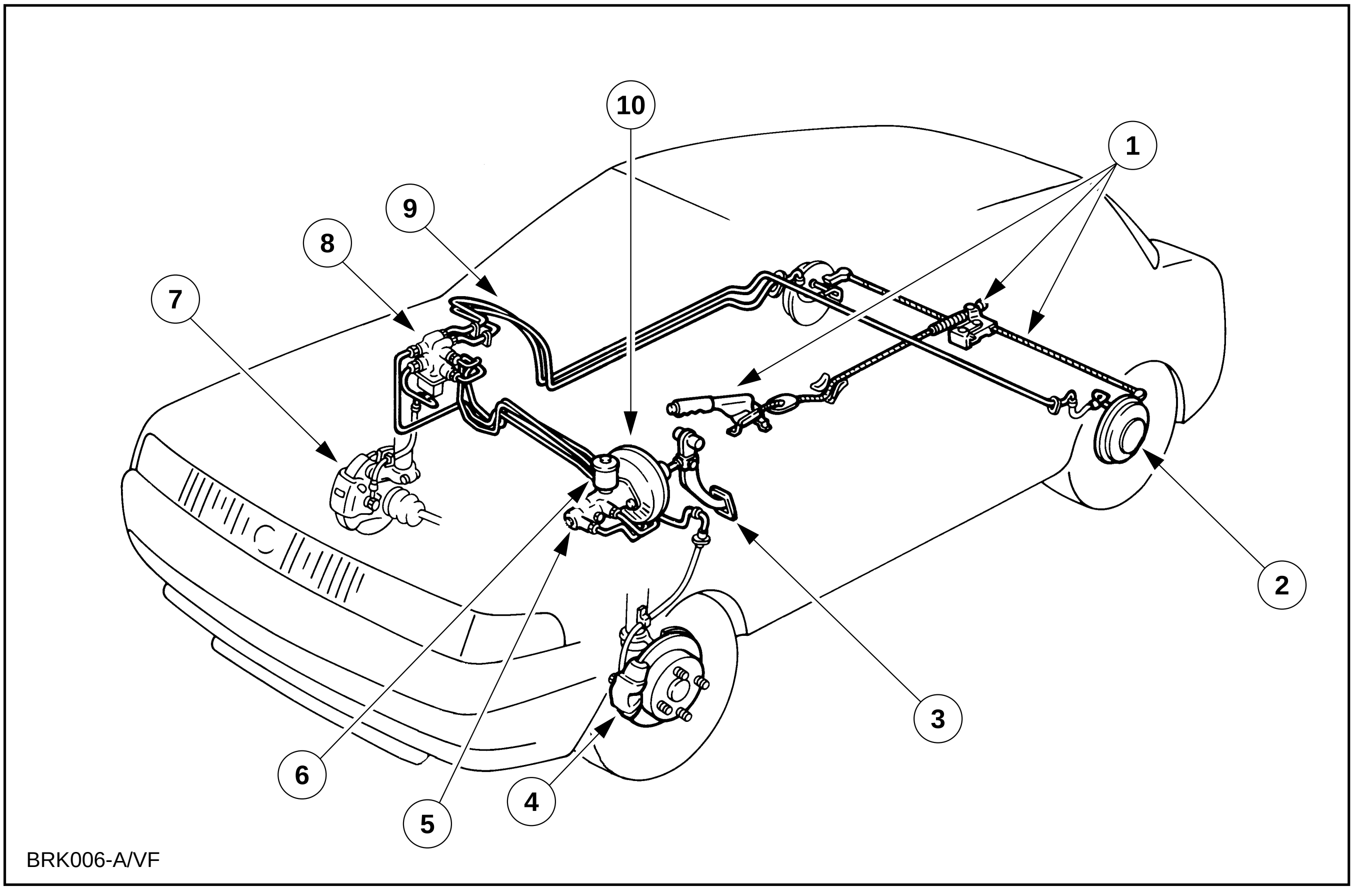
Objectives

Upon completion of this lesson you will be able to:

- Explain the purpose and function of a braking system.
- Identify the brake components.
- Describe brakes and identify brake types.
- Explain the theory and operation of braking.

Brake system



Brake system components

1 Parking brake assembly
2 Drum and brake shoe assembly
3 Brake pedal
4 Disc brake caliper
5 Master cylinder
6 Brake fluid reservoir
7 Brake disc and pad assembly
8 Combination valve
9 Brake lines
10 Power brake assist assembly

The purpose of a brake system is to allow the driver to stop the vehicle safely in the shortest distance possible on all types of road surfaces and conditions. The brakes reduce the vehicle's speed through the application of friction.

When people traveled in wagons, brake systems did not need to be powerful or sophisticated. A wooden block, attached to a lever and applied to a wheel, produced enough friction to stop a wagon. However, this brake system was not powerful enough for faster, heavier, motorized vehicles. Today's sophisticated systems use mechanical, hydraulic, and electronic components to control braking.

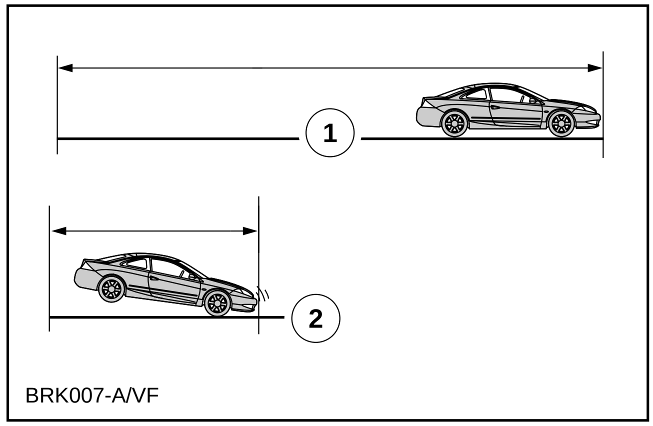
Energy

Energy is the ability to do work. Energy can be converted from one form to another but can never be destroyed. Moving a vehicle requires the use of energy. Energy is never lost, it just changes forms. When you put fuel in a car it is a liquid, but it contains potential energy or the ability to do work. When the gasoline is injected into the engine and ignited, the potential energy of the liquid fuel changes states and becomes heat energy. The engine converts heat energy into motion, and then, using different components of the vehicle, transfers motion to the wheels. The wheels rotate, using this motion to move the vehicle. Finally, the longer the vehicle is driven the warmer the tires become. Energy is released in the form of heat.

Power

Automotive engines change the potential energy of gasoline or diesel fuel into heat energy. The rate at which an engine can perform this change can be considered the "power" of an engine. Thus an engine that causes energy to change states quickly is said to be "powerful". But what about the "power" of the brake system? If "power" can be defined as the rate a device can change the state of energy, then the brakes must be capable of delivering much more power than the engine.

On a modern fuel-efficient vehicle, accelerating from zero to 100 kph (62 mph) in 10 seconds is an acceptable level of acceleration. But if it takes a brake system 10 seconds to stop a vehicle from 100 kph (62 mph), it is considered weak at best. A properly functioning brake system should stop that vehicle in 3 to 4 seconds from 100 kph (62 mph). If we use a device's ability to change the state of energy as the measure of its "power", then the brake system of a vehicle must be two to three times as powerful as the engine. The faster and heavier a vehicle is, the larger and more efficient the brake system must be.



Braking power

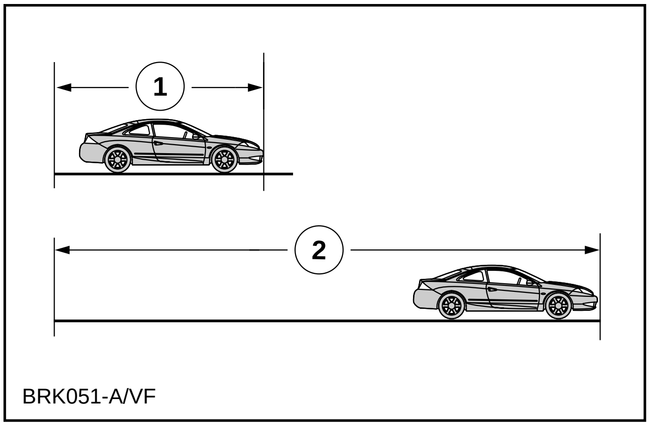
1 Vehicle accelerating from 0 to 96 100 kph (62 mph) in 10 seconds
2 Vehicle stopping in 3-4 seconds from 96 kph (60 mph)

Friction

Friction is the resistance to motion between two objects in contact with each other. By rubbing two surfaces together, a rotating energy is changed into heat energy. This change occurs because of the friction between the two surfaces. Brake systems use friction to slow down, stop, and hold the wheels of a vehicle. To stop a vehicle, friction has to be made to convert the energy to heat. Brake pads and shoes apply friction to the brake drums or discs to convert motion energy to heat energy.

Traction

Traction and friction work together to let the tires grip the road. Just as the brake shoes and drums require friction to slow or stop the rotation of the wheels, the tires require friction to slow or stop the momentum of the vehicle. The ability of the tires to supply friction is called traction. No matter how well the brakes stop the rotation of the wheels, if the tires do not supply traction the vehicle does not stop. The amount of traction available to stop a vehicle depends on many conditions. If the vehicle is used on ice or snow, the traction of the tires is reduced. Tire tread pattern must be correct to match the conditions of the road. When stopping, it is actually the friction between the tires and the road that stops the vehicle.

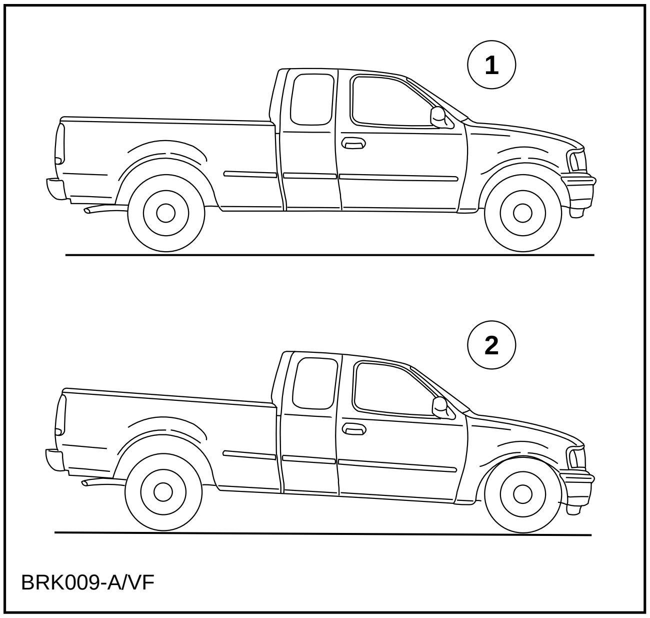


Road surface condition affects stopping

1 Good traction
2 Poor traction

Weight and balance

Weight and balance are two important factors in safely stopping a vehicle. There must be a balance between the brake force sent to the wheels from side to side, and from front to rear. If brake force is not balanced, it could cause a wheel to lock up. When a vehicle’s wheel locks up or does not turn because of the brakes holding the wheel from turning, traction is lost between the tire and the road. Loss of traction can cause poor stopping, skidding and loss of control. Braking weight ratio is the comparison of front wheel and rear wheel braking effort. When a vehicle brakes, its weight tends to transfer to the front wheels. The front wheels are pressed against the road with greater force. At the same time, the rear wheels lose some of their grip on the road. As a result, the front brakes do more braking than the rear brakes.

