Automotive Mechanics

Level III

Based on October 2023, Curriculum Version II

Module Title: Maintaining Brake System

Module Code: EIS AUM3 M07 1023

Nominal Duration: 60 Hours

Prepared by: Ministry of Labor and Skill

October, 2023

Addis Ababa, Ethiopia

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Acknowledgment

The Ministry of Labor and skill wishes to thank and appreciation to MoLS leaders and experts, Regional Labor and skill/training Bureaus leader, experts, TVT College Deans, Instructors and industry experts who contribute their time and professional experience to the development of this Training Module.

Acronym

ABS	Anti-Lock Brake System
ASA	Automatic Slack Adjuster
AST	Automotive Special Tools
CTEA	Canadian Transportation Equipment Association
IC	Internal Combustion (IC)
LAP TEST	Learning Activity Performance Test
LRO	Lateral Run-Out
MOC	Motor On Caliper
OHS	Occupational Health Safety
OSHA	Occupational Standards To Hazard Against
PBBT	A Performance-Based Brake Tester
SST	Special Service Tools
TTLM	Teaching, Training And Learning Materials

Introduction to Module

Baking system is necessary in an automobile for stopping the vehicle. Brakes are applied on the wheels to stop or to slow down the vehicle. The friction of the tires against the road is what slows down and stops a vehicle. The brake system slows or stops the rotation of the wheels. This is a minor point but one that extends the responsibility for braking to the tires as well as the brake system. This module is designed to meet the industry requirement under the automotive mechanics occupational standard, particularly for the unit of competency: maintaining brake system.

This module covers the units:

- Brake system
- Inspecting Brake system components
- Overhauling Brake System

Learning Objective of the Module

- Understand Brake System.
- Perform inspecting brake system components
- Overhaul Brake System

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit One: Fundamentals of Brake System

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Principles Of Hydraulics And Pneumatics
- Concept Of Friction
- Factor Affecting Braking Force
- Brake Lining Friction Materials
- Purpose Of Brake System
- Types Of Brake System
- Components Of Brake System
- Brake Retarder
- Antilock Brake System.
- Special Service Tools And Equipment

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand Hydraulics and Pneumatics Principles
- Understand the Concept Of Friction
- Identify the Factor Affecting Braking Force
- Identify Brake Lining Friction Materials
- Understand the Purpose Of Brake System
- Identify the types Of Brake System
- Identify the components Of Brake System
- Grasp the Brake Retarders
- Rationalize Antilock Brake System
- Identify Special Service Tools And Equipment

1.1 Principles of Hydraulics and Pneumatics

1.1.1 Principles of Hydraulics

The word "hydraulics" generally refers to power produced by moving liquids. Modern hydraulics is defined as the use of confined liquid to transmit power, multiply force, or produce motion.

The basic principle governing hydraulics goes back to a seventeenth century French mathematician and philosopher, Blaise Pascal. Pascal's Law states that a pressure applied to a confined liquid is transmitted instantly, equally, and undiminished, at right angles, to all surfaces of the container. Since oil is virtually non-compressible (only 0.5% per 1,000 PSI) any force applied to one end of an oil-filled tube or hose will be instantly transmitted to the other end.

Pascal's law states that pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid.

- P1 = P2 (since the pressures are equal throughout).
- Since pressure equals force per unit area, then it follows that

$$F1 / A1 = F2 / A2$$

- Because the volume of fluid pushed down on the left side equals the volume of fluid that is lifted up on the right side, the following formula is also true.

V1 = V2by substitution, **A1 D1 = A2 D2**

A = cross sectional area

D = the distance moved

A1/A2=D2/D1

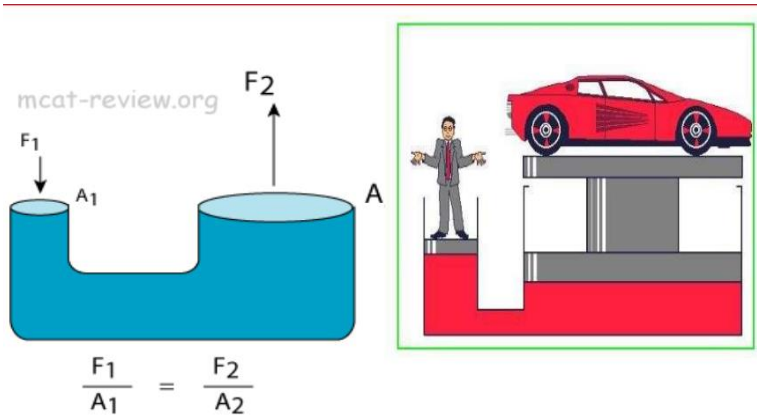


Figure 1:1 Power Is Produced By Moving Liquids

The foundation of modern hydraulics was established when Blaise Pascal, a French scientist, discovered the fundamental law for the science of hydraulics. Pascal's law states that pressure applied to a confined liquid is transmitted undiminished in all directions and acts with equal force on all equal areas, at right angles to those areas.

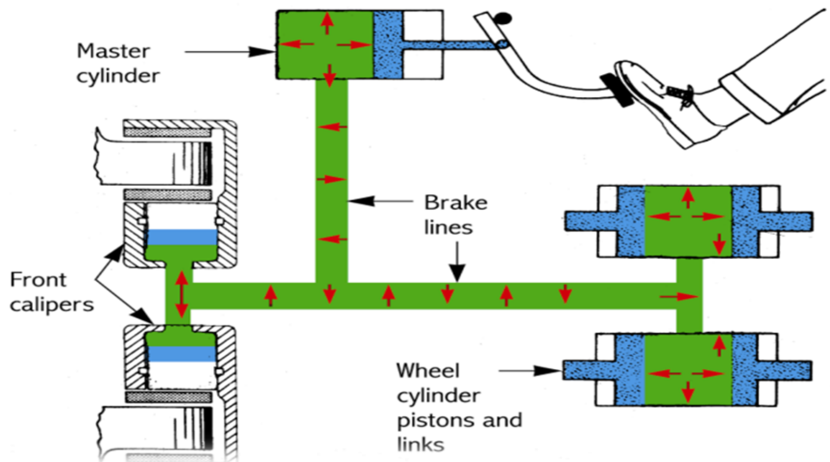


Figure 1: 1 Principles of Hydraulics

1.1.2 Principles of Pneumatic

- The pneumatic braking system is one of the types of automobile braking system. it is also known as the air braking system. In this braking system, compressed air is used to apply the brake.
- The brake force produce by the hydraulic brake is not sufficient to stop the heavy vehicles. Therefore pneumatic brake is used in heavy vehicles.
- The five basic components of a pneumatic or air brake system are air compressor, storage tank/air reservoir, brake valve, brake chamber, brake drum.

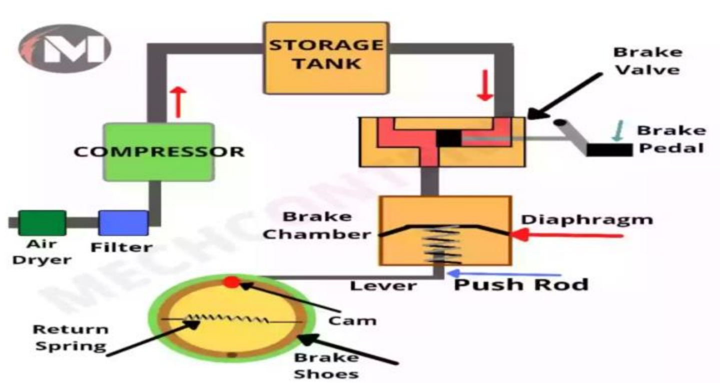


Figure 1: 2 Pneumatic brake system

1.2 Concept of Friction

There are two basic types of friction that explain how brake systems work: kinetic, or moving, and static, or stationary 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. As the brakes on a moving automobile are applied, rough-textured pads or shoes are pressed against rotating parts of the vehicle—either rotors (discs) or drums. 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.

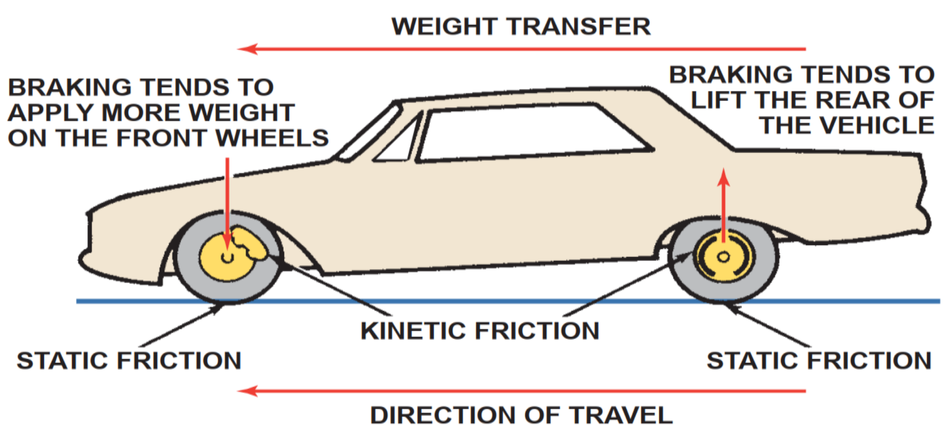


Figure 1:5 Vehicle Braking Action

1.3 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.

An additional factor influences how well a vehicle will stop when the brakes are applied, that being weight transfer. When the brakes are applied while the vehicle is moving forward, the weight of the vehicle shifts forward. This causes the front of the vehicle to drop or "nose dive." It also means that the front brakes will need the most stopping power. If the vehicle is overloaded or if the front suspension is weak, more weight will be thrown forward and the brakes will need to work harder.

A. Pressure

The amount of friction generated between moving surfaces in contact with each other 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 desk, you will feel a gradual increase in friction.

In a brake system, 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. The amount of pressure is determined by the pressure on the brake pedal and the design of the brake system.

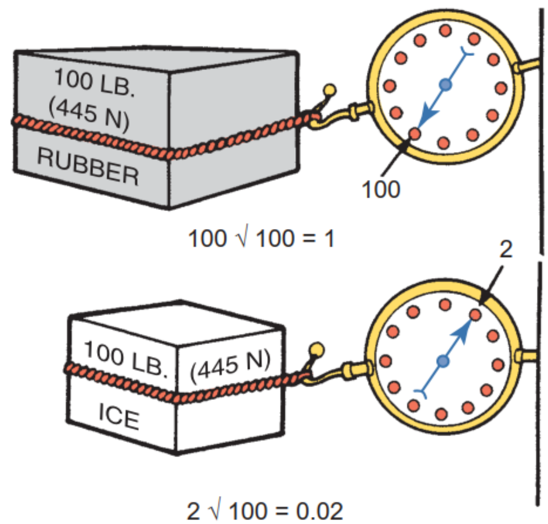


Figure 1: 3 Coefficient of friction is equal to the pounds of pull divided by the weight of the object.

B. Coefficient of Friction

The amount of friction generated between two surfaces is expressed as a coefficient of friction (COF). The COF is determined by dividing the force required to pull an object across a surface by the weight of the object. For example, if it requires 100 pounds (455 N) of pull to slide a 100-pound (45.4 kg) metal part across a concrete floor, the COF is 100 divide 100 or 1. To pull a 100mpound (45.4 kg) block of ice across the same surface may require only 2 pounds (9 N) of pull. The COF 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. The required COF depends on the vehicle and other factors and is carefully chosen by the manufacturer to ensure safe and reliable braking. 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 will be 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 surface of the drum or rotor rather than slowing it down. Most automotive friction materials are engineered with a COF of between 0.25 and 0.55.

C. Frictional Contact Surface

The third factor is the amount of surface area that is in contact. Simply put, bigger brakes stop a car more quickly than smaller brakes used on the same car. For the most part, the vehicle's weight and potential speed determines the size of the friction surface areas. Also, the greater the surface areas of the wheel brake units, the faster heat can be dissipated.

D. 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. Brakes that do not effectively dissipate heat experience brake fade during hard, continuous braking.