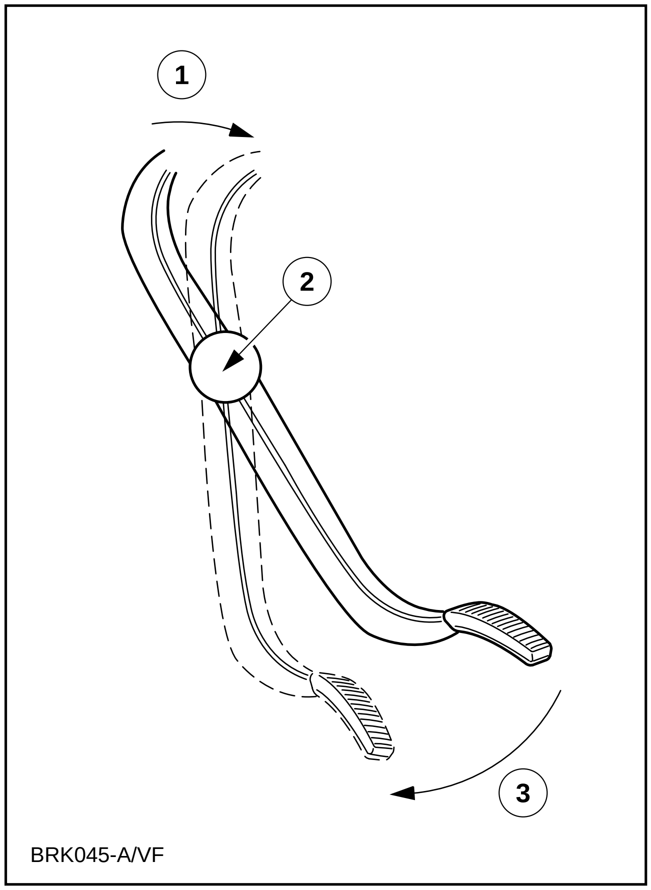


Braking and vehicle weight

1 Normal brake application
2 Hard brake application, front of vehicle pushed down because of weight transfer. Rear brakes of vehicle doing little braking

Mechanical leverage

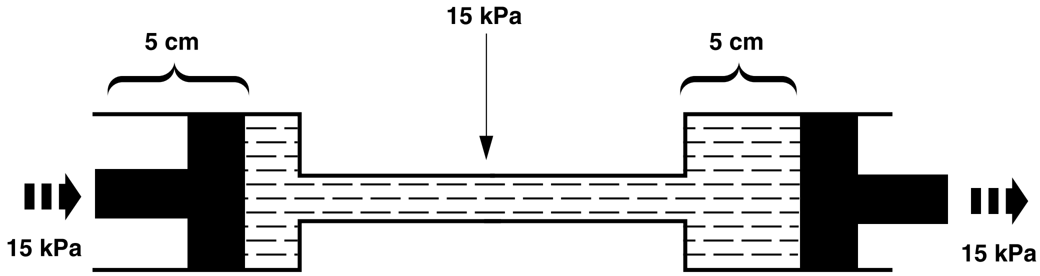
Mechanical levers are used in the brake system to increase braking power. The brake pedal arm or brake pedal linkage are simple levers. When the driver steps on the brake pedal, the force applied by the driver's foot is increased to the braking system because the pedal arm pivots or moves from a fixed point. The longer the lever is the more force that can be applied. A longer lever produces more force but must travel farther. A shorter lever applies less force but travels a shorter distance. A long lever can produce a lot of mechanical force from a short distance from the pivot point.



Mechanical levers

1 Short travel, powerful movement
2 Pivot point
3 Long lever, long travel

Hydraulic principles



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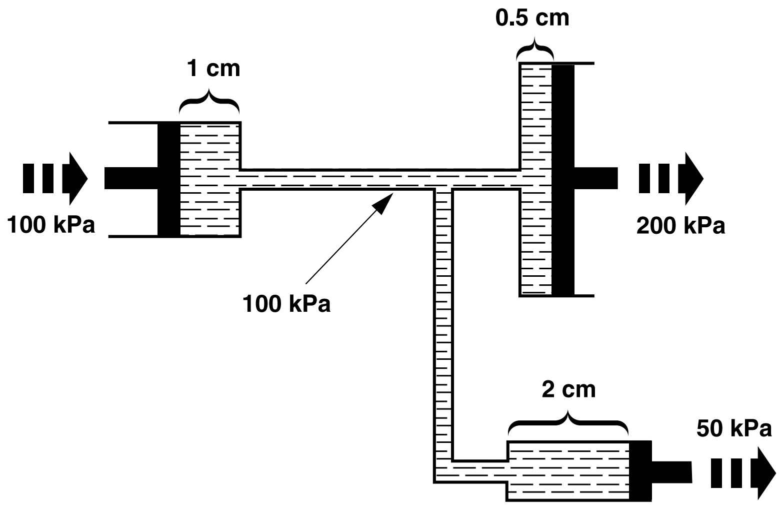
Hydraulic force

Hydraulics are used on modern brake systems to add additional force to mechanical leverage. Hydraulics combined with mechanical leverage and brake components slow and stop a vehicle. Hydraulic theory is based on the fact that a liquid does not compress. A steel spring compresses when a weight or force is placed on it. A liquid in a container does not compress when the same force is applied to the surface of the liquid. The force or pressure is applied equally to all surfaces of the container. If two pistons of equal size are in a contained hydraulic system, any force applied to one of the pistons is transferred to the other, moving the pistons an equal distance.



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Force and surface areas

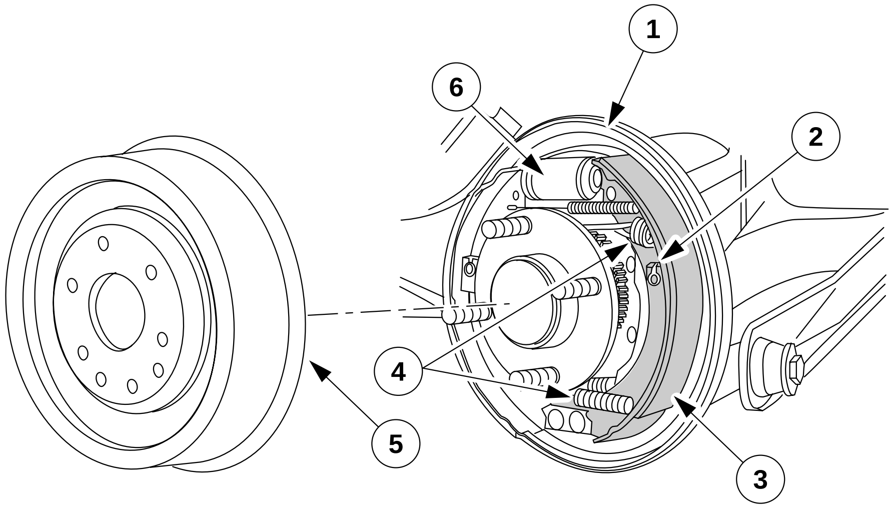
Pistons having a larger surface area create more force using the same pressure as a piston with a smaller surface area. The area of a piston determines how much force a piston exerts on an object. A piston of a greater surface area moves a shorter distance using more fluid, but has more force to move an object. A smaller piston area size moves a longer distance with the same amount of fluid but has much less force because of the smaller surface area. Because air compresses, there must be no air in the system. If there is air in the brake system, the air compresses and the fluid motion is reduced or even completely stopped.

Objectives

Upon completion of this lesson you will be able to:

- Explain the purpose and function of drum brakes.
- Describe drum brakes.
- Identify drum brake components.
- Explain the theory and operation of drum brakes.
- Explain the theory and operation of the parking brake.

Drum brakes



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Drum brake components

1 Backing plate
2 Brake shoe retainer
3 Brake shoe
4 Brake springs
5 Brake drum
6 Wheel cylinder

Drum brakes are the oldest type of brake and are still widely used. The drum rotates with the wheel and the brake shoes rub against the drum.

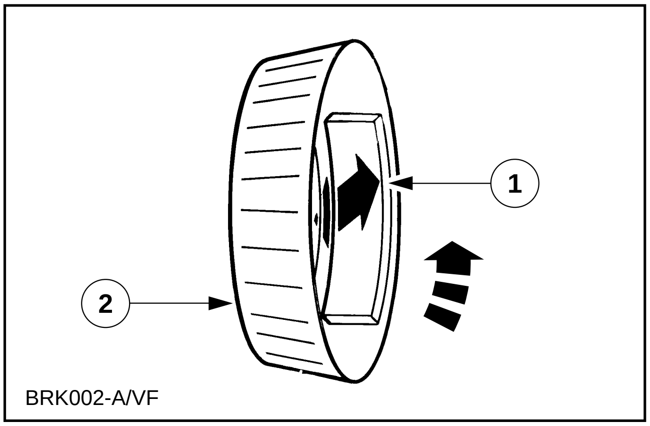
Drum brakes convert the moving motion of the vehicle into heat energy to slow or stop the vehicle. Drum brake shoes are contained inside the brake drum and press outward against the sides of the brake drum when pressure is applied to the brake pedal.

Spring and reainers hold the brake shoes onto the backing plate. The backing plate is bolted to the axle assembly.

The brake shoes are mounted to a backing plate. The backing plate is a flat round steel disk that is bolted to the axle. The backing plate anchors the brake shoes with springs and retainers. Hydraulic pressure forces a pair of pistons in the wheel cylinders outward, pushing the brake shoes outward so they contact the rotating brake drum. The friction between the brake shoes and the rotating brake drum cause the rotation of the wheel to slow or stop. The brake springs in the drum assembly hold the brake shoes in place. The brake springs also return the brake shoes to the rest position when the driver removes the pressure from the brake pedal.

Brake drum

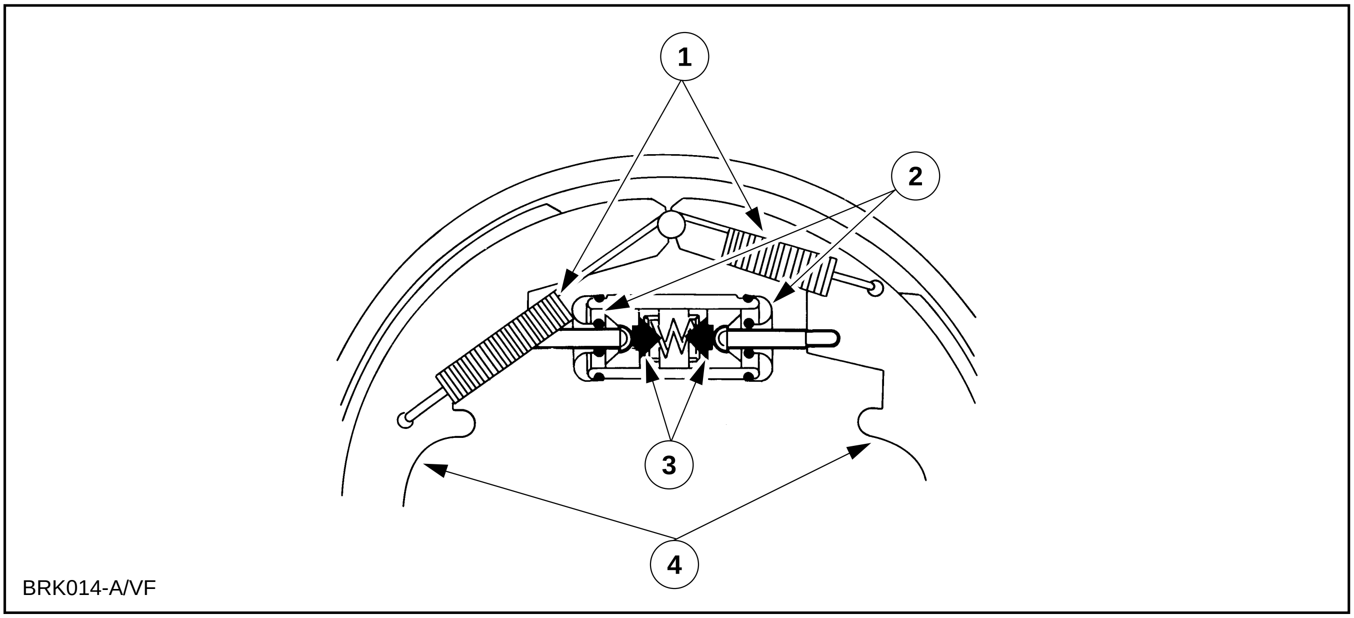
The brake drum is made from steel and is attached to the axle and rotates with the wheel assembly. The brake drum has a machined inner surface that serves as the braking surface. It is against this machined surface that the brake shoes make contact with the brake drum. Brake drums must be capable of releasing large amounts of converted energy or heat back to the surrounding air.



Drum brake operation

1 Friction material
2 Brake drum

Wheel cylinders



Wheel cylinder components

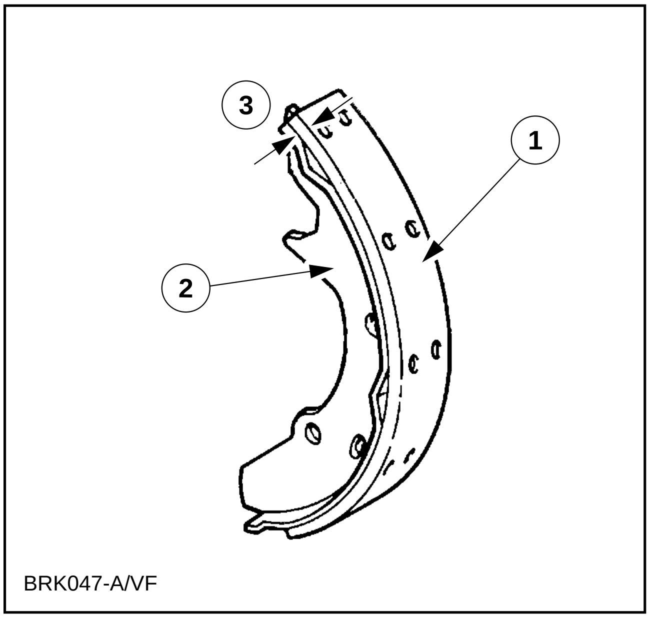
1 Brake shoe return springs
2 Wheel cylinder dust boots
3 Wheel cylinder pistons
4 Brake shoes

Wheel cylinders of drum brakes are mounted to the backing plate with retainers. The wheel cylinder receives hydraulic pressure when the driver pushes on the brake pedal. The hydraulic pressure acts on the wheel cylinders, pushing the pistons outward and into the brake shoes. The brake shoes are then forced into the rotating brake drum, slowing the vehicle. The wheel cylinders have dust boots to keep dirt and water from entering the wheel cylinder.

Brake drum (continued)

Brake shoe assembly

At one time brake shoes used asbestos fibers as friction material. Asbestos has been found to cause lung cancer. Today's vehicles use asbestos free materials for brake systems. The material now used varies with the manufacturer. Some companies use the man-made fiber Kevlar. Others use a combination of steel and mineral fiber. The friction material is riveted or glued to a steel shoe or pad. The brake friction or lining material must be changed once the lining reaches a minimum thickness. If the minimum lining thickness is exceeded, the steel shoe that the friction material is attached to rubs the steel brake drum causing noise and damage

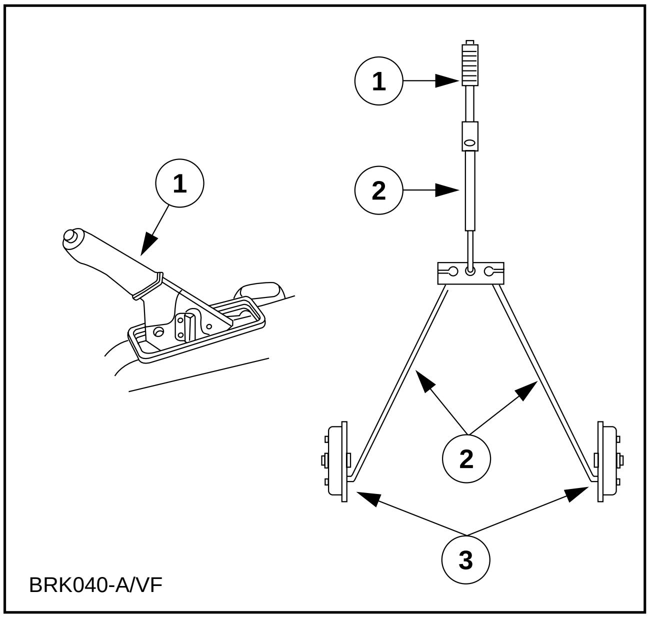


Parts of the brake shoe assembly

1 Brake lining
2 Steel brake shoe
3 Brake lining thickness

Parking brakes

The parking brakes use cables and a handle or foot pedal to mechanically apply the brakes. The parking brake system is independent of the hydraulic braking system so in case of hydraulic brake system failure the vehicle can be stopped. The parking brake system uses disc or drum type brakes to make up the rest of the parking brake system.



Parking brakes components

1 Brake handle
2 Parking brake cables
3 Rear brakes

Objectives

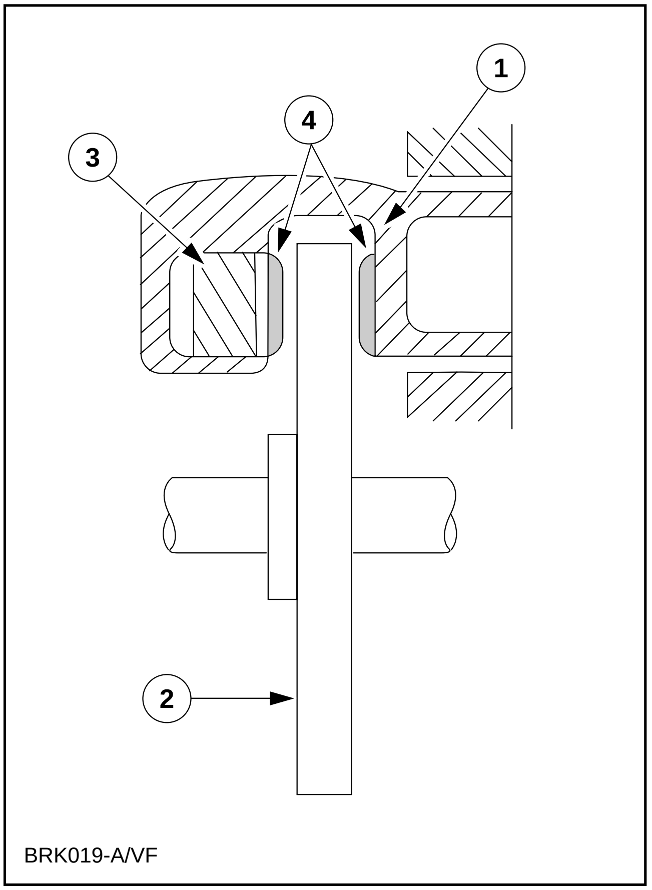
Upon completion of this lesson you will be able to:

- Explain the purpose and function of disc brakes.
- Describe disc brakes and identify types of disc brakes.
- Identify disc brake components.
- Explain the theory and operation of the disc brakes.

Disc brakes

Disc brakes have more stopping power than most drum brakes. Many new vehicles use disc brakes because of higher vehicle speeds and vehicle weight. Brake pads rubbing against the surface of the disc stop the rotating disc.

Disc brakes also convert vehicle motion or speed into heat energy using friction. Disc brakes were developed as a more efficient means of stopping a vehicle. Although drum brakes perform well, they retain much of the heat and dust generated during braking. Disc brakes operate at cooler temperatures because disc brakes are exposed to the passing airflow of the vehicle. Disc brakes are also self-cleaning and give greater durability and longer braking life. Disc brakes use two friction pads pushing against a rotating disc to slow and stop a vehicle.



Disc brake components

1 Brake caliper
2 Brake disc
3 Caliper piston
4 Brake pads

Operation of disc brakes

The pressurization of the brake fluid in the hydraulic brake system forces the piston out of the caliper assembly. The inboard brake pad is against the piston.

The brake pad is driven into contact with the brake rotor as the piston moves. Reaction pressure from contact with the rotor slides the brake caliper in the opposite direction. This motion brings the outboard brake pad into contact with the opposite side of the brake rotor. Now the brake rotor is sandwiched between the two brake pads.

As braking pressure is increased, the brake disc is pinched tighter and the rotational speed of the disc is decreased. As a result, the vehicle’s speed is reduced. As with drum brakes, the pads must be occasionally replaced and the brake rotors may need to be machined.

Disc brakes (continued)

Brake caliper

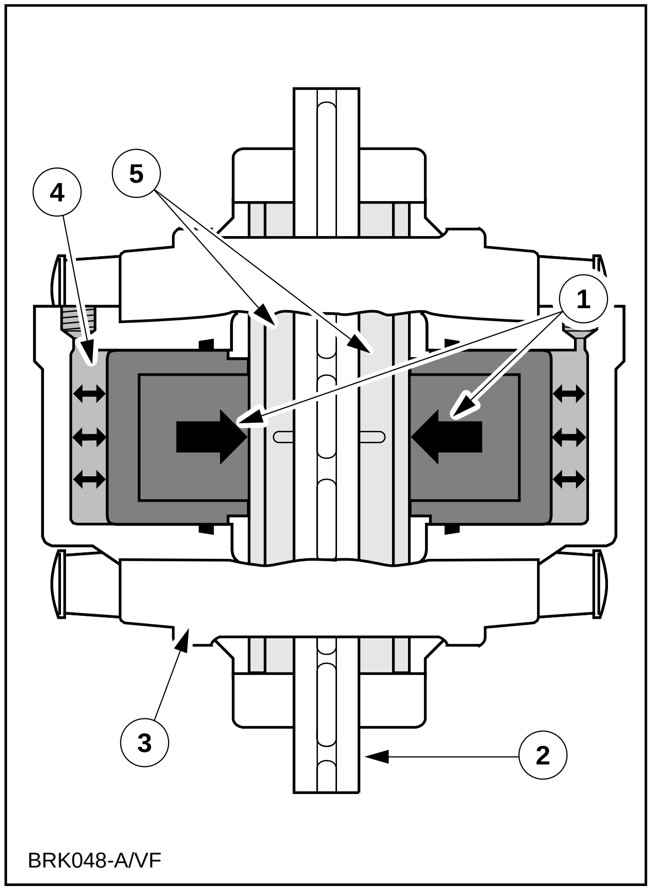
The brake caliper is mounted to the wheel axle and does not rotate with the wheel assembly. The brake caliper looks and works much like a C-clamp. The brake caliper may use one or more hydraulic pistons, and contains seals to retain the hydraulic fluid and to keep dirt out. Calipers have one or more bleed screws used to remove trapped air from the hydraulic system.

Brake calipers may use one or two pistons to clamp the brake pads against the brake rotor. The brake pads are held in place by the brake caliper. Brake calipers are fastened to the axle assembly using a variety of retainers depending on the manufacturer.

There are three types of brake calipers: fixed, floating and sliding.

Fixed caliper brake

The fixed caliper brake is an older style of disc brake. Fixed caliper disc brakes make use of two pistons using hydraulic pressure to push the brake friction material or pads against both sides of a rotating brake rotor. The stationary caliper contains the pistons that push the pads inward to contact the brake rotor.



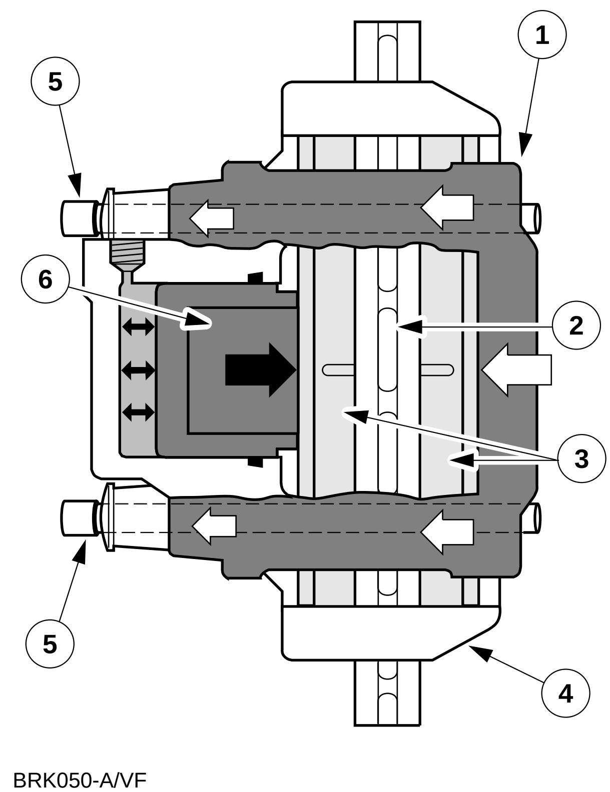
Fixed caliper brake components

1 Caliper pistons
2 Brake disc
3 Caliper mount
4 Brake fluid
5 Brake pads

Floating brake caliper

The floating brake caliper uses hydraulic pressure and one piston or more to press the inner brake pad against the rotor. The caliper is designed to move on pins, and because the caliper is not fixed the caliper can float or move. The floating action allows the caliper to move in the opposite direction of the brake caliper piston and draws the outer brake pad against the brake disc, at the same time clamping the pads against the brake disc.

The floating brake caliper is used when there is little room between the caliper and the wheel assembly.