1.4 Brake Lining Friction Materials

Brake linings are made up relatively soft but tough and heat-resistant material with a high coefficient of friction. The lining is typically attached to a metal backing with rivets or high-temperature adhesives. For many decades, asbestos was the standard brake lining material. It offers good friction qualities, long wear, and low noise. But new materials are being used because of the health hazards of breathing asbestos dust. Asbestos has not been used in brake linings or pads since 2003. Many different materials are used as lining material and the type of lining is defined by its composition. Each type has different heat dissipation, fade resistance, rotor wear, noise generation, and braking force characteristics.

A. Non asbestos organic (NAO)

Non asbestos organic (NAO) linings are installed on many vehicles by the OEM. Organic linings are made of nonmetallic fibers bonded together to form a composite material. Today's organic brake linings contain the following types of materials:

B. **Metallic Linings**

Fully metallic materials were used for many years in racing. Metallic lining is made of powdered metal that is formed into blocks by heat and pressure. These materials provide excellent resistance to brake fade but require high brake pedal pressure; they create the most wear on rotors and drums. Metallic linings work very poorly until they are fully warmed.

C. Semi-metallic Linings

Semi-metallic materials are made of a mixture of organic or synthetic fibers and certain metals molded together. Semi-metallic linings are harder and more fade resistant than organic materials but require higher brake pedal effort.

D. Synthetic Linings

The goals of improved braking performance and the disadvantages of the other lining materials have led to the development of synthetic lining materials. They are classified as synthetic because they are made of nonorganic, nonmetallic, and non-asbestos materials. Two types of synthetic materials are commonly used as brake linings for drum brakes: fiberglass and aramid fibers.

E. Ceramic

Linings are found on many FWD vehicles, because they have high heat resistance. Most ceramic pads are made of a ceramic material mixed with copper fibers. These pads are quiet and produce little dust, making them popular as both OE and as aftermarket replacement parts.

F. Carbon-Metallic/Ceramic

Carbon-metallic pads are often used on high-performance cars due to their good COF and high heat resistance. Carbon linings are also able to withstand very high temperatures without causing brake fade. A few aftermarket companies offer linings made of carbon, Kevlar, and various other materials.

Figure 1:6 Brake Friction materials

1.5 Purpose of Brake System

There are two main functions of brake systems:

(a) To slow down or stop the vehicle in the shortest possible time at the time of need.

(b) To control the speed of vehicle at turns and also at the time of driving down on a hill.

Automotive brakes are designed to slow and stop a vehicle by transforming kinetic (motion) energy into heat energy. As the brake linings contact the drums/rotors they create friction which produces the heat energy. The intensity of the heat is proportional to the vehicle speed, the weight of the vehicle, and the quickness of the stop.

1.6 Types of Brake System

1.6.1 On the Basis of Application

A. Service Brake

This brake is used when the vehicle is in running condition to stop or slow down the vehicle. This is the main braking system, which is situated in both rear and front wheels of the vehicle.

B. Parking Brakes

Secondary brakes, which is also known as parking brake or emergency brake, are used to keep the vehicle stationary. It is generally operated by hand, so also known as hand brake. The main function of this brake, is to keep the vehicle stationary when it is parked.

1.6.2 On the Basis of Power Source

A. Mechanical Braking System

The Mechanical Braking System Powers the Hand Brake or Emergency Brake.it is the type of braking system in which the brake force applied on the brake pedal is carried to the final brake drum or disc rotor by the various mechanical linkages like cylindrical rods, fulcrums, springs etc. in order to stop the vehicle. Mechanical brakes were used in several old automobile vehicles but they are archaic nowadays due to their less effectiveness

B. Hydraulic Braking System

A hydraulic system uses 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 100 pounds per square inch (psi) (690 kPa) through the master cylinder and you can measure 100 psi (690 kPa) anywhere in the lines and at each wheel where the brakes operate. (We will discuss it briefly)

C. Air or Pneumatic Braking System

It is the types of braking system in which atmospheric air through compressors and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor. Air brakes are mainly used in heavy vehicles like busses and trucks because hydraulic brakes fails to transmit high brake force through greater distance and also pneumatic brakes generates higher brake force than hydraulic brake which is the need of the heavy vehicle.

The chances of brake failure is less in case of pneumatic brakes as they are usually equipped with a reserve air tank which comes in action when there is a brake failure due to leakage in brake lines. High end cars these days are using air brakes system due to its effectiveness and fail proof ability.

D. Vacuum Braking System

A vacuum-assisted braking among this system, the pressure applied to the pedal by the driver is increased. They use the vacuum that is produced in petrol engines by the air intake system in the engine's intake pipe or via a vacuum pump in diesel engines. Servo braking system boosters used with the hydraulic brake system. Vacuum boosters increase the braking force. Pushing the brake pedal releases the vacuum on the side of the booster. The difference in the air pressure pushes the diaphragm for breaking the wheel.

E. Magnetic Brakes

In this type of braking system, the magnetic field generated by permanent magnets is used to cause the braking of the vehicle. It works on the principle that when we pass a magnet through a cooper tube, eddy current is generated and the magnetic field generated by this eddy current provide magnetic braking. This is the friction less braking system thus there is less or no wear and tear. This is the advanced technology in which no pressure is needed to cause braking. The response to the braking in this is quite quick as compared to other braking systems.

F. Electrical Brakes

It is type of braking used in electric vehicle in which braking is produced using the electrical motors which is the main source of power in electric vehicles, it is further divided into 3 types-

I. Plugging Brakes

When the brake pedal is pressed in the electric vehicle equipped with plugging braking, the polarity of the motors changes which in turn reverses the direction of the motor and causes the braking.

II. Regenerative Braking

It is the type of electrical braking in which at the time of braking the motor which is the main power source of the vehicle becomes the generator i.e. when brakes are applied, the power supply to the motor cuts off due to which the mechanical energy from the wheels becomes the rotating force for the motor which in turn converts this mechanical energy into the electric energy which is further stored in the battery. Regenerative braking saves the energy and are widely used in today's electric vehicles.

III. Dynamic or Rheostat Braking

It is the type of electrical braking in which resistance provided by the rheostat causes the actual braking, in this type a rheostat is attached to the circuit that provides the resistance to the motor which is responsible for de acceleration or stopping of the vehicle.

1.6.3 On the Basis of Frictional Braking Contact

A. Internal Expanding Brakes (Drum Brakes)

Internal expanding brakes are used almost exclusively as wheel brakes, but can be found on some cranes. This type of brake permits a more compact and economical construction. The brake shoes and brake-operating mechanism are supported on a backing plate or brake shield attached to the vehicle axle. The brake drum, attached to the rotating wheel, acts as a cover for the shoe and operating mechanism and furnishes a frictional surface for the brake shoes.

B. External Contracting Brakes (Disc Brakes)

External contracting brakes are sometimes used for parking brakes on motor vehicles, for cranes, and for controlling the speed of auxiliary equipment drive shafts.

In operation, the brake band (or shoe) of an external contracting brake is tightened around the rotating drum by moving the brake lever. The brake band is made of comparatively thin, flexible steel, shaped to fit the drum, with a frictional lining riveted to the inner surface.

1.7 Components of Brake System

Let's take a closer look at each of the components in a brake system

1.7.1 Brake Pedal

The brake pedal is located on the floor to the left of the accelerator. When pressed, it applies the brakes, causing the vehicle to slow down and/or stop. You must use your right foot (with your heel on ground) to exert force on the pedal to cause the brakes to engage.

Figure 1:4 Brake Pedal

1.7.2 Master Cylinder

The master cylinder is located in the engine compartment on the firewall, directly in front of the driver's seat. A typical master cylinder is actually two completely separate master cylinders in one housing, each handling two wheels. This way if one side fails, you will still be able to stop the car.

The brake warning light on the dash will light if either side fails, alerting you to the problem. Master cylinders have become very reliable and rarely malfunction; however, the most common problem that they experience is an internal leak. This will cause the brake pedal to slowly sink to the floor when your foot applies steady pressure.

Figure 1: 5 Master Cylinder

1.7.3 Brake Fluid

Brake fluid is a special oil that has specific properties. It is designed to withstand cold temperatures without thickening as well as very high temperatures without boiling. (If the brake fluid should boil, it will cause you to have a spongy pedal and the car will be hard to stop.) Brake fluid must meet standards that are set by the Department of Transportation

(DOT). The current standard is DOT-3 which has a boiling point of 460º F. But check your owner's manual to see what your vehicle manufacturer recommends.

The brake fluid reservoir is on top of the master cylinder. Most cars today have a transparent reservoir so that you can see the level without opening the cover. The brake fluid level will drop slightly as the brake pads wear. This is a normal condition and no cause for concern.

If the level drops noticeably over a short period of time or goes down to about two thirds full, have your brakes checked as soon as possible. Keep the reservoir covered except for the amount of time you need to fill it and never leave a can of brake fluid uncovered. Brake fluid must maintain a very high boiling point .Exposure to air will cause the fluid to absorb moisture which will lower that boiling point.

Figure 1: 6 Brake Fluid

1.7.4 Brake Lines

The brake fluid travels from the master cylinder to the wheels through a series of steel tubes and reinforced rubber hoses. Rubber hoses are only used in places that require flexibility, such as at the front wheels, which move up and down as well as steer. The rest of the system uses non-corrosive seamless steel tubing with special fittings at all attachment points.

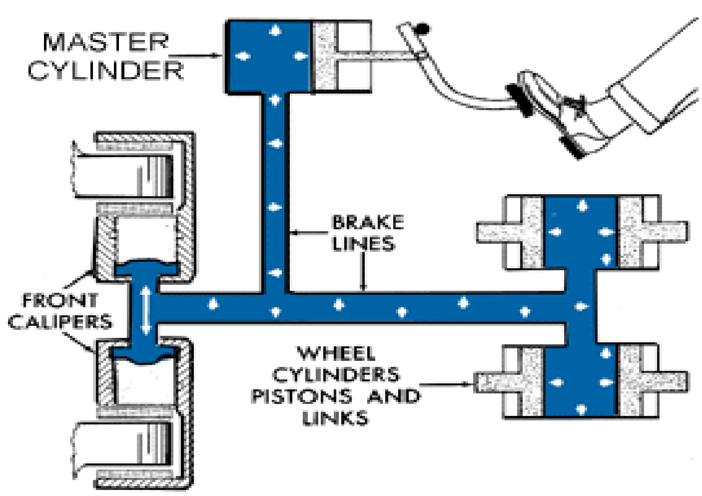


Figure 1: 7 Brake Lines

1.7.5 Brake System Valves

A. Proportioning valve or Equalizer Valve

These valves are mounted between the master cylinder and the rear wheels. They are designed to adjust the pressure between the fronts and rear brakes depending on how hard you are stopping. The shorter you stop, the more of the vehicle's weight is transferred to the front wheels, in some cases, causing the rear to lift and the front to dive. These valves are designed to direct more pressure to the front and less pressure to the rear the harder you stop. This minimizes the chance of premature lockup at the rear wheels.

Figure 1: 8 Proportioning valve or Equalizer Valve

B. Pressure Differential Valve

This valve is usually mounted just below the master cylinder and is responsible for turning the brake warning light on when it detects a malfunction. It measures the pressure from the two sections of the master cylinder and compares them. Since it is mounted ahead of the proportioning or equalizer valve, the two pressures it detects should be equal. If it detects a difference, it means that there is probably a brake fluid leak somewhere in the system.