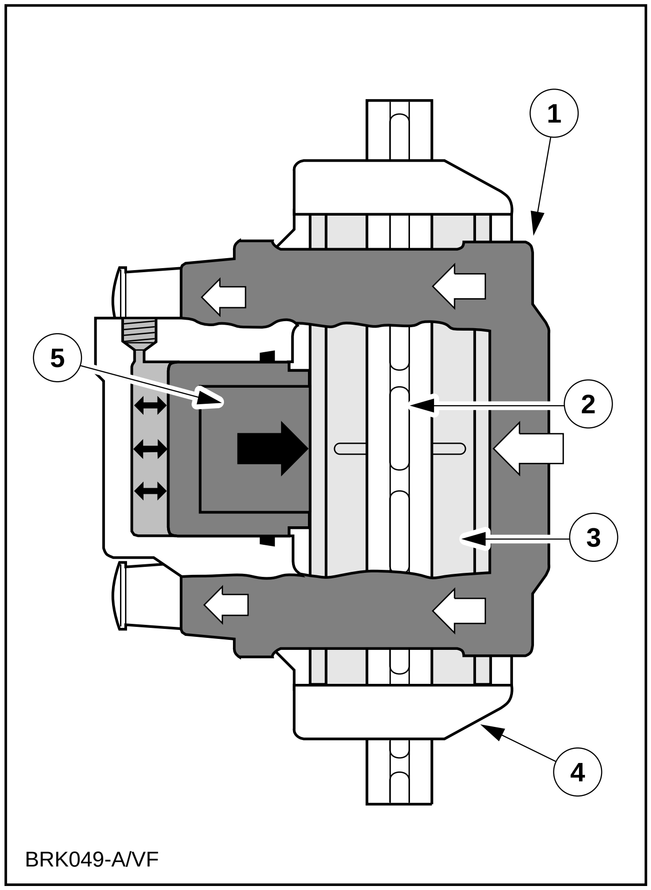
Floating brake caliper components

1 Brake caliper
2 Brake disc
3 Brake pads
4 Caliper mount
5 Caliper slide pins
6 Caliper piston

Disc brakes (continued)

Sliding brake caliper

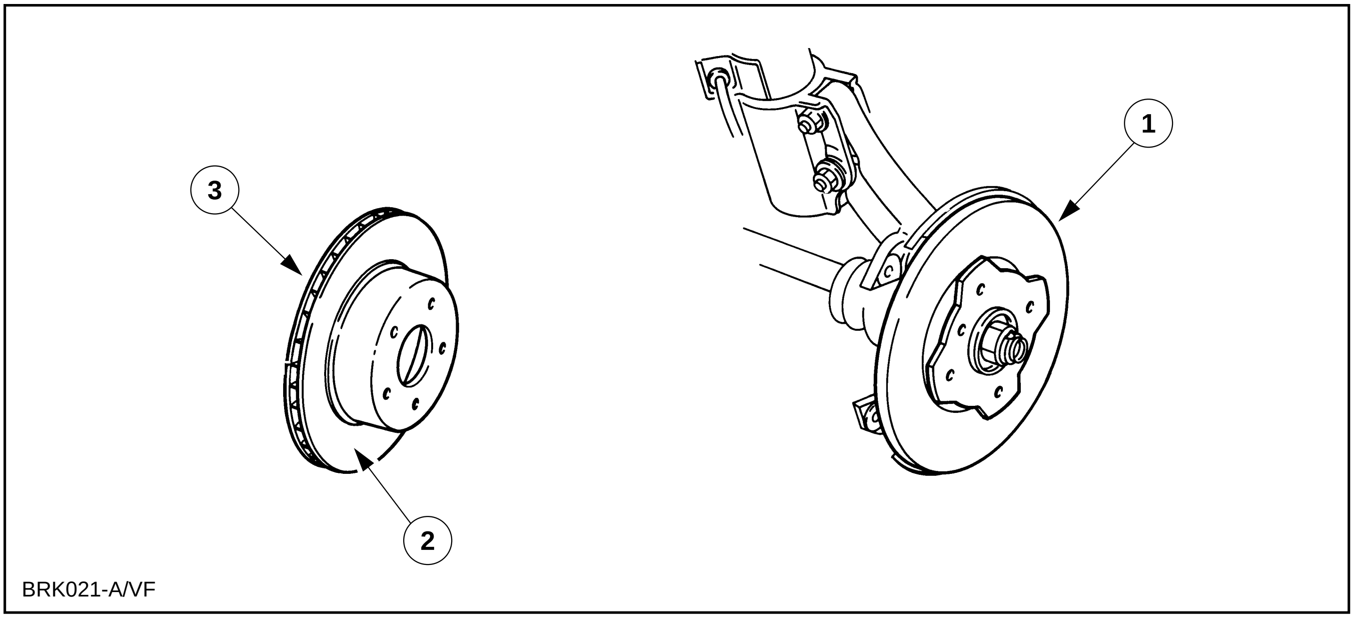
The sliding brake caliper works much like the floating brake caliper. The sliding brake caliper makes use of a larger piston(s) and larger brake pads to increase stopping power. Some sliding brake calipers may use two opposing pistons to further increase stopping power.



Sliding brake caliper components

1 Brake caliper
2 Brake disc
3 Brake pad
4 Caliper mount
5 Caliper piston

Brake discs



Types of brake discs

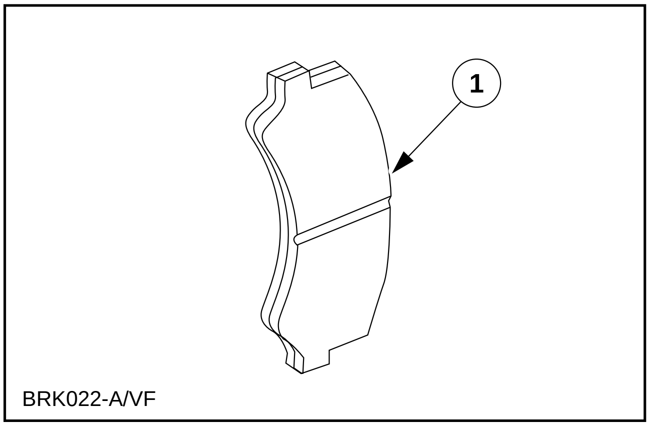
1 Solid brake disc
2 Vented brake disc
3 Air gaps

Brake discs are typically smooth and made from cast iron. Most brake discs are either internally vented or solid, to dissipate heat. As air from the moving vehicle passes by the disc, the heat is dissipated into the passing airflow. Internally vented discs have more surface area to dissipate heat, allowing them to transfer heat more efficiently than solid brake discs. The brake disc must be perfectly round and smooth. A brake disc that is not flat or true on the brake pad contact areas causes poor and erratic braking. To restore the brake disc to a smooth, flat surface the brake disc can be machined. As with brake drums, brake discs have a minimum thickness that cannot be exceeded. If the brake disc is machined beyond this minimum thickness, brake disc and system failure may occur.

Disc brakes (continued)

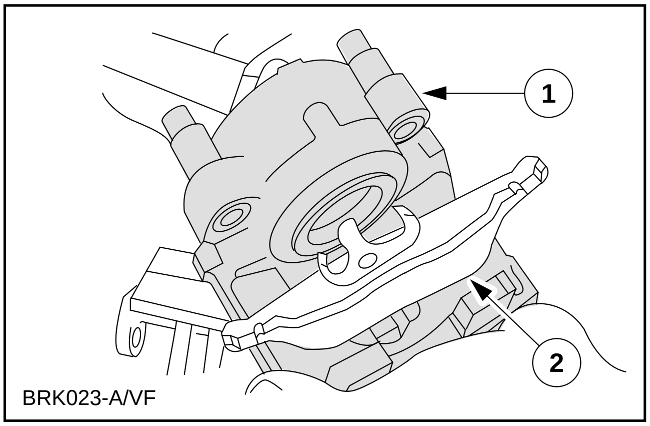
Brake pad

Like drum brakes, disc brakes also must have some form of friction material to contact the brake disc and produce friction. Since friction produces heat, the brake pads must be able to get rid of the heat and withstand the clamping force of the brake caliper. Most brake pads use a combination of metallic fibers in a resin material to create the friction material. The friction material is bonded to a steel backing to form a brake pad. The brake caliper piston pushes the steel pad with the bonded friction material into the rotating brake disc.



Brake pad

1 Brake pad



Caliper assembly

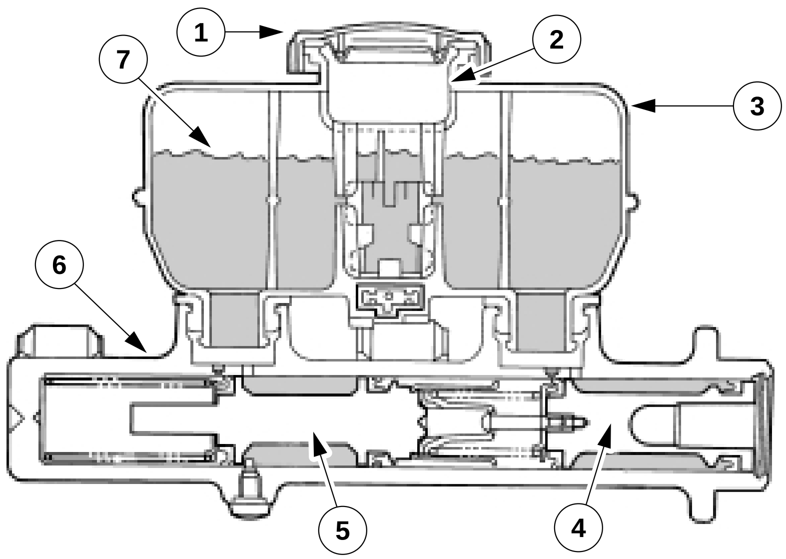
1 Brake caliper
2 Brake pad

Objectives

Upon completion of this lesson you will be able to:

- Identify the components of the master cylinder.
- Explain purpose and function of the master cylinder and brake lines.
- Describe a master cylinder and brake lines and identify types of brake lines.
- Explain the theory and operation of the master cylinder and brake lines.
- Explain the theory and operation of braking force control valves.

Master cylinder



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Master cylinder components

1 Reservoir cover
2 Reservoir gasket
3 Reservoir
4 Primary piston
5 Secondary piston
6 Master cylinder housing
7 Brake fluid

The master cylinder is the heart of the hydraulic brake system. The master cylinder pressurizes the fluid in the brake system when the driver depresses the brake pedal. The brake lines route the pressurized brake fluid to the wheel, cylinders or calipers.

The master cylinder provides a separate reservoir, pistons, and piston cups for each pair of diagonally opposite or split brake systems. The two pistons are typically found one behind the other. The two separate pistons in the master cylinder allow the brake system to have two individual brake systems. If one brake system fails due to a leak, the other system still allows two wheels to have hydraulic brake pressure.

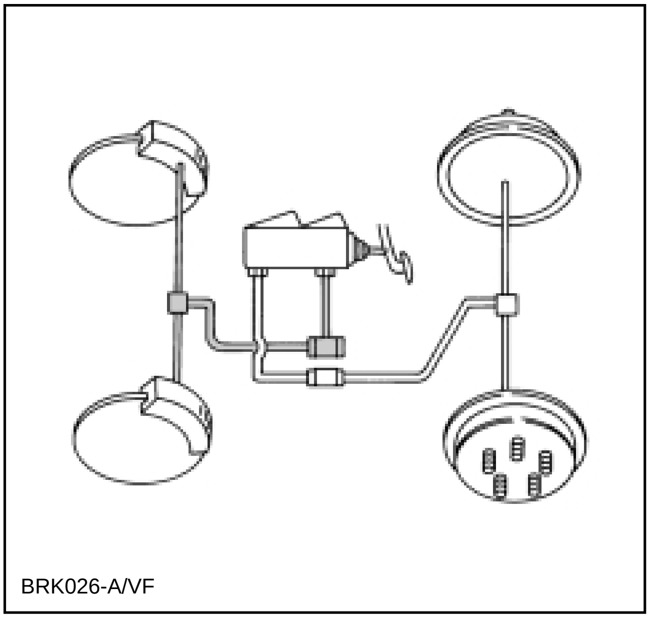
The pistons in the master cylinder push brake fluid to the individual brakes, causing the pistons in the brake cylinders/calipers to apply the brakes. As the brakes wear, fluid is added to the system from the brake fluid reservoir in the master cylinder.

The reservoir’s gasket and cover are designed to keep contaminants out of the fluid. A brake master cylinder contains a primary piston and a secondary piston. When the brake pedal is pressed, the master cylinder push rod pushes the primary piston. The primary piston closes the return port and applies pressure to the hydraulic fluid between the primary and secondary pistons. The secondary piston is pushed forward and hydraulic pressure is transferred to the brakes controlled by that piston.

Once pressure on the brake pedal is released, hydraulic pressure and a spring return the primary piston. The piston returns more quickly than the brake fluid can return from the brakes, so brake fluid from the reservoir fills the space between the two pistons. Once the primary piston has returned, all excess brake fluid returns to the reservoir. This process is similar for the secondary piston.

Split front and rear brake system

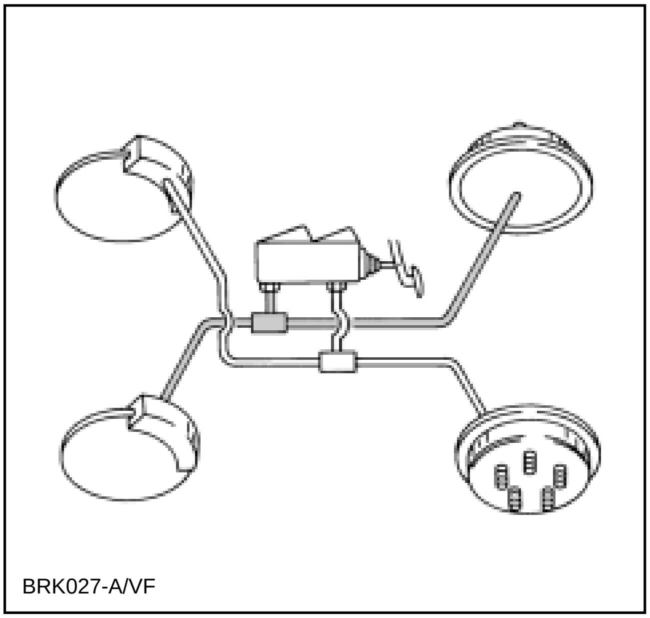
Master cylinders use two pistons to divide the brake systems into two individual brake systems. On some vehicles, the front two brakes are connected to one half of the dual master cylinder, while the rear two brakes are connected to the other half. This system is known as a split front and rear brake system.



Split front and rear brake system

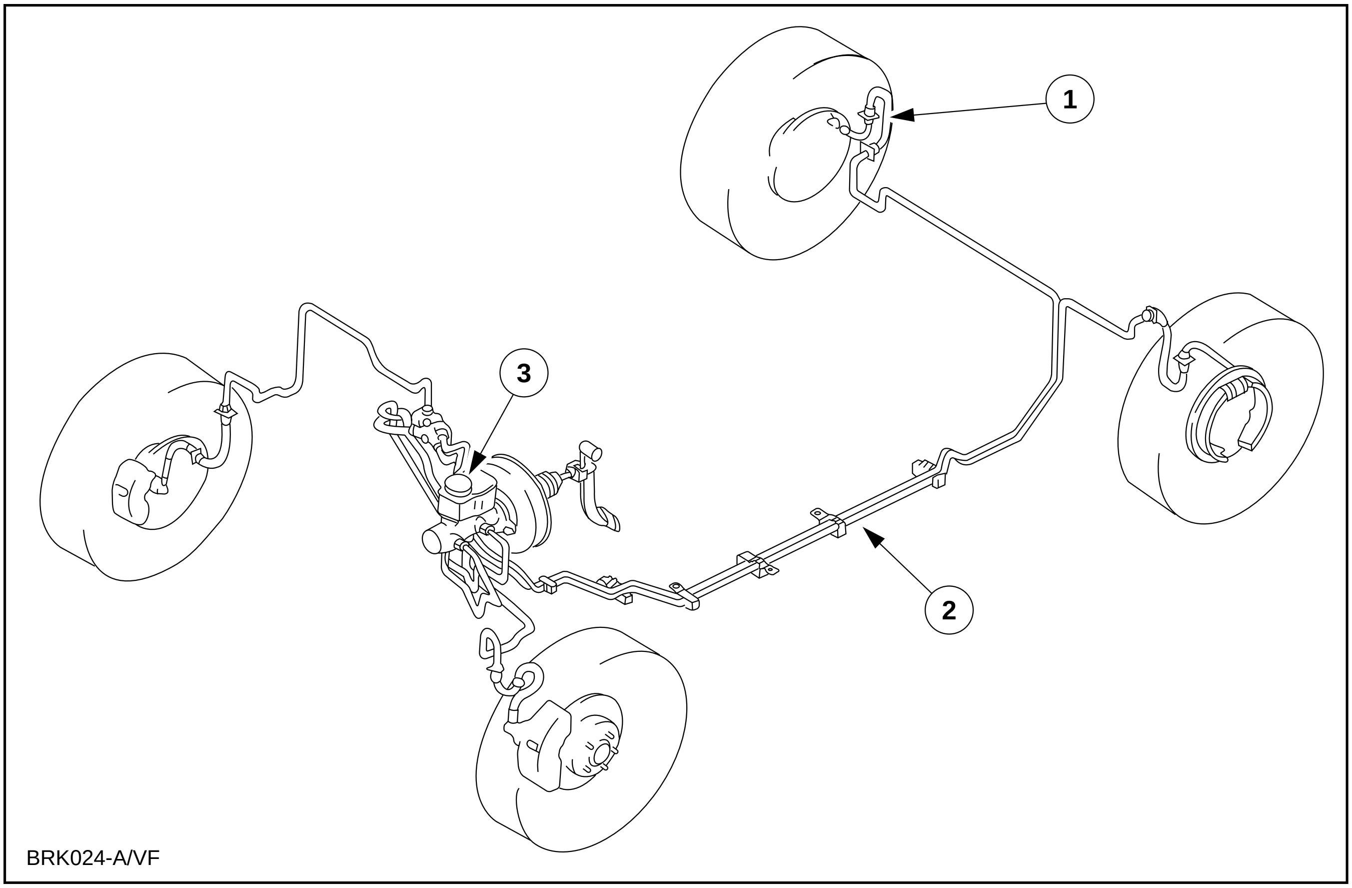
Diagonally split brake system

On other vehicles, the brake system may be diagonally split. A diagonally split brake system has one front brake connected to the opposite rear brake. A front wheel brake is always in operation, even during a partial brake failure. Since the front brakes contribute the largest part of a vehicle's braking ability, a diagonally split brake system can improve safety during partial brake failure.



Diagonally split brake system

Brake lines



Brake line system

1 Rubber brake hoses
2 Metal brake lines
3 Master cylinder

Brake lines are a series of steel tubes that contain brake fluid. Pressure created in the hydraulic system by the master cylinder is transmitted through the fluid in the brake lines to other brake system components. Brake lines must be strong enough to withstand the great pressures exerted by the brake fluid. Steel brake lines are used on the vehicle except in areas where the line must move or flex. Special rubber flexible lines are used in areas that require the brake line to move or flex. The underbody to the brakes at the wheels is one example of when a flexible line is needed.

Brake fluid

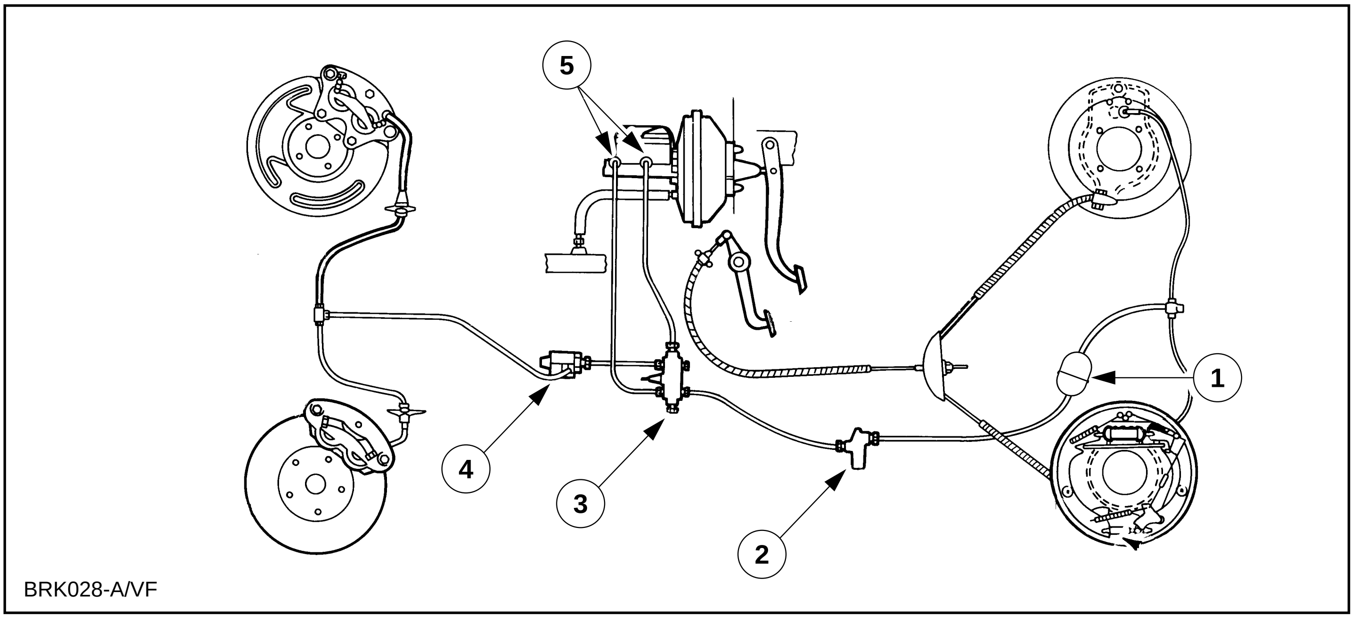
Brake fluid maintains its performance even when extremely hot or cold. The United States of America federal government's Department of Transportation (DOT) sets minimum standards for brake fluid. Brake fluid must be noncorrosive to all brake system parts and have a very high boiling point. Chemical and physical characteristics must not change as a result of long storage, cooling, or heating.

Brake fluid must have a low freezing point and must have lubrication properties. Brake fluid must be able to absorb small amounts of moisture that accumulate in the system. Air and water must be kept out of the system. As the brake fluid ages, the brake fluid absorbs contaminants and should be replaced according to manufacture specifications. Brake fluid should never be reused and should be stored in a airtight container to avoid moisture contamination.

Brake fluid with the correct DOT rating must be used according to the vehicle manufacturer. Brake fluid ratings determine fluid boiling points and chemical compounds used in the oil. DOT fluid types should never be mixed and the correct fluid should always be used. Some common DOT brake fluid ratings are:

- DOT 3 boils at 205° C (401° F)
- DOT 4 boils at 230° C (446° F)
- DOT 5 boils at 260° C (500° F)

Braking force control valves



Control valve component locations

1 Load apportioning valve or (LAV) valve
2 Proportioning valve
3 Combination valve
4 Metering valve
5 Pressure conscious regulator or (PCR) valve

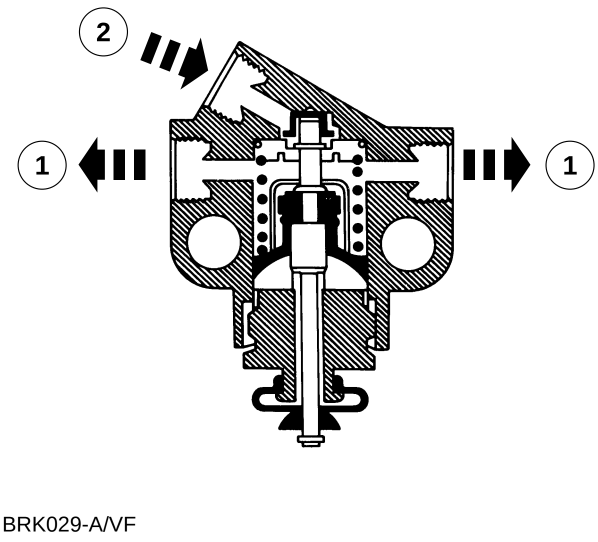
Brake control valves help monitor and control hydraulic pressure sent to each of the brakes. Since front brakes typically do more work than rear brakes, if too much brake fluid is sent to the rear brakes, they may lock up prematurely. Premature lock-up reduces the ability of the brakes to stop the vehicle. Brake control valves can reduce hydraulic pressure to the rear brakes.

Braking force control valves (continued)

Metering valve

The metering valve is designed to equalize braking action on vehicles that combine front disc and rear drum brakes. Located in the disc brake line, the metering valve prevents the front disc brakes from applying until the rear brakes begin to work. The metering valve is required because disc brakes are fast-acting. The front wheels would lock up before the rear drum brakes because drum brakes must overcome spring retainer tension before they apply.

When the brake pedal is first applied, full pressure is immediately applied to the rear brakes, while the pressure to the front brakes is limited. As the pedal is depressed further, master cylinder pressure builds up. When master cylinder pressure reaches a calibrated point, the metering valve opens to allow full pressure to be supplied to the disc front brakes.