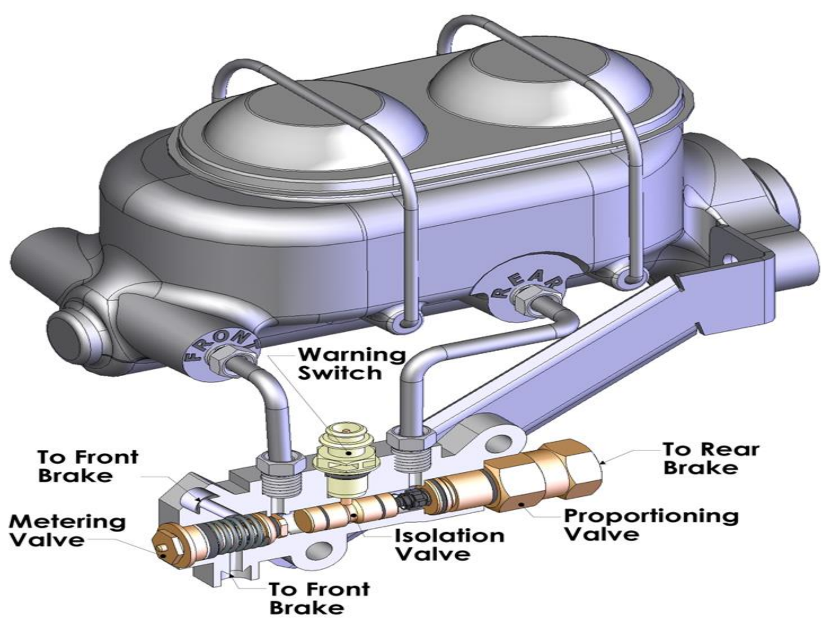


Figure 1: 9 Pressure Differential Valve

C. Combination Valve

The Combination valve is simply a proportioning valve and a pressure differential valve that is combined into one unit.

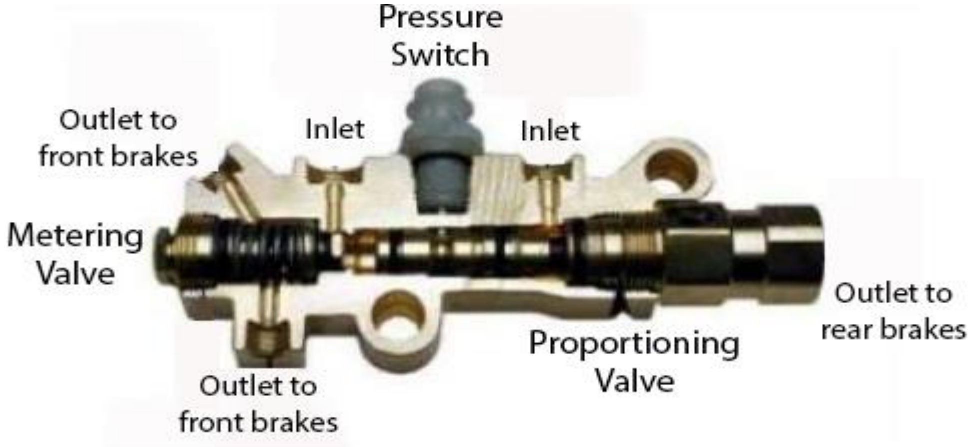


Figure 1: 10 Combination Valve

1.7.6 Wheel Cylinder

The wheel cylinder consists of a cylinder that has two pistons, one on each side. Each piston has a rubber seal and a shaft that connects the piston with a brake shoe. When brake pressure is applied, the pistons are forced out pushing the shoes into contact with the drum. Wheel cylinders must be rebuilt or replaced if they show signs of leaking.

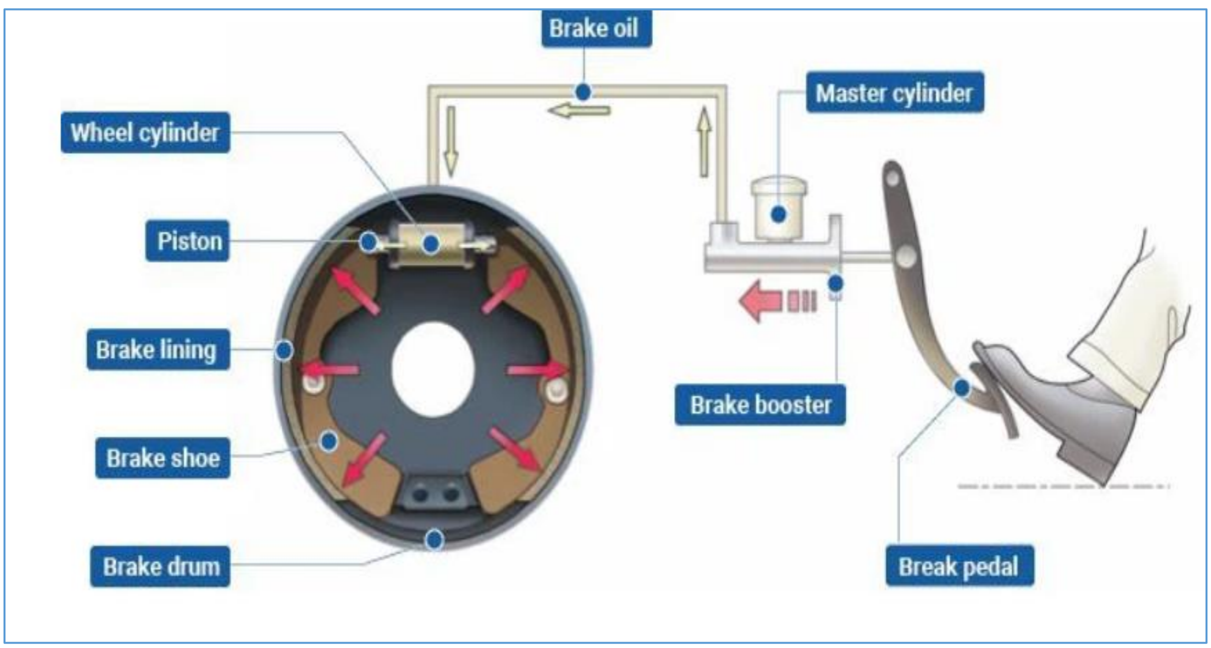


Figure 1: 11 Wheel Cylinder Application

1.7.7 Drum Brakes

A drum brake is a brake that uses friction caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum. The term drum brake usually means a brake in which shoes press on the inner surface of the drum. When shoes press on the outside of the drum, it is usually called a clasp brake.

Where the drum is pinched between two shoes, similar to a conventional disc brake, it is sometimes called a pinch drum brake, though such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum.

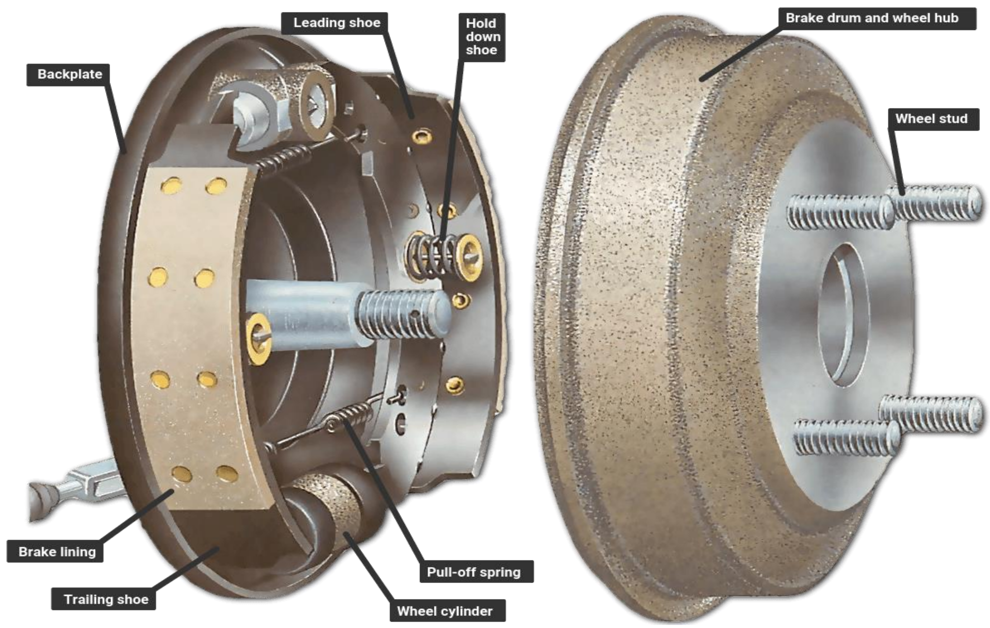


Figure 1: 12 Drum Brake Construction

I. Types of Drum Brake

Generally, there are three types of drum brake,

a) Leading trailing shoe drum brake In this type, the forward shoe is held stationary at the bottom and pushed against the drum by the wheel cylinder at the top. As the drum rotates, this leading shoe is pulled tighter into the drum and tends to rotate with the drum.

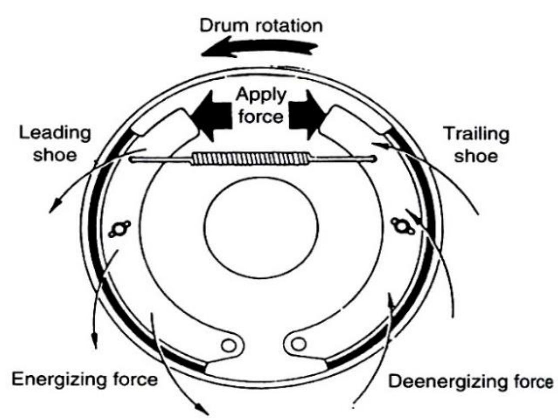


Figure 1: 13 Leading Trailing Shoe Drum Brake

b) Two leading shoe drum brake

This system is arranged with two single-acting wheel cylinder instead of a one double-acting cylinder as leading trailing and duo servo types. The effect of this is to produce a wedging action in both the front and rear shoes. Each cylinder forces one end of its shoe outwards and a self-energizing effect is imported to each shoe due to drum rotation. Thus both shoes provide equal breaking with a force greater than that, which could be applied by normal means.

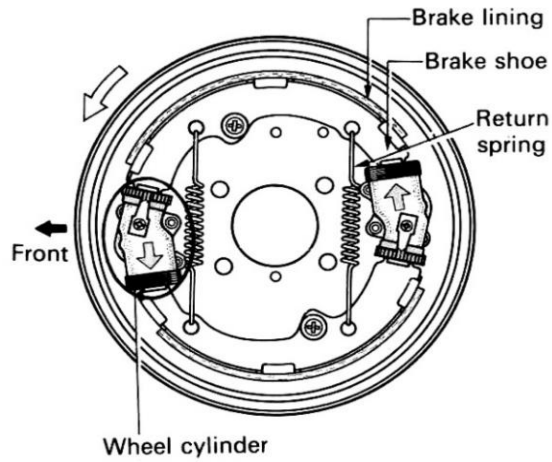


Figure 1: 14 Two Leading Shoe Drum Brake

c) Duo Servo Drum Brake

The tops of the shoes rest against a single anchor pin. The bottoms of the shoes are linked together by a floating adjusting screw. The shoe towards the front of the vehicle is the primary shoe. The shoe toward the rear is the secondary shoe. The primary shoe normally has shorter lining than the secondary shoe. When the shoes contact the rotating drum, the friction causes both shoes to try to rotate with the drum. The top of the primary shoe tends to pull into the drum and move downward. The bottom of the shoe then pushes the adjusting screws rearward. This forces the bottom of the secondary shoe against the drum that moves the secondary shoe upward against the anchor pin. Further drum rotation tends to pull both shoes more tightly into the drum. This further increases the self-energizing action of the secondary shoe.