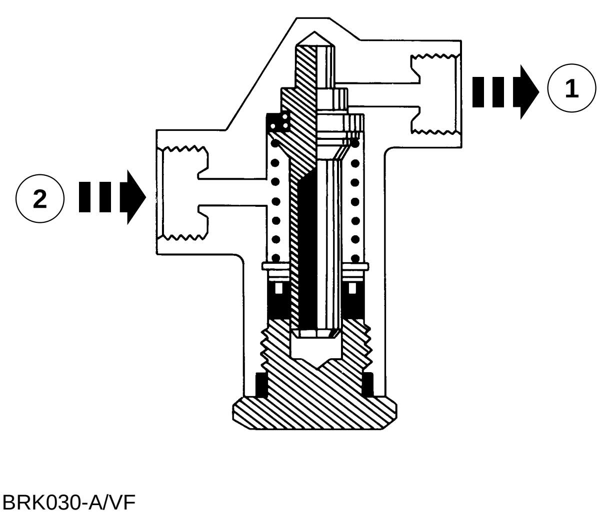


Metering valve operation

1 Hydraulic pressure to the front brakes
2 Hydraulic pressure from master cylinder

Proportioning valve

The proportioning valve is also used to regulate brake force on rear brake systems. Located in the rear brake lines, the proportioning valve limits the pressure to the rear brakes. On initial application of the brake pedal, full pressure is applied to the rear brakes. After the pressure reaches a certain point, the proportioning valve regulates pressure to the rear brakes, allowing a balanced front/rear braking ratio.

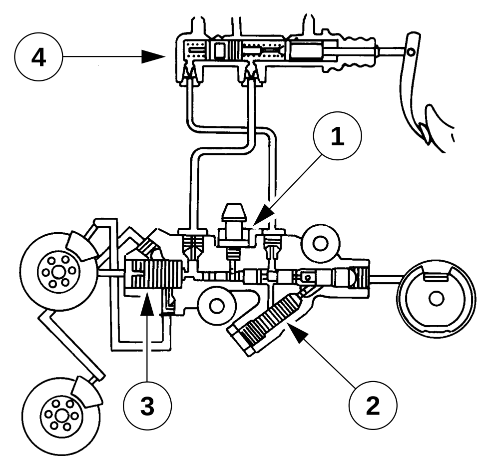


Proportioning valve operation

1 Hydraulic pressure to the rear brakes
2 Hydraulic pressure from the master cylinder

Combination valve

Some vehicles combine the pressure differential valve, metering valve, and proportioning valve into a single valve body commonly called the combination valve. While combination valves are often used in modern vehicles, some master cylinders have proportioning valves built into them.



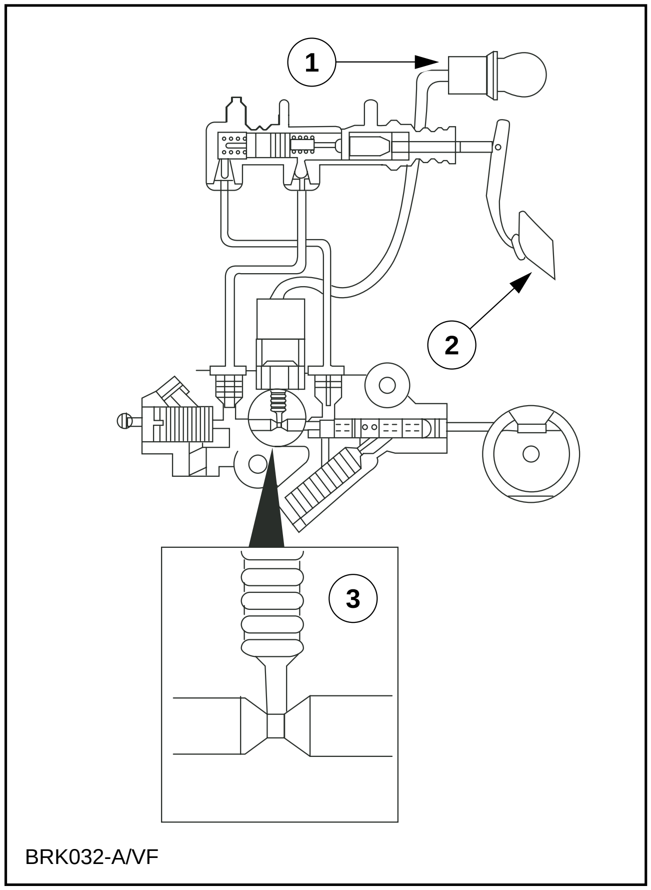
Combination valve operation

1 Pressure differential valve
2 Proportioning valve
3 Metering valve
4 Master cylinder

Braking force control valves (continued)

Pressure differential valve

The pressure differential valve lets the driver know if there is a brake fluid pressure problem. The driver may notice increased brake pedal travel and braking effort. The pressure differential valve monitors the vehicle's two brake systems. If either system is leaking, the pressure differential valve activates the brake warning light. A piston in the valve is normally centered, held in place by equal pressure at both ends. If the pressure becomes unequal, the piston moves to the side with lower pressure, causing the switch trigger plunger to slide up from its groove in the piston, turning on a warning light.



Pressure differential valve operation

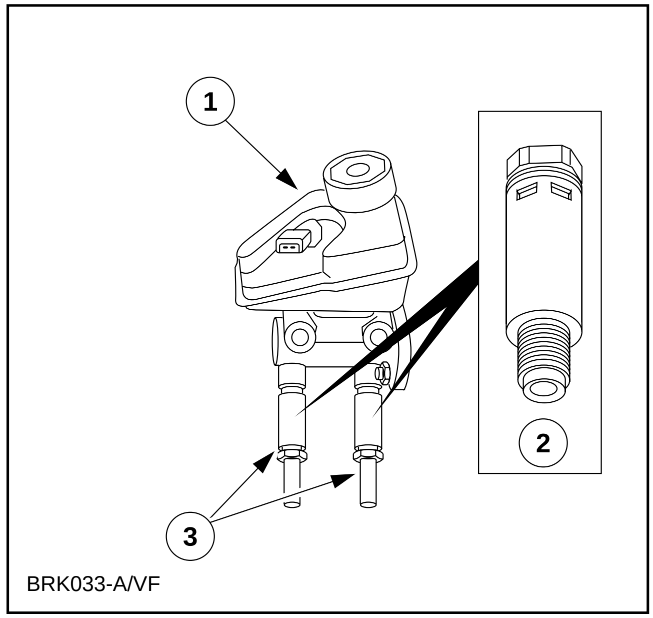
1 Brake warning lamp
2 Brake pedal
3 Trigger switch assembly

Load apportioning valve (LAV)

The weight at the rear of some vehicles can vary greatly between when they are unloaded and loaded. Since heavier loads require more braking force at the rear, the height-sensing brake proportioning valve automatically adjusts rear brake force. Increasing the weight pressing down on the rear of the vehicle compresses the valve's linkage and opens it. This valve increases the rear brakes' stopping power when the vehicle is loaded.

Pressure conscious regulator (PCR)

The pressure conscious regulator (PCR) is a valve that limits the brake fluid pressure going to the rear wheels. Brake fluid pressure to the rear wheels must be limited at times because the front brakes normally have more stopping power and do more work than the rear brakes. With the pressure conscious regulator the pressure to the rear brakes is held below the front brake pressure, preventing the rear wheels from locking up. The pressure conscious regulators are normally screwed into the master cylinder outlet ports. The brake lines are screwed into the valve. The pressure conscious regulators are controlled by a spring acting against the brake fluid pressure.



Pressure conscious regulator component location

1 Master cylinder
2 Pressure conscious regulators
3 Brake lines screwed into the PCR valve

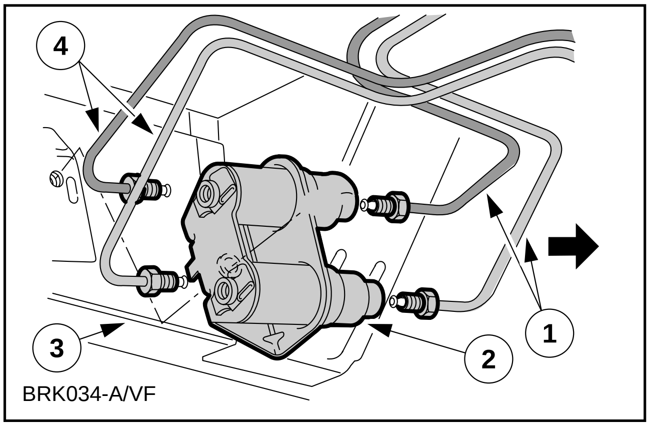
Braking force control valves (continued)

Deceleration-sensing brake pressure reducer

The deceleration-sensing brake pressure reducers have one valve for each brake circuit. The deceleration-sensing brake pressure reducer valve is needed because as the front of the vehicle dives toward the ground on a hard brake application, less weight is on the rear wheels. The weight transfer from the rear to the front axle may cause the rear wheels to lock and loss of vehicle control may result.

The deceleration valve is mounted on the floor in front of the rear axle at a certain angle and level with the vehicle floor. With a deceleration of approximately 0.5 gravity force or more, the valves allow the pressure to rise more slowly to the rear wheel brakes than to the front wheel brakes.

The preset installation angle determines the switching point of the valves. As more g's or gravity force is applied, there is less braking force sent to the rear wheels. The deceleration-sensing brake pressure reducers prevent rear wheel lockup during a hard brake application.



Deceleration valve assembly

1 Hydraulic lines to brake assemblies
2 Deceleration-sensing brake pressure reducer valve
3 Body of vehicle
4 Hydraulic lines from master cylinder

Objectives

Upon completion of this lesson you will be able to:

- Explain the purpose and function of power-assisted brakes.
- Describe power-assisted brakes and identify types of power-assisted brakes.
- Identify power-assisted brake components.
- Explain the theory and operation of power-assisted brakes.

Power-assisted brakes

Power-assisted brakes help the driver to slow and stop a vehicle by using hydraulic fluid from the power steering system or air pressure and engine vacuum to multiply the force provided by mechanical leverage to push the master cylinder pistons. Power-assisted brakes use single and double diaphragm vacuum boosters or hydroboost systems to accomplish this task.

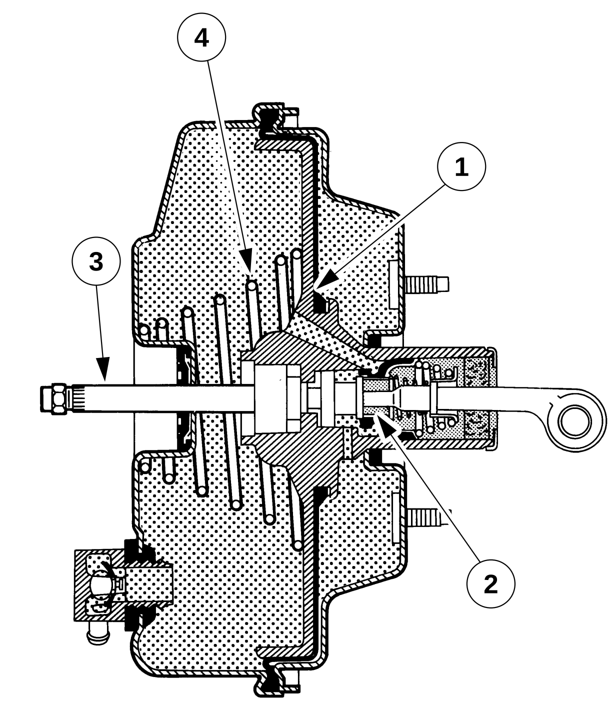
Single-diaphragm booster

The brake pedal arm is connected to the vacuum booster by the brake booster push rod. Within the vacuum booster is a power chamber, consisting of two vacuum chambers divided by a moveable diaphragm. The diaphragm is a rubber piston-like assembly that separates the atmospheric air pressure from vacuum inside the vacuum booster.

The brake pedal moves the brake booster push rod against a vacuum valve assembly, which moves the master cylinder push rod. Atmospheric pressure is higher than vacuum pressure. The atmospheric pressure on the other side of the diaphragm forces the diaphragm towards the chamber with the increased vacuum. As the diaphragm moves, it pushes the push rod into the master cylinder, sending hydraulic fluid to the brakes.

Depending on the amount of brake pedal effort applied, the valve closes the vacuum supply and opens one side of the diaphragm to atmospheric pressure.

The resulting pressure difference acting on the diaphragm provides the assist force for the master cylinder push rod. When the brake pedal is released, the reaction valve allows vacuum to immediately build in the booster. With vacuum on both sides of the diaphragm, booster action is halted.