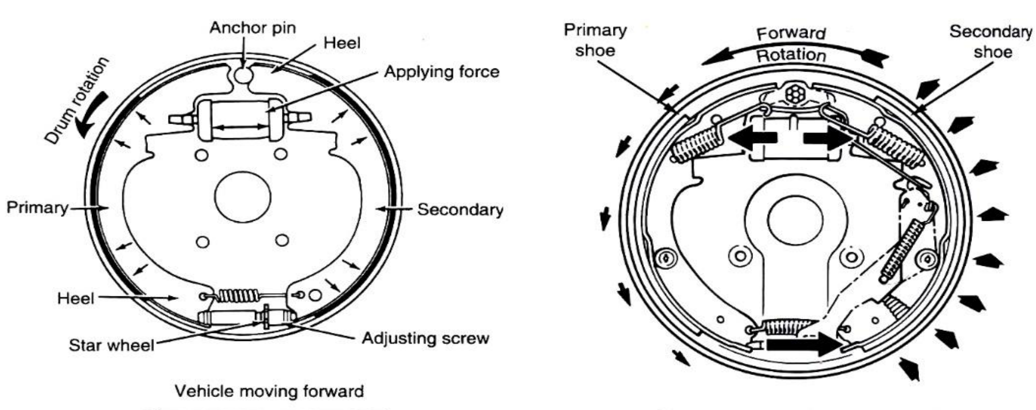


Figure 1: 15 Duo Servo Drum Brake

II. Component of Drum Brake

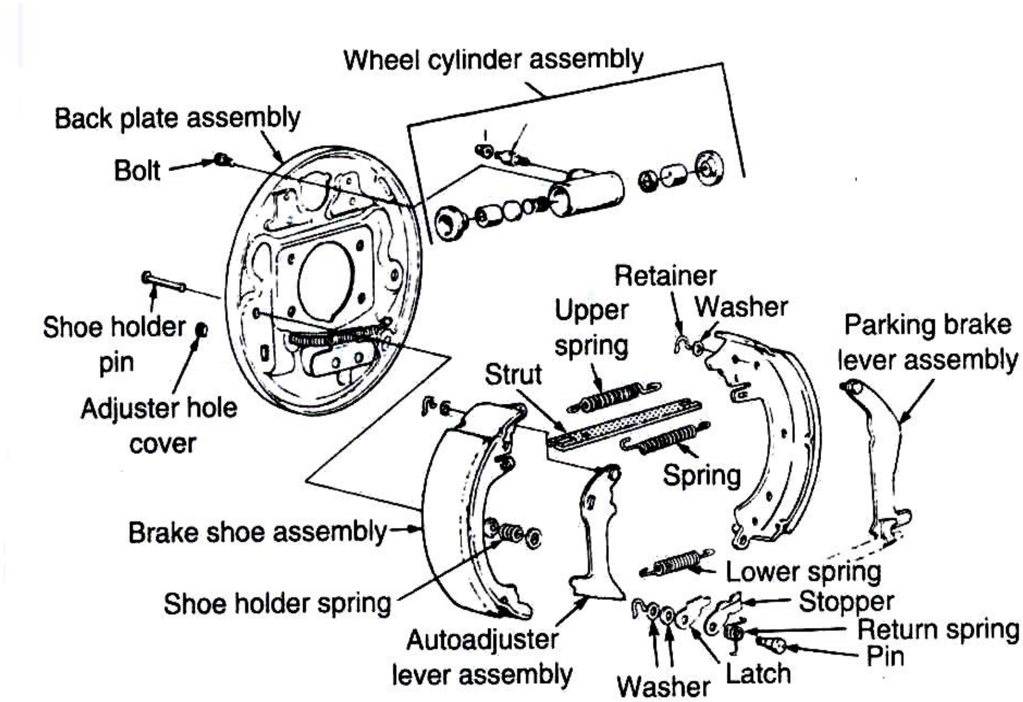


Figure 1: 16 Component of Drum Brake

a) Brake drum

It is rotates with the wheel of the vehicle and provides a braking surface against which the brake linings operate .The brake shoes are expanded inside the drum and so the drum must be capable of withstanding the force applied by the brake shoes without distorting .The brake drum must be capable of absorbing the heat produced by friction between the shoes to prevent excessively high temperatures developing in the brake assembly

Cast iron is the used for braking drum because it has the necessary properties which make it suitable for this purpose.

b) Backing Plate

The backing plate for the front brake is mounted to the steering knuckle and the backing plate for the rear brake is mounted to the axel flange. The backing plate carries all the stationary brake parts, which include the wheel cylinders, brakes shoes, return springs, retaining spring, anchor and adjuster .It is not only acts as a support for the brake shoes and associated parts, but also acts as a shield to exclude road dirt.

The backing plate is steel pressing which has its outer edge flanged to over the edge of the drum. .

c) Brake Linings

The brake shoes are shaped to fit the contour of the brake drum with which they are used .A shoe consists of the web and the flange .The web is provided to stiffen the flange. The flange is fitted with a lining of friction material, which is either riveted or bonded to it.

Most passenger cars and light commercial vehicles have bonded brake linings.

d) Brake springs

Springs are fitted to the brake shoes to locate the shoes on the backing plate. The return springs oppose the action of the brake shoes when the brakes are applied and return the shoes to their normal position when the brakes are released.

Retaining springs and clips are used to hold the brake shoes against the backing plate. Other springs are used to locate the shoes in position or to hold the ends of the return springs.

e) Anchors

Anchors are used to locate the ends of the shoes by providing an abutment against which the shoes can rest. Anchor pins are used to hold the ends of the return springs.

f) Adjusters

Various types of adjusters are used to adjust the working clearance between the brake shoes and the drum.

g) Wheel cylinders

The wheel cylinder is bolted to the backing plate. It forms an anchor for one end of the shoe and expands the shoes when the brakes are applied.

III. Operation of the Drum Brakes

G. Brakes not applied

Pistons inside the wheel cylinder are constantly pushed backward, via brake shoes, by the return spring. They are pushed back to the strut touches the shoes.

The compression spring in the wheel cylinder is fitted so that piston and shoes will contact each other at all time. This prevents unusual noise from the brakes.

H. Brakes applied

When the brake pedal is depressed, hydraulic presser inside the master cylinders, forces shoes apart so that they rub against the lining and stop the wheel rotation. The hydraulic pressure in the wheel cylinder also acts on the lips of the piston cup. It pushes the lips against the cylinder and prevents from leaking

1.7.8 Disc Brakes

Disc brake consists of two main parts: the disc, also called the rotor, and the caliper assembly. The disc rotates with the wheel hub. The caliper, which straddles the disc, is held stationary.

In front wheel brakes the caliper is bolted to the steering knuckle, in rear-wheel brakes the caliper is bolted to the axle flange. The caliper assembly includes a hydraulic cylinder, piston & the brake pads.

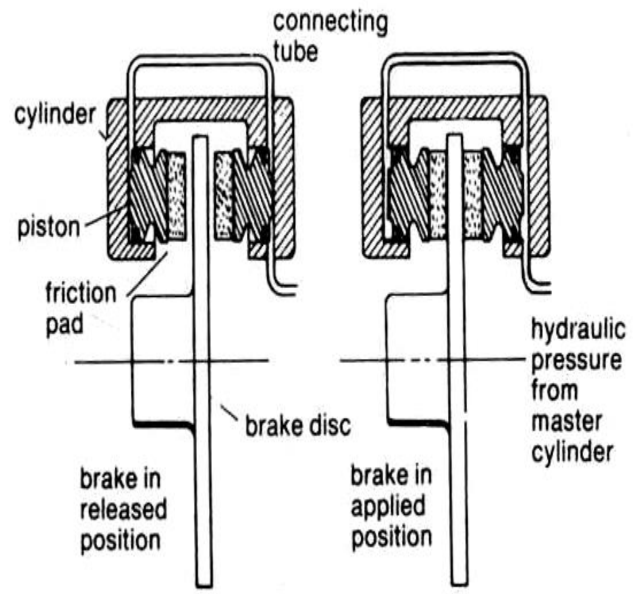


Figure 1: 17 Disc Brake Operation

The diagrams below show the principle of disc brake operation. With the brake in the released position, the pads are slightly clear of the disc, which rotates between them. When the brake is applied, pressure from the master cylinder forces the pistons against the pads, which are then forced against the disc. This produces a clamping action, which slows or stops the disc.

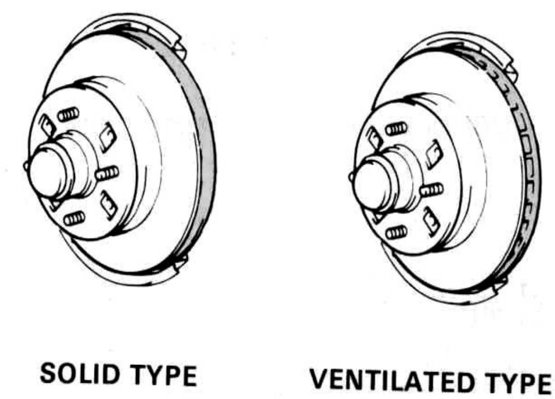


Figure 1: 18 Types of Disc

When the brake is released, the pistons retract slightly to allow the pads to move away from the disc. The pads have no return springs, but the pistons are returned slightly in their bores by the resilience of the piston seals. The small run out of the disc (around 0.05) moves the pads away from the disc surface to provide clearance and prevent wear.

I. Components of Disc Brake

a) Brake disc

Disc is made of cast iron, with a machined surface on each side against which the pads are applied. The disc is usually shaped to fit the wheel hub to which it is bolted. Some brakes use a ventilated disc. This is of hollow construction, consisting of two flanges separated by fins.

The rotating disc acts as a form of air pump to maintain a flow of air through the disc and so remove heat generated during braking.

b) Disc brake calipers

The typical disc brake caliper assembly has caliper housing, one or more pistons seal on each piston, a dust boot for each piston, and two brake pads.

The disc brake caliper may be fixed, sliding, or floating. The fixed caliper has piston on both sides of the caliper. The force of each piston is applied directly to a brake pad. The sliding and floating caliper designs use one piston, which acts to put apply force on the inside pad. The reaction force of the caliper applies the out-side pad.

c) Disc Pads

A disc pad consists of a steel backing plate with friction material bonded to it surface. The pad is positioned by guide lugs that fit into slots in the caliper or in the anchor plates. Ant rattle clips are fitted to lugs to prevent the pad from rattling in the slots when the brakes are released. A steel shim is often fitted between the back of the inner pad and the piston.

d) Caliper Pistons

Caliper pistons have the piston seal mounted stationary in the housing and the piston in the seal. This design requires a good piston surfaces finish for maximum seal life. Mounting the seal in this way produces the force to pull the released piston and pad away from the rotor to reduce drag. This design provides "self-adjustment" to automatically maintain the correct lining-to-rotor clearance.

e) Piston Seals

Most sliding and floating calipers have the piston seal mounted stationary in the housing and the piston moves in the seal. This design requires a good piston surface finish for maximum seal life. Mounting the seal in this way produces the force to pull the released piston and pad away from the rotor to reduce drag. This design provides "self-adjustment" to automatically maintain the correct lining-to-rotor clearance. Some fixed-caliper type has the seal mounted on the piston and the seal slides on the cylinder bore. The cylinder bore in these calipers must have a smooth surface finish for maximum seal life. The seal does not move the piston back into the cylinder on release.

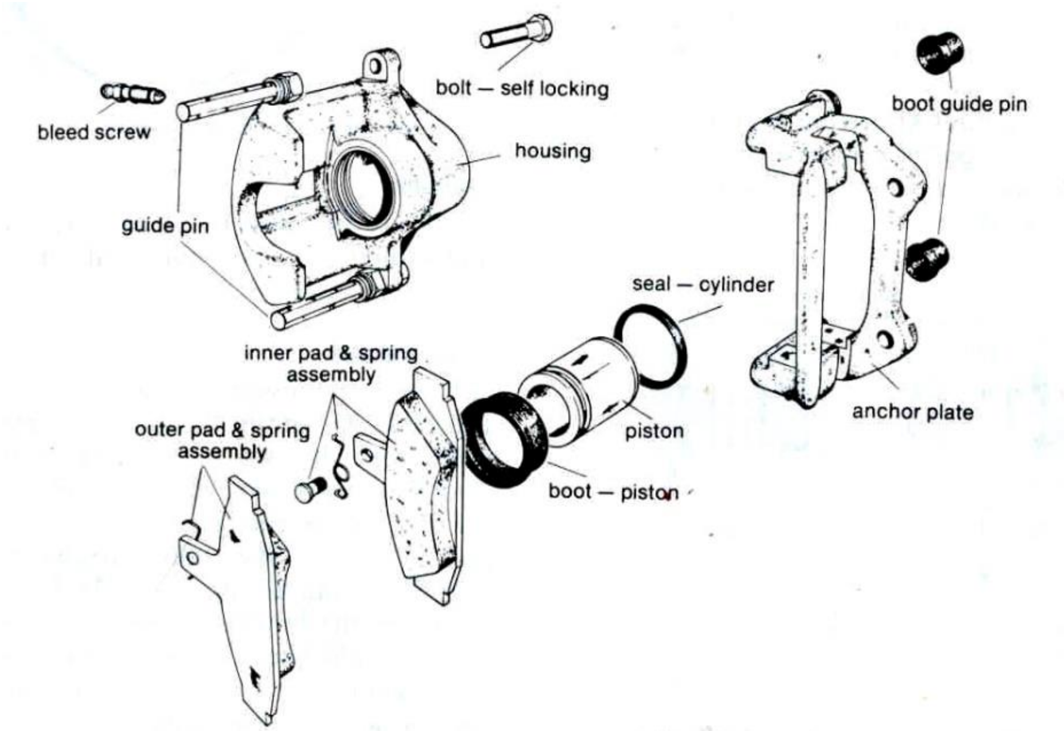


Figure 1: 19 Dismantled Disc brake

f) Pad Wear Indicator

When pad thickness is reduced the pad wear indicator, fixed to the backing plate of the pad, come into contact with the rotor disc and produces a screeching noise during driving.

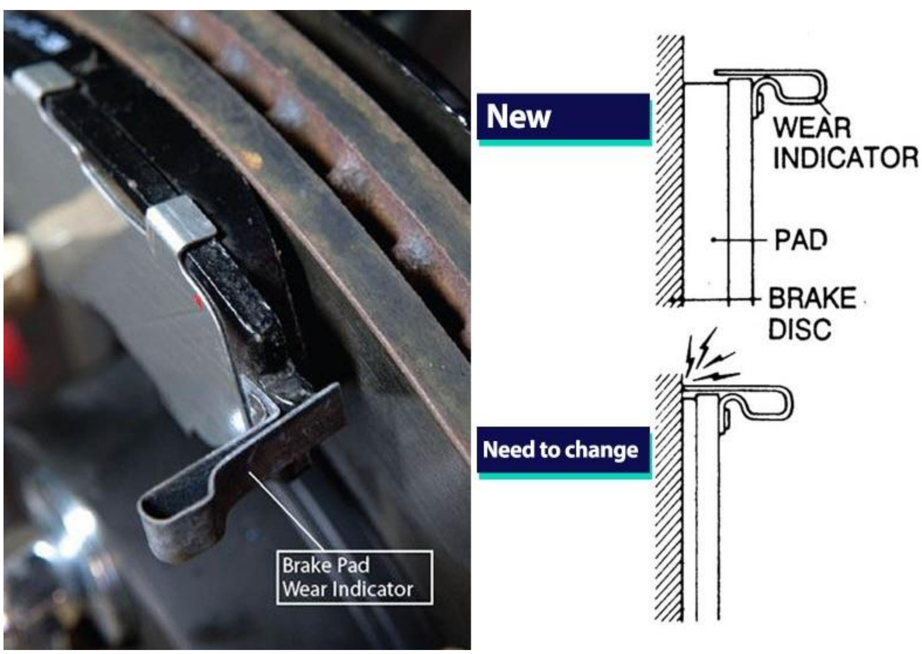


Figure 1: 20 Wear Indicator

II. Types of Disc Brakes

There are three general types: Fixed-caliper, Sliding-caliper, and Floating-caliper.

a) Fixed-Caliper

The fixed caliper disc brake has piston on both sides of disc. Some fixed-caliper disc brakes have two pistons, one on each side. Other has four pistons two on each side. The caliper is rigidly attached to the stationary car parts. In operation, the two or four pistons are forced out ward from their caliper bores by hydraulic pressure. This causes the two shoes to move in against the rotating disc.

b) Floating-Caliper

The floating caliper, or swinging caliper can pivoted, or swinging in or out It is suspended from rubber bushings on - 3 - Created by Automotive Department bolts, Which give enough to permit. The caliper has either one or two piston.

In operation, hydraulic pressure from back of the piston forces the brake pad on the piston side against the rotating disc. This produces a reaction force against the caliper that causes the caliper to move inward slightly, so other side of the rotating disc. Now, braking action is the same as with the fixed-caliper type.

c) Sliding-Caliper

The principle of operation of a sliding caliper is the same as that of a floating caliper. The difference is in the method - 3 - Created by Automotive Department of attaching the caliper to the mounting bracket. The grooves (or the sliding surfaces) in the caliper and mounting bracket, are called ways. The caliper is held in the ways by a retaining key, a spring, and a lock screw. There is no sideward motion of the caliper when the brakes are applied.

The mounting bracket is bolted to the steering knuckle. The brake pads are held in the bracket whit two retaining pins. The cylinder housing is attached to the yoke, and the yoke is free to slide on the mounting bracket. When the brakes are applied, hydraulic pressure pushes against the piston in the cylinder housing. The piston pushes the inner brake pad against the inner sides of the rotor. The hydraulic pressure also pushes the cylinder housing inward to the center of the car. Because the yoke is attached to the cylinder housing, the yoke moves with the housing. This pushes the outer brake pad against the other side of the rotor.

1.7.9 Parking Brakes

The parking brake (emergency brake) system controls the rear brakes through a series of steel cables that are connected to either a hand lever or a foot pedal. The idea is that the system is fully mechanical and completely bypasses the hydraulic system so that the vehicle can be brought to a stop even if there is a total brake failure.

On drum brakes, the cable pulls on a lever mounted in the rear brake and is directly connected to the brake shoes. This has the effect of bypassing the wheel cylinder and controlling the brakes directly.

Disk brakes on the rear wheels add additional complication for parking brake systems. There are two main designs for adding a mechanical parking brake to rear disk brakes. The first type uses the existing rear wheel caliper and adds a lever attached to a mechanical corkscrew device inside the caliper piston. When the parking brake cable pulls on the lever, this corkscrew device pushes the piston against the pads, thereby bypassing the hydraulic system, to stop the vehicle. This type of system is primarily used with single piston floating calipers, if the caliper is of the four piston fixed type, then that type of system can't be used. The other system uses a complete mechanical drum brake unit mounted inside the rear rotor. The brake shoes on this system are connected to a lever that is pulled by the parking brake cable to activate the brakes. The brake "drum" is actually the inside part of the rear brake rotor.

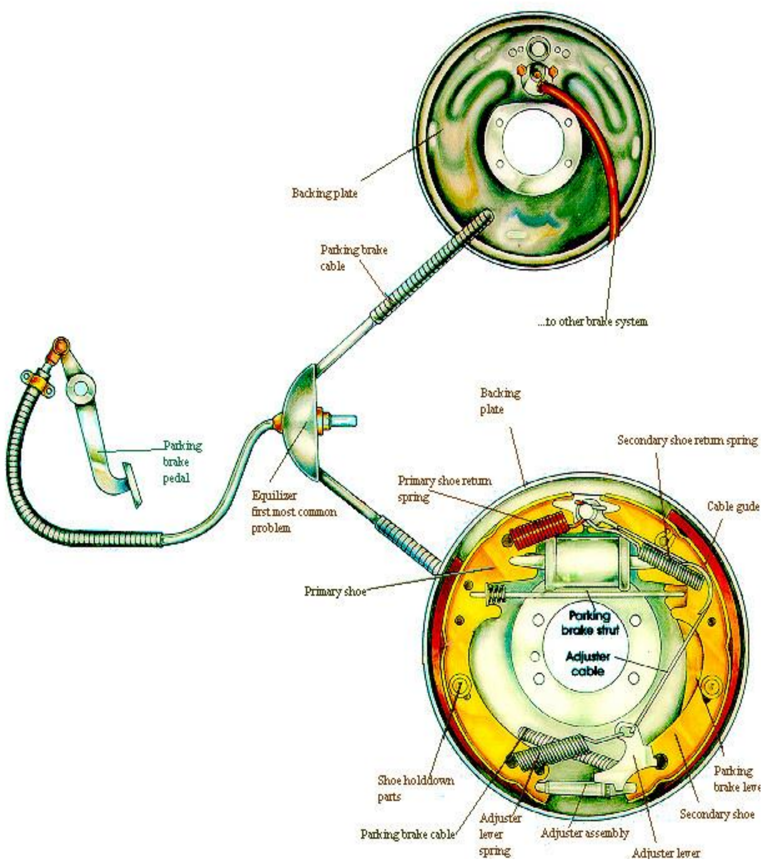


Figure 1: 21 Parking Brake Circuit

1.7.10 Brake Booster

The brake booster is mounted on the firewall directly behind the master cylinder and, along with the master cylinder, is directly connected with the brake pedal. Its purpose is to amplify the available foot pressure applied to the brake pedal so that the amount of foot pressure required to stop even the largest vehicle is minimal. Power for the booster comes from engine vacuum. The automobile engine produces vacuum as a by-product of normal operation and is freely available for use in powering accessories such as the power brake booster. Vacuum enters the booster through a check valve on the booster.

The check valve is connected to the engine with a rubber hose and acts as a one-way valve that allows vacuum to enter the booster but does not let it escape. The booster is an empty shell that is divided into two chambers by a rubber diaphragm. There is a valve in the diaphragm that remains open while your foot is off the brake pedal so that vacuum is allowed to fill both chambers. When you step on the brake pedal, the valve in the diaphragm closes, separating the two chambers and another valve opens to allow air in the chamber on the brake pedal side. This is what provides the power assist.

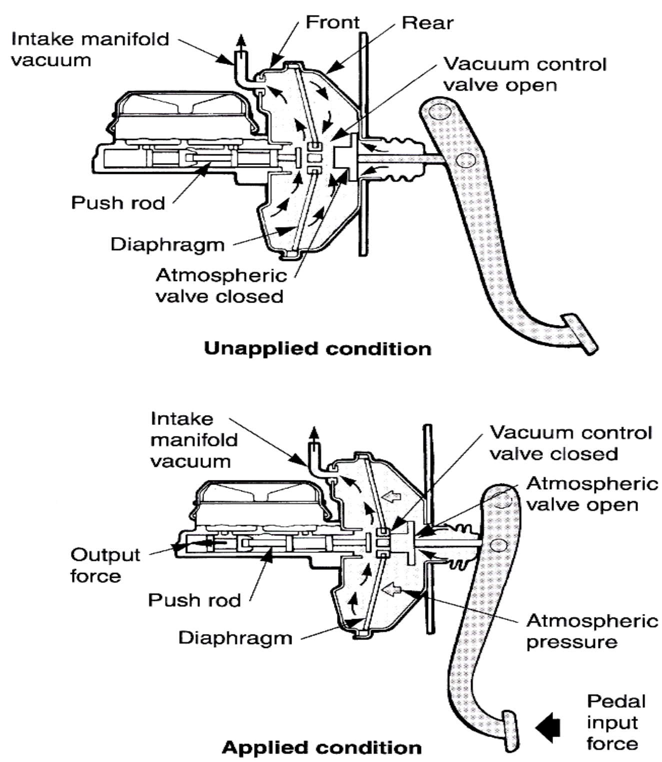


Figure 1: 22 Brake Booster Operation

Power boosters are very reliable and cause few problems of their own, however, other things can contribute to a loss of power assist. In order to have power assist, the engine must be running. If the engine stalls or shuts off while you are driving, you will have a small reserve of power assist for two or three pedal applications but, after that, the brakes will be extremely hard to apply and you must put as much pressure as you can to bring the vehicle to a stop.

Refer: https://www.youtube.com/watch?v=wbTUvp-tD5M

1.8 Brake Retarder

Retarder is a device used to augment or replace some of the functions of primary friction-based braking systems, usually on heavy vehicles.

Friction-based braking systems are susceptible to 'brake fade' when used extensively for continuous periods, which can be dangerous if braking performance drops below what is required to stop the vehicle – for instance if a truck or bus is descending a long decline. For this reason, such heavy vehicles are frequently fitted with a supplementary system that is not friction-based.

Retarders serve to slow vehicles, or maintain a steady speed on declines, and help prevent the vehicle 'running away' by accelerating down the decline because of the nature of the road(natural factor i.e. gravity) . They are not usually capable of bringing vehicles to a standstill, as their effectiveness diminishes as vehicle speed lowers.

They are usually used as an additional 'assistance' to slow vehicles, with the final braking done by a conventional friction braking system. As the friction brake will be used less, particularly at higher speeds, their service life is increased. There are four different types of retarders used on vehicles to assist the main brake system (service brake) driving downhill.

1.8.1 Engine Braking

Engine braking occurs when the retarding forces within an internal combustion engine are used to slow down a motor vehicle, as opposed to using additional external braking mechanisms such as friction brakes or magnetic brakes. The term is often confused with several other types of braking, most notably compression-release braking or "jake braking" which uses a different mechanism.