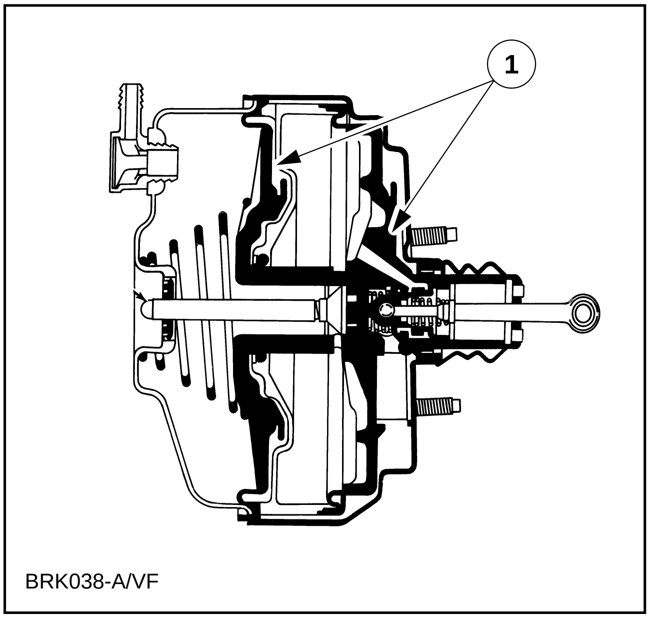


Single-diaphragm booster operation

1 Diaphragm
2 Reaction valve
3 Master cylinder push rod
4 Return spring

Dual-diaphragm booster

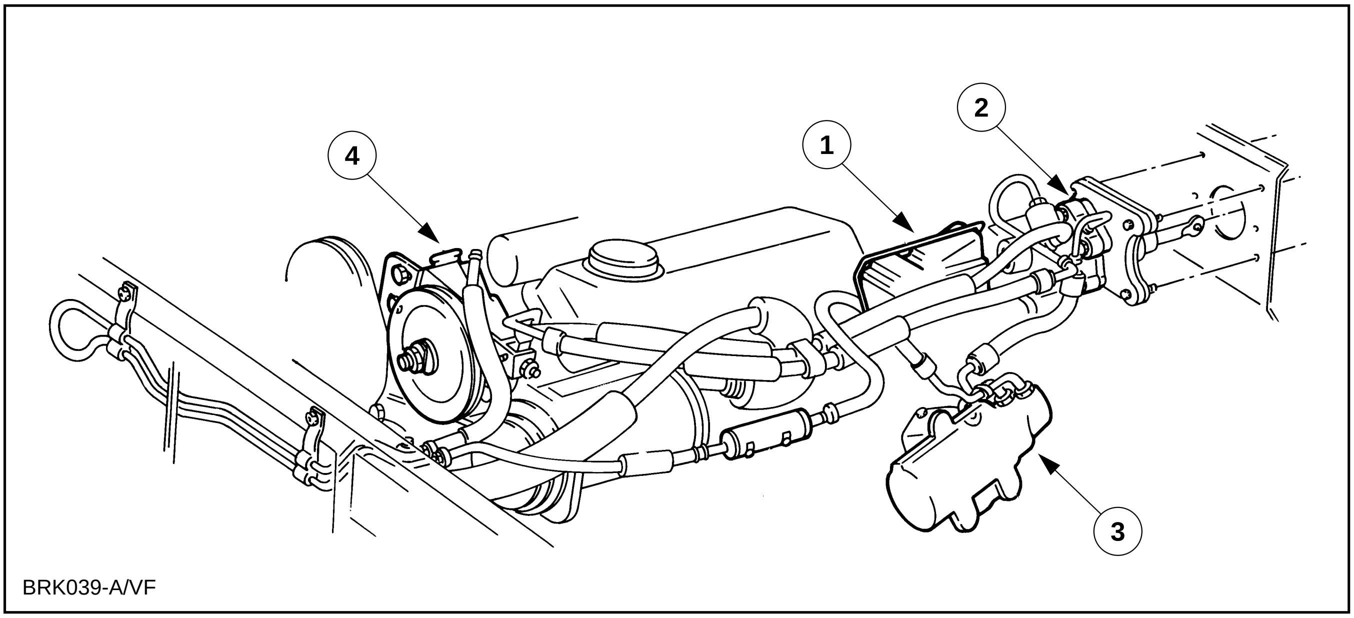
The dual-diaphragm booster works like the single-diaphragm booster with the exception that two diaphragms are used instead of one. The dual-diaphragm booster doubles the output of the booster and can be made smaller but have the same power as a single diaphragm booster of the same size. The dual-diaphragm booster is well suited for confined areas where a larger single diaphragm booster may not fit.



Dual-diaphragm booster operation

1 Dual diaphragms

Hydroboost power-assisted brakes



Hydroboost system components

1 Master cylinder
2 Hydroboost
3 Gear box
4 Power steering pump

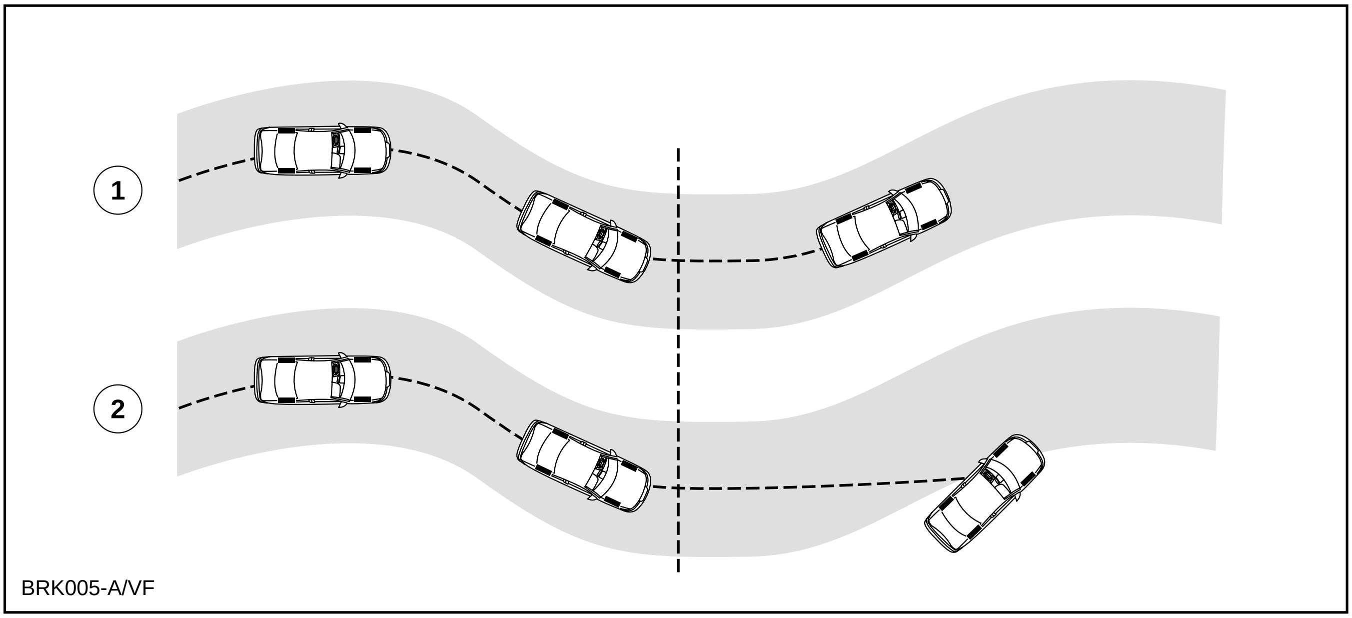
Hydroboost is a different type of power assisted brake system. Hydroboost uses power steering pump fluid pressure or a separate hydraulic system to operate components to assist power brake application. Hydroboost is sometimes used on diesel engine powered vehicles because of lack of vacuum to power a vacuum brake booster.

Objectives

Upon completion of the lesson you will be able to:

- Identify ABS components.
- Explain the purpose and function of anti-lock brake systems (ABS).
- Describe ABS braking systems.
- Explain the theory and operation of ABS.

Anti-lock brake system (ABS)

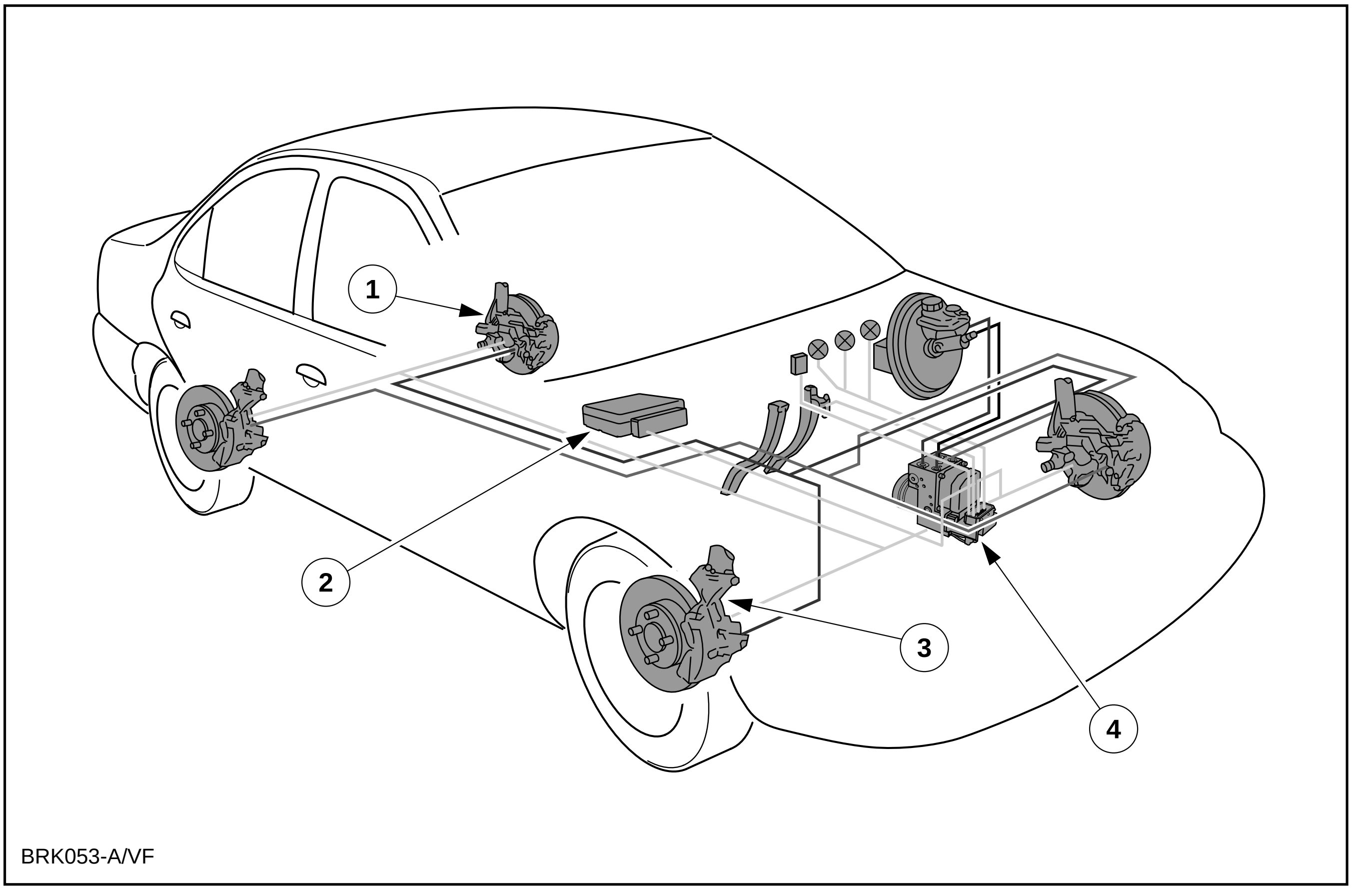


Advantages of the anti-lock braking systems

1 Vehicle with anti-lock brakes
2 Vehicle without anti-lock brakes

Anti-lock brakes prevent the wheels on a vehicle from skidding across the surface of the road during a hard brake application, allowing the driver to maintain steering control of the vehicle. The anti-lock brake system uses electronics to control the braking force applied to the wheels.