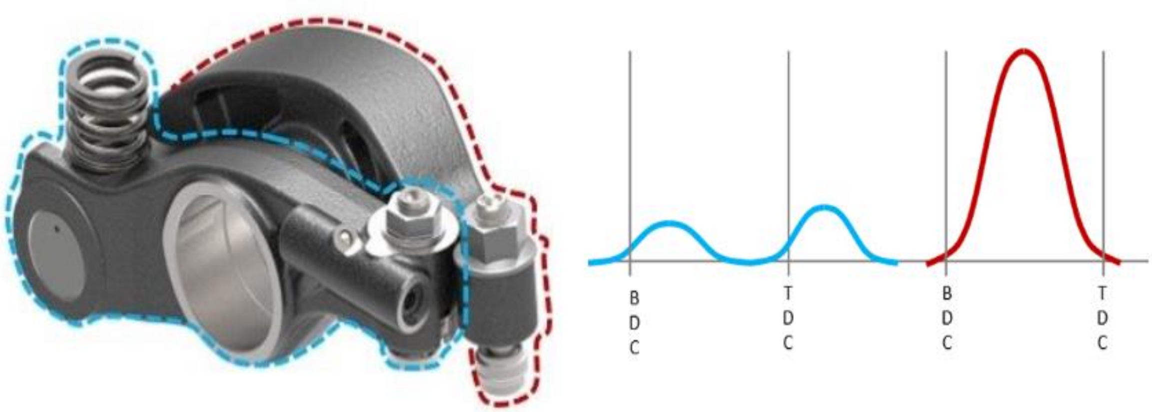


Figure 1: 23 Engine Braking

Traffic regulations in many countries require trucks to always drive with an engaged gear, which in turn provides a certain amount of engine braking (viscous losses to the engine oil and air pumped through the engine and friction losses to the cylinder walls and bearings) when no accelerator pedal is applied. (Refer https://www.eaton.com/us/en-us/catalog/engine-valvetrain/decompression-engine-brake.html#tab-1)

1.8.2 Exhaust Brake

An exhaust brake is a means of slowing a diesel engine by closing off the exhaust path from the engine, causing the exhaust gases to be compressed in the exhaust manifold, and in the cylinder. Since the exhaust is being compressed, and there is no fuel being applied, the engine slows down the vehicle. The amount of negative torque generated is usually directly proportional to the back pressure of the engine.

An exhaust brake is a device that essentially creates a major restriction in the exhaust system, and creates substantial exhaust back pressure to retard engine speed and offer some supplemental braking. In most cases, an exhaust brake is so effective that it can slow a heavily loaded vehicle on a downgrade without ever applying the vehicle's service brakes.

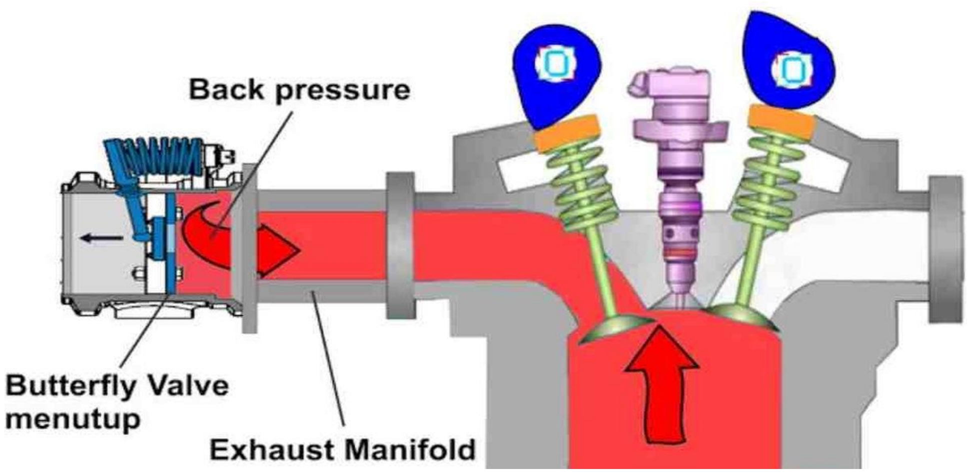


Figure 1: 24 Exhaust Brake

1.8.3 The Hydraulic Retarder

Hydraulic retarders use the viscous drag forces between dynamic and static vanes in a fluid-filled chamber to achieve retardation. There are several different types which can use standard transmission fluid (gear oil), a separate oil supply.

A simple retarder uses vanes attached to a transmission driveshaft. They can also be driven separately via gears of a driveshaft. The vanes are enclosed in a static chamber with small clearances to the chamber's walls (which will also be vaned), as in an automatic transmission.

When retardation is required, fluid is pumped into the chamber, and the viscous drag induced will slow the vehicle. The working fluid will heat, and is usually circulated through a cooling system. The degree of retardation can be varied by adjusting the fill level of the chamber.
Hydraulic retarders are extremely quiet, often inaudible over the sound of a running engine, and are especially quiet in operation compared to engine brakes.
Refer https://www.youtube.com/watch?v=bXai8z99lUg

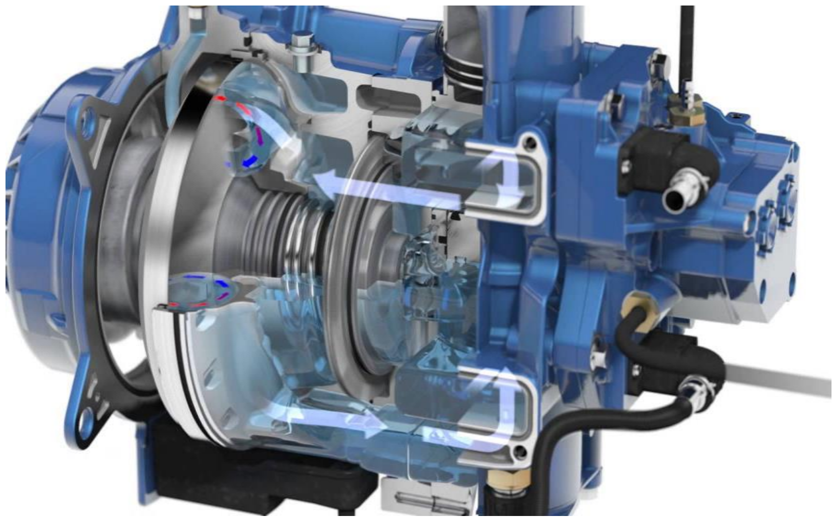


Figure 1: 25 Hydraulic Retarder

1.8.4 Electrical Retarder

The electric retarder uses electromagnetic induction to provide a retardation force. An electric retardation unit can be placed on an axle, transmission, or driveline and consists of a rotor attached to the axle, transmission, or driveline - and a stator securely attached to the vehicle chassis. There are no contact surfaces between the rotor and stator, and no working fluid. When retardation is required, the electrical windings in the stator receive power from the vehicle battery, producing a magnetic field through which the rotor moves.
This induces eddy currents in the rotor, which produces an opposing magnetic field to the stator. The opposing magnetic fields slows the rotor, and hence the axle, transmission or driveshaft to which it is attached. The rotor incorporates internal vanes (like a ventilated brake disk) to provide its own air cooling, so no load is placed on the vehicle's engine cooling system. The operation of the system is extremely quiet.
(Refer https://www.youtube.com/watch?v=5FMoUEmSsdE)
TELMA is the most known types of electrical braking. The TELMA is permanently connected to the drive shaft. The TELMA contains two rotating discs called rotors and a

stationary component called the stator. The rotors rotate at the same speed as the drive shaft. The stator is mounted between the two rotors and has eight coils.

When the TELMA is activated, current flows through the coils which induces a magnetic field that passes through the rotors. This magnetic field produces "eddy currents" within the rotors which slows the motion of the drive shaft, thus decelerating the vehicle. There is no physical contact (friction) within the TELMA and, therefore, no wear. The system is configured so that it will be applied gradually in four stages. The four stages reflect 25%, 50%, 75% and 100% of TELMA power that is applied. The system is air-cooled. The heat generated by the rotors is dissipated directly to the air through the rotor vanes, therefore the system is said to be self-regulating (the heat absorbed equals the heat dissipated).

A list of specific retarders is noted below:

- **Chassis Mounted Units Driveline concept:** Retarder is installed between transmission and axle by means of independent brackets.
- **Transmission Concept**: Retarder is installed on the transmission with an adapter.
- **Axle Concept:** Retarder is being installed on the differential of the axle with an adapter.

Figure 1: 26 Types of TELMA Retarder

1.9 Antilock Brake System

The most efficient braking pressure takes place just before each wheel locks up. When you slam on the brakes in a panic stop and the wheels lock up, causing a screeching sound and leaving strips of rubber on the pavement, you do not stop the vehicle nearly as short as it is capable of stopping. Also, while the wheels are locked up, you lose all steering control so that, if you have an opportunity to steer around the obstacle, you will not be able to do so. Another problem occurs during an extended skid is that you will burn a patch of rubber off the tire which causes a "flat spot" on the tread that will produce an annoying thumping sound as you drive. Refer: https://www.youtube.com/watch?v=98DXe3uKwfc&t=132s

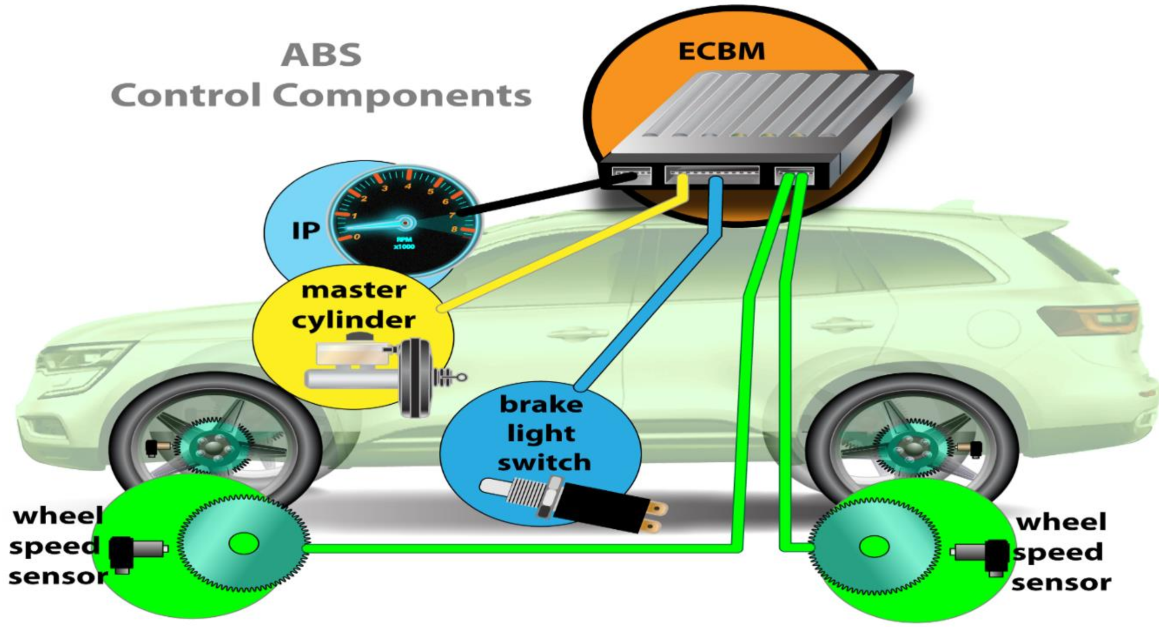


Figure 1: 27 ABS System Component

Anti-lock brake systems solve this lockup problem by rapidly pumping the brakes whenever the system detects a wheel that is locked up. In most cases, only the wheel that is locked will be pumped, while full braking pressure stays available to the other wheels. This effect allows you to stop in the shortest amount of time while maintaining full steering control. The system uses a computer to monitor the speed of each wheel. When it detects that one or more wheels have stopped or are turning much slower than the remaining wheels, the computer sends a signal to momentarily remove and reapply or pulse the pressure to the affected wheels to allow them to continue turning.

The system consists of an electronic control unit, a hydraulic actuator, and wheel speed sensors at each wheel. If the control unit detects a malfunction in the system, it will illuminate an ABS warning light on the dash to let you know that there is a problem.

During hard braking conditions, it is possible for the wheels of a vehicle to lock, resulting in reduced steering as well as braking. On the vehicles equipped with the Anti-Lock Braking System, however, an electronic sensor constantly monitors wheel rotation. If one or more of the wheels begins to lock, the system opens and closes solenoid valves, cycling up to 10 times per second. This releases and re-applies the brakes rapidly and repeatedly, to control brake pressure to maintain directional stability and steer ability during braking.

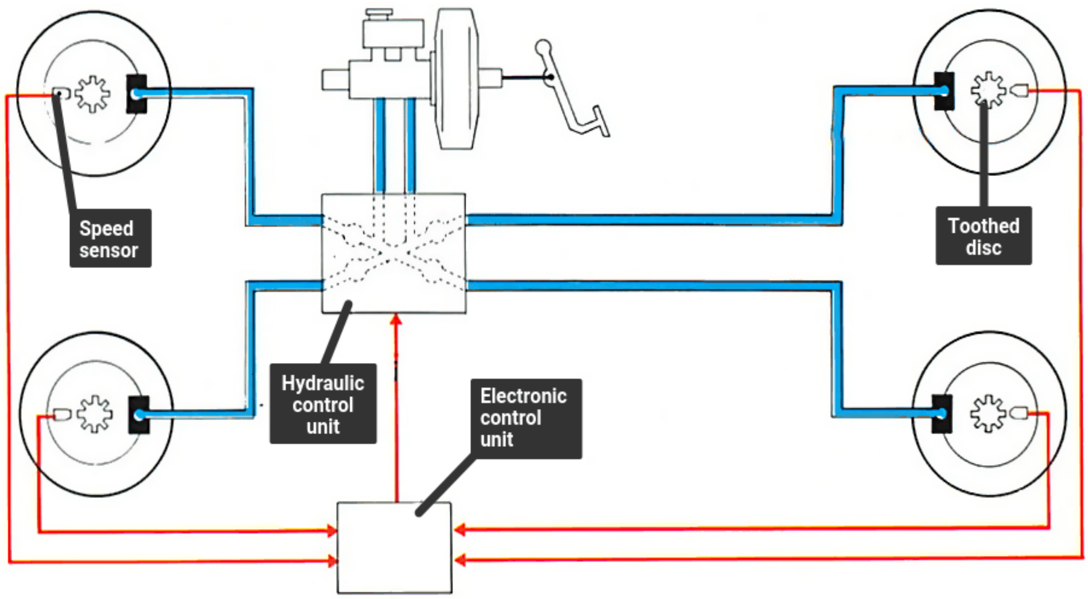


Figure 1: 28 Antilock Brake Systems Operation

1.9.1 ABS Components

A. Wheel-Speed Sensor

The wheel-speed sensors for the front and rear wheels are installed on the knuckles. These produce electrical pulses by monitoring the rotation of the sensor rotor installed on the wheel hub.

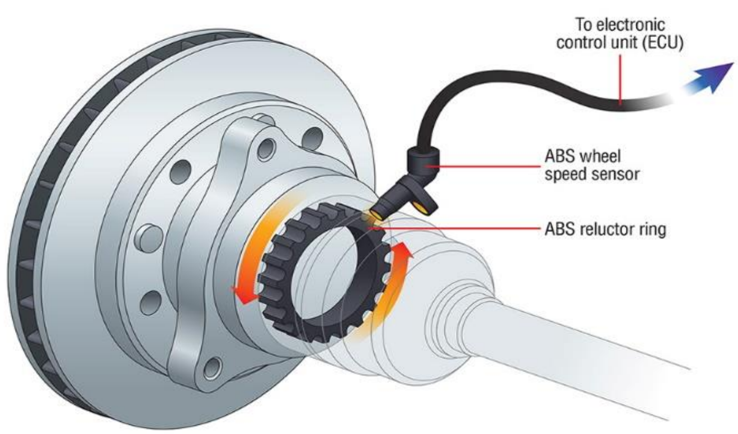


Figure 1: 29 Wheel Speed Sensor

B. Hydraulic Unit

The solenoid valves in the hydraulic unit are controlled by the control unit and operate the control pistons. The movement of these four control pistons control the hydraulic pressure in the wheel cylinders.

The hydraulic unit has six solenoid valves which operate the S-channel system. Two of these valves are for individual front wheel control and the other valve is for pressure regulation of the rear brake circuit. Proportioning valves are incorporated in the rear brake hydraulic circuit within the hydraulic unit for front to rear pressure bias during normal braking. The hydraulic unit contains its own brake fluid for operation. The fluid in the hydraulic unit and the brake hydraulic circuit is completely separate.

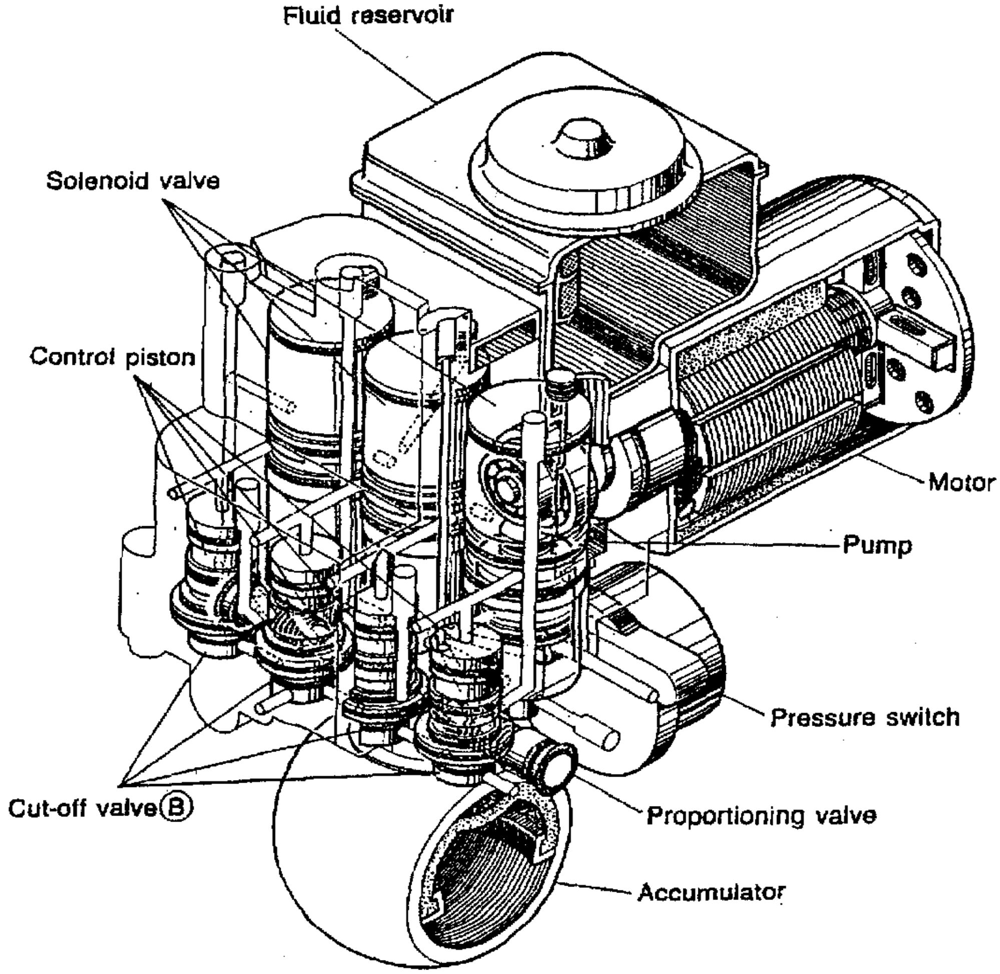


Figure 1: 30 Hydraulic Unit

C. Control Unit

The control unit tar ABS mounted under the front seat calculates wheel speeds and calculates de-acceleration of the wheels based on signals from the wheel-speed sensors.

Figure 1: 31 Control Unit

D. Fail-Safe Function

If the control unit detects an ABS malfunction, the warning light comes ON to warn the driver, and the system reverts to normal braking (no ABS) by operation of the fail-safe relay in the relay box.

E. Self-Diagnosis Function

If the control unit detects an ABS malfunction, it stores it in its memory by using the check connector, failures can be diagnosed with the ABS warning light and a voltmeter or a suitable diagnostic tester all failures are stored in the memory of the control unit and are not erased when the ignition switch is turned OFF.

F. Relay Box

The relay box, mounted in the engine compartment, has the following functions:

G. Motor Relay

Closes the pump motor circuit to build up hydraulic pressure in the hydraulic unit.

H. Fail-Safe Relay

Supplies the solenoids and motor relay with electrical power under normal conditions. Cuts power to ABS system if failure occurs, and assures normal brake operation.

1.9.2 Advantages of Anti-Lock Brake System

- During straight-ahead travel on a slippery road surface (low-friction coefficient) on one side.

- **Without ABS**

  When the brakes are applied during straight-ahead travel, the wheels on the slippery surface lock and the front of the vehicle veers toward the side of the road with the highest friction coefficient, thus causing a spin.

- **With ABS**

  Because the braking force is controlled in such a way that the wheels do not lock when the brakes are applied the vehicle does not spin during braking and, as an added benefit, the braking distance is usually shortened.

- During a turn on a slippery road surface (low-friction coefficient)
  - **Without ABS**

    When the brakes are applied suddenly, the wheels lock and the vehicle veers in the direction of the turn, thus resulting in a spin.

  - **With ABS**

    Because the braking tome is controlled in such a way that the wheels do not lock, steering performance is maintained and the vehicle can be driven around the turn.