Anti-lock braking system (ABS) control module

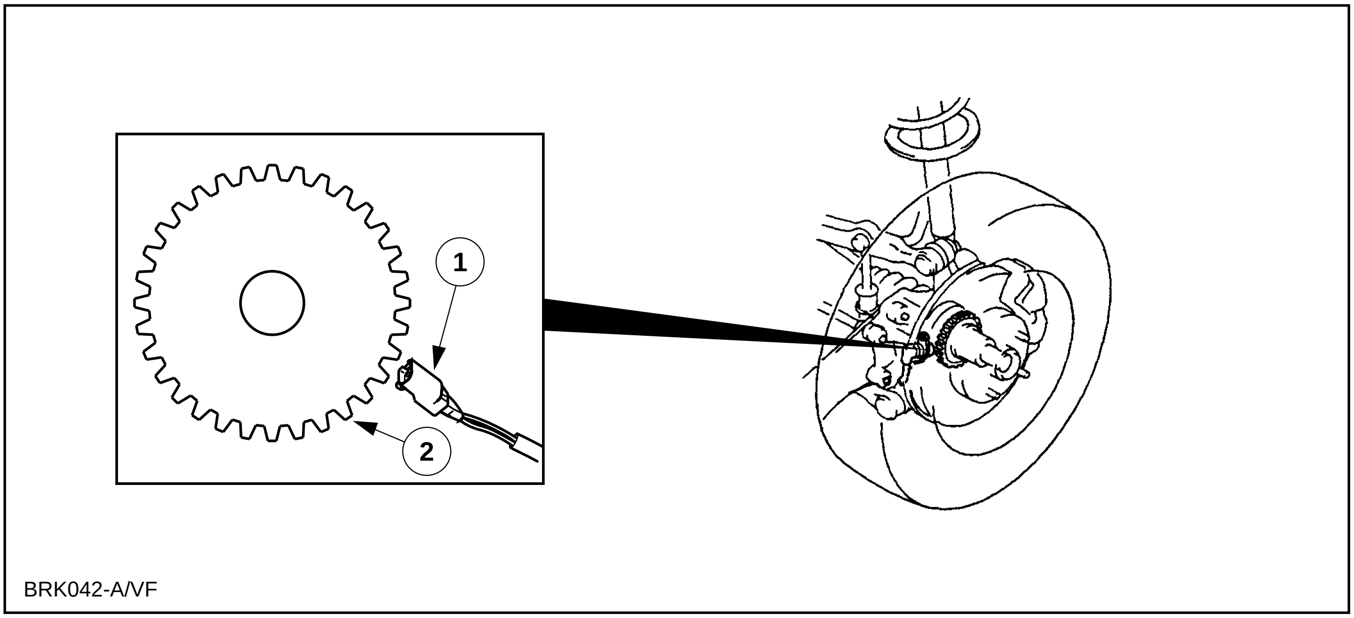


Anti-lock system components

1 Rear wheel speed sensors
2 ABS control module
3 Front wheel speed sensors
4 Hydraulic control unit

Under the direction of a control module, the anti-lock brake system uses a number of valves to direct brake fluid to where it is needed. Hydraulic brake pressure is decreased if the ABS control module determines that wheel lockup is imminent. The ABS control module is the “brain” of the system. The ABS computer determines if a brake or brakes need pressure modulation to prevent wheel lockup, and then acts upon its determinations. The control module receives electronic signals from wheel speed sensors.

Wheel speed sensors

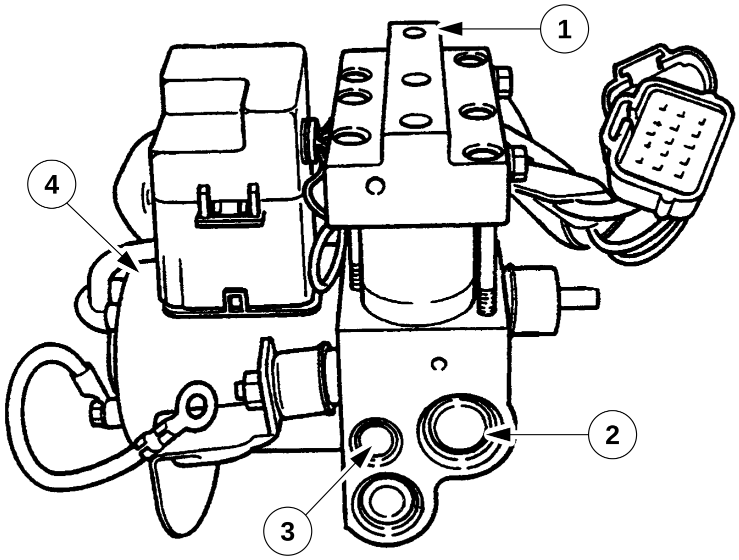


Wheel speed sensor operation

1 Wheel speed sensor
2 Gear tooth

Wheel speed sensors monitor vehicle wheel speed. The wheel speed sensors may be at each wheel, on the differential ring gear of some rear wheel drive vehicles, or a combination of both. As the wheel assembly rotates, a gear with teeth passes by the wheel speed sensor. The wheel speed sensor detects the passing teeth and passes the wheel speed information to the ABS computer. The ABS computer, using wheel speed sensor information, can detect if one of the four wheels of the vehicle has stopped rotating. The ABS computer sends commands to other ABS components to prevent vehicle skidding and loss of vehicle control.

Hydraulic control unit (HCU)



Hydraulic control unit components

1 Hydraulic control unit
2 Accumulator
3 Pump
4 Pump motor

The HCU takes the signals from the ABS control module and applies or removes hydraulic pressure to the brake assemblies. Electric solenoids in the HCU control hydraulic valves. The hydraulic valves reduce the flow of pressurized brake fluid to the brakes.

The pump motor turns on and restores fluid flow by pressurizing the fluid when the anti-lock brake control module determines that the wheels are no longer about to lock up.

On some systems the pump can be used both to pump fluid to reservoir when the wheels are about to lock-up and to pump fluid to brake units when wheels are no longer about to lock-up.

Backpressure from the pump is what the driver feels through the brake pedal. If the computer determines that a wheel is decelerating too quickly, it activates valves that open and close the hydraulic lines leading to the brake units. These valves are located in the hydraulic control unit and are not serviceable. If a valve is defective, the hydraulic control unit must be replaced.

On some systems, the hydraulic and electronic control units are combined to form one assembly. The inlet and outlet valves are controlled by solenoids. A solenoid contains an electrical coil called a winding. When current is passed through this winding, a strong magnetic field is created that activates the valve. The anti-lock brake control module turns the current on and off in these solenoids based on input signals it receives from the wheel speed sensors.

Anti-lock brakes (ABS) operation

Sliding tires provide poor braking and no steering control. The increased friction of rolling tires produces much greater vehicle control.

During hard braking conditions, it is possible for the wheels of a vehicle to lock or stop rotating. A locked wheel causes reduced steering and braking. Electronic wheel sensors and a computer system constantly monitor wheel rotation on vehicles equipped with an anti-lock brake system. If one or more of the wheels begins to lock, the system opens and closes electric valves, cycling up to 10 times per second. The brakes are applied and released and applied rapidly, so that the front wheels alternately steer and brake. The rear wheels are also prevented from locking up.

Anti-lock brake systems make it possible for vehicles to avoid skidding. The anti-lock brake system has an electronic control module, wheel speed sensors and a hydraulic control module to apply the correct hydraulic brake pressure to prevent wheel lockup.

Traction

Maximum wheel braking occurs just before wheel lockup. When the wheels skid, steering control is lost. The point at which lockup occurs is determined by the frictional coefficient of the road, the grip of the tires, the speed and weight of the vehicle, the suspension, and more.

Frictional coefficient

The frictional force or grip between the road and the tires can be expressed as a frictional coefficient that is dependent on the road. A dry asphalt road has a greater frictional coefficient than an icy road.

Slip Ratio

The difference between how fast the vehicle is going, and wheel speed when the brakes are applied, is called slip. A slip ratio of zero reflects no slippage. ABS significantly limits slip, improving braking effectiveness.

Objective

Upon completion of this lesson you will be able to:

- Explain the Symptom-to-System-to-Component-to-Cause diagnostic procedure and provide an example.

Symptom-to-system-to-component-to-cause diagnostic procedure diagnosis

Diagnosis requires a complete knowledge of the system operation. As with all diagnosis, a technician must use symptoms and clues to determine the cause of a vehicle concern. To aid the technician when diagnosing vehicles, the strategies of many successful technicians have been analyzed and incorporated into a diagnostic strategy and into many service publications.

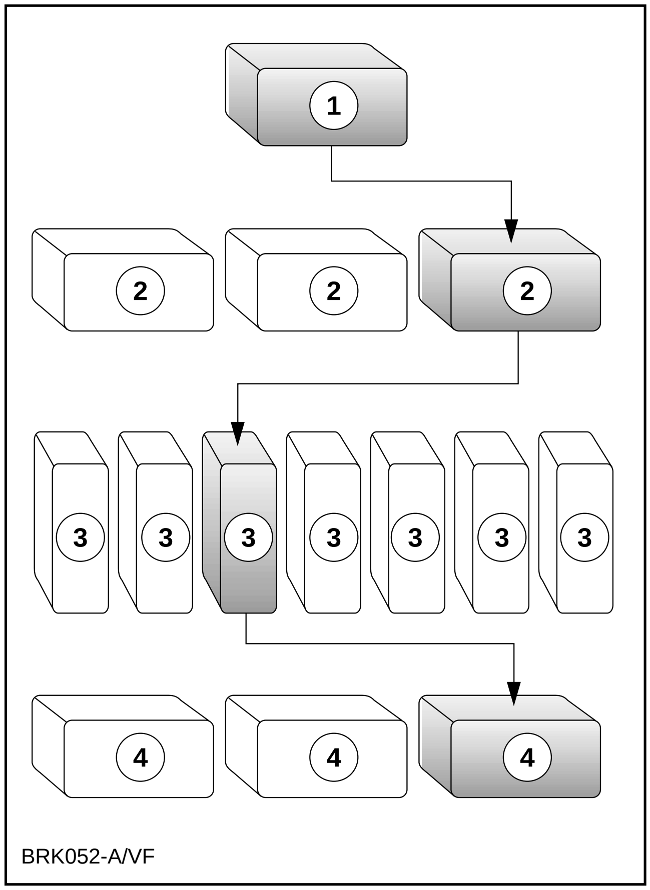
Symptom-to-system-to-component-to-cause diagnostic method

Using the Symptom-to-System-to-Component-to-Cause (SSCC) diagnostic routine provides you with a logical method for correcting customer concerns:

- First, confirm the “Symptom” of the customer’s concern.
- Next, determine which “System” on the vehicle could be causing the symptom.
- Once you identify the particular system, determine which “Component(s)” within that system could be the cause for the customer concern.
- After determining the faulty component(s) you should always try to identify the cause of the failure.

In some cases parts just wear out. However, in other instances something other than the failed component is responsible for the problem.

For example, as the driver steps on the brakes the vehicle swerves to the left because of contaminated brake pads. The brake pads are contaminated because of a brake fluid leak at the brake caliper. Replacing the brake pads will correct the problem for a short time until the pads again become oil soaked. Both the brake pads and oil leak must be corrected together to repair the vehicle correctly.



SSCC diagram

1 Symptom
2 Vehicle systems
3 Components
4 Causes

Workshop manual

The vehicle Workshop Manual contains information for diagnostic steps and checks such as: preliminary checks,verification of customer concern, special driving conditions, road tests and diagnostic pinpoint tests.

The abbreviations conform to the standard SAE J1930 except those marked with an asterisk (*).

ABS*	**A**nti-lock **B**rake **S**ystems
BTU*	**B**ritish Thermal Unit x 251.99 = CAL
C°*	**C**elsius = $\left(\frac{5}{9} \times F\right) -32$
CAL*	**C**alories = .00396 = BTU
Disc*	Rotor
ECU*	**E**lectronic **C**ontrol **U**nit
F°*	**F**ahrenheit = $\left(\frac{9}{5} \times C\right) +32$
Gasoline	Petrol
IN*	**I**nches x 25.4 = centimeters
kPa*	**K**ilo**p**ascals x .145 PSI
L*	Liter x 0264 = gallons
LAV*	**L**oad **A**pportioning **V**alve
LB-FT*	**P**ounds-**F**eet x 1.3558 = 1 Nm
MM*	**M**illi**m**eter x 0.04 = inches
PCR*	**P**ressure **C**onscious **R**egulator
Petrol	Gasoline
PSI*	**P**ounds per **S**quare **I**nch x 6.89 = kPa
SSCC	**S**ymptom-to-**S**ystem-to-**C**omponent-to-**C**ause
Tires	**Tyres**