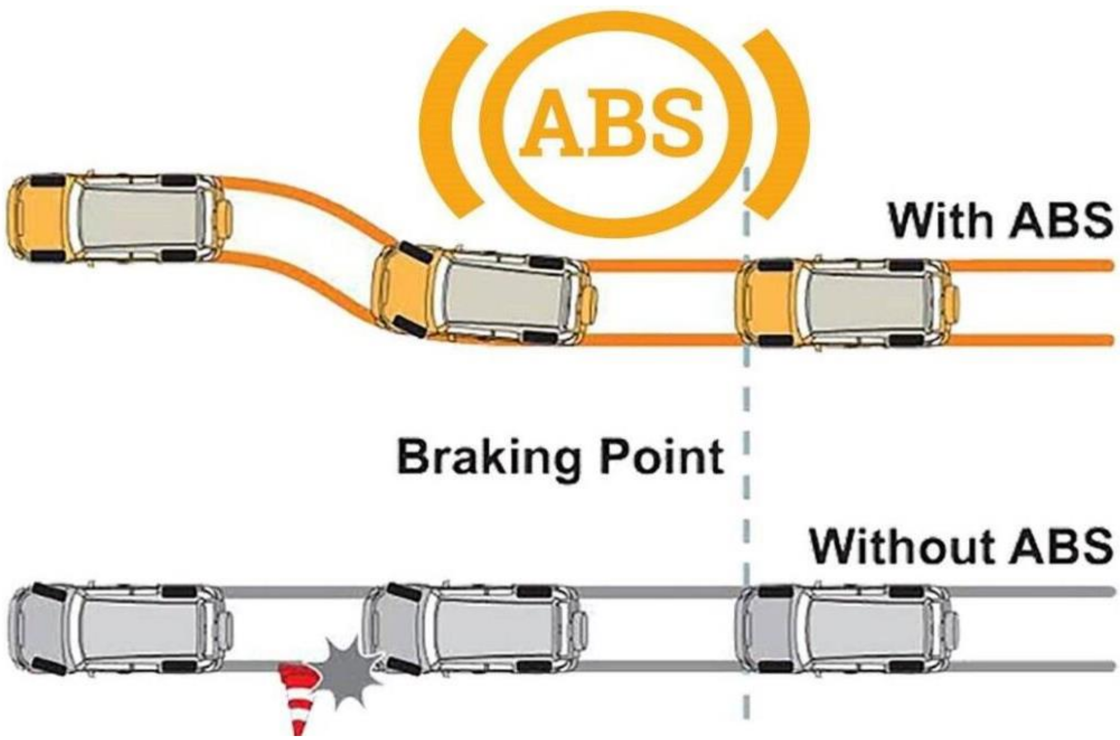


Figure 1: 32 With and Without ABS

System Diagram

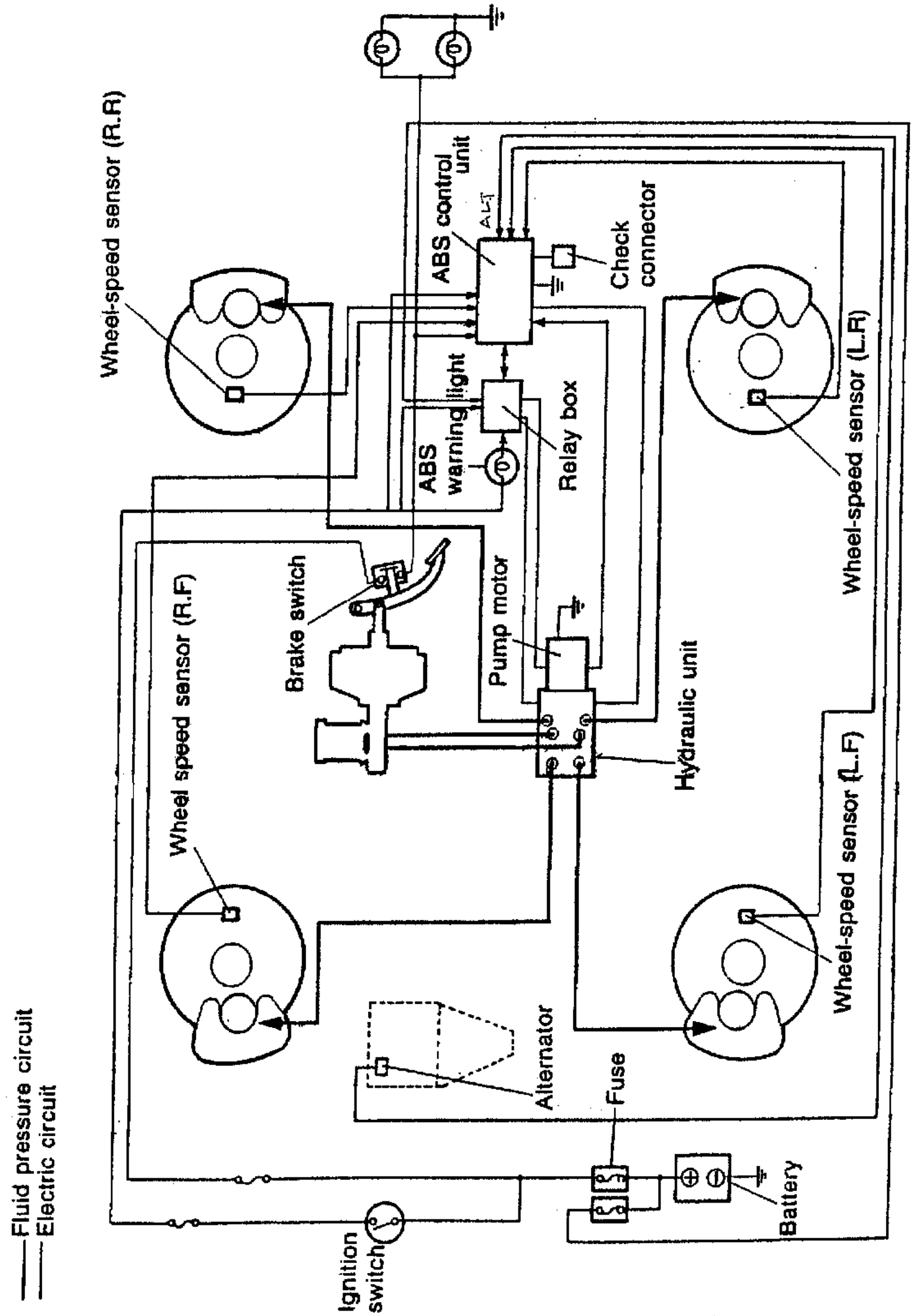


Figure 1: 33 System Diagram

Hydraulic System Diagram

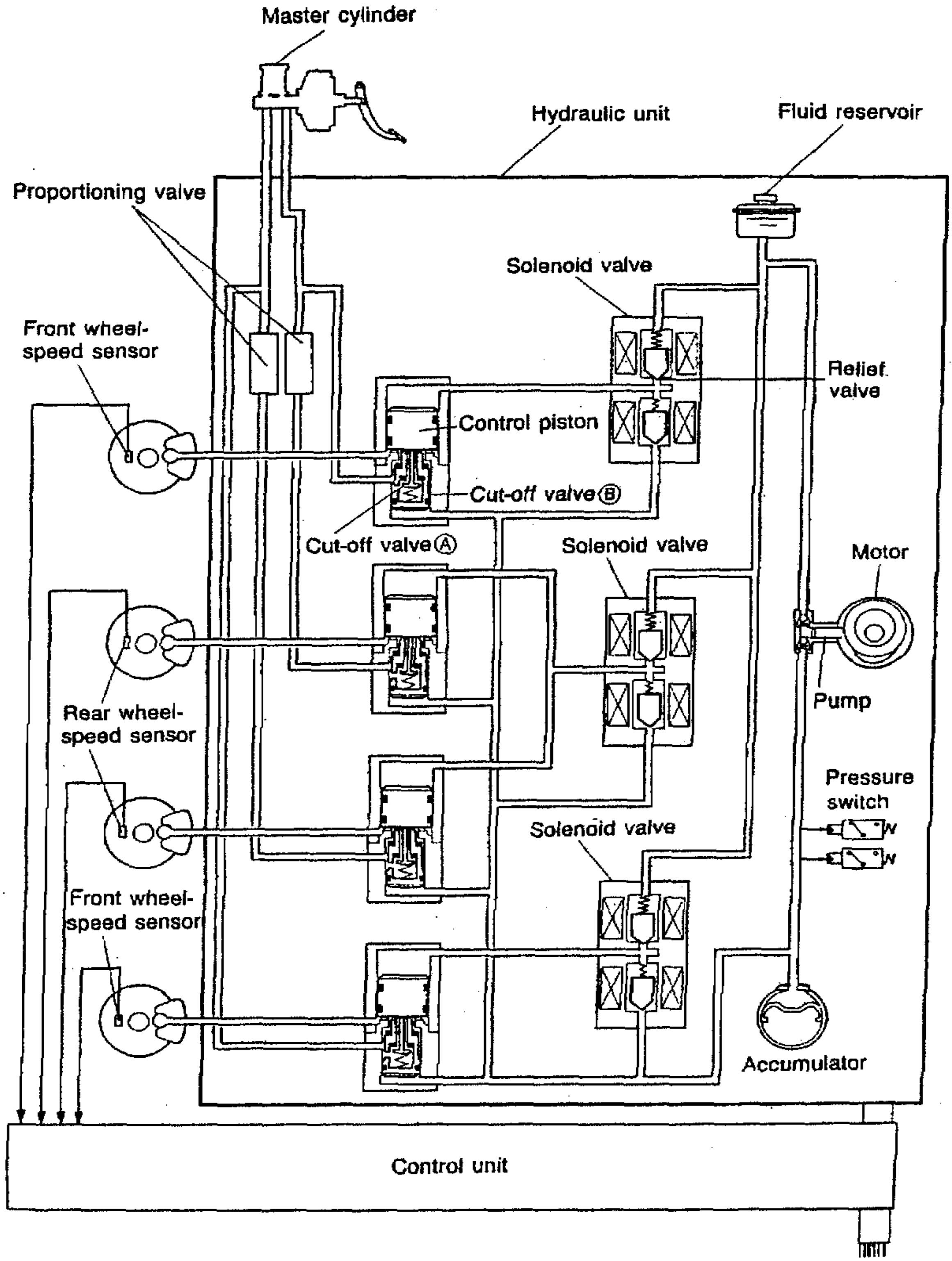


Figure 1: 34 Hydraulic System Diagram

Electrical System

Electrical system for ABS consists of the control unit, wheel speed sensors, brake light switch, relay box, hydraulic unit, and warning light, and wire harnesses.

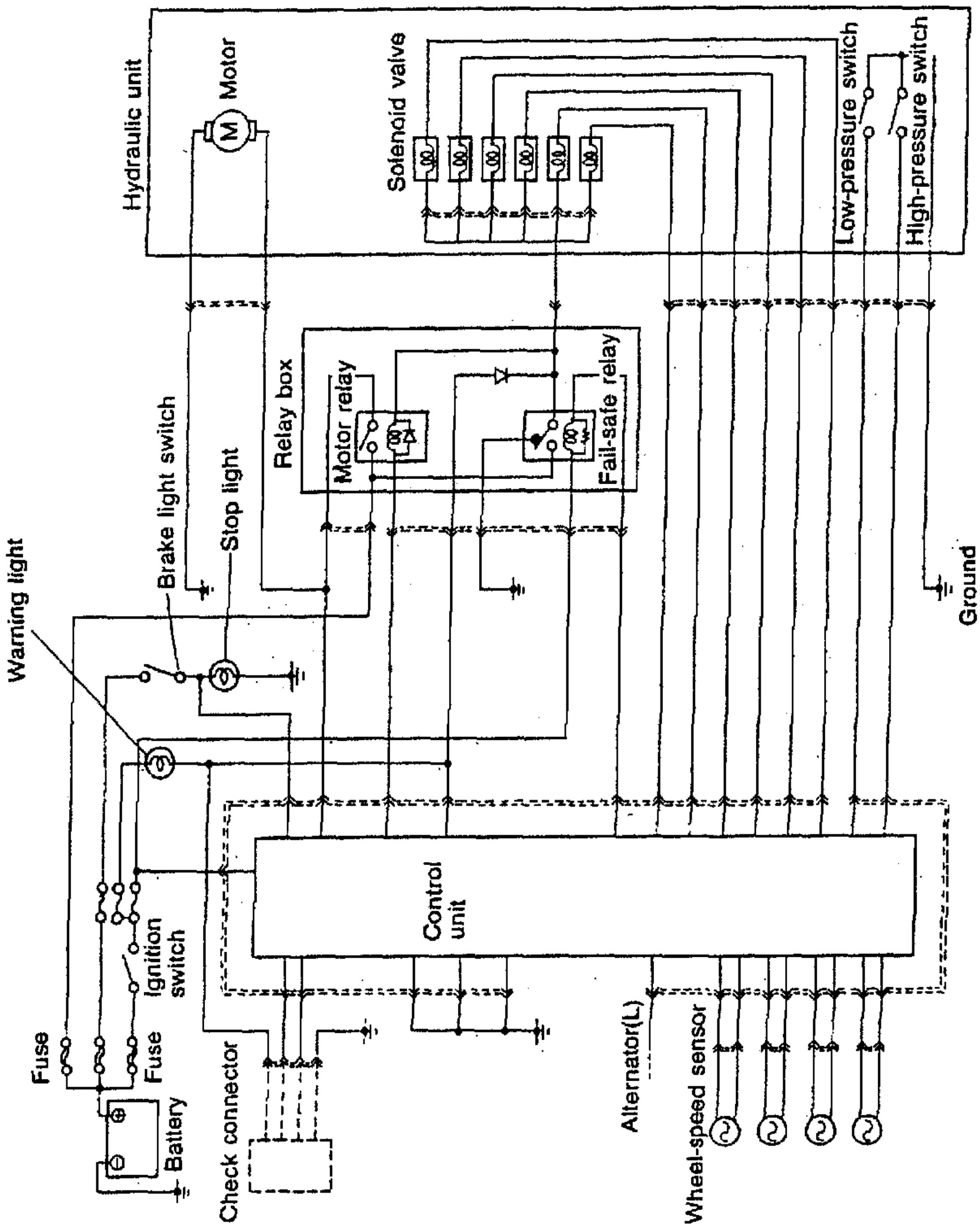


Figure 1: 35 Electrical System

1.9.3 Types of ABS

A. Integral systems

The exact manner in which hydraulic pressure is controlled depends on the ABS design. A great majority of the earlier ABSs were integrated or integral systems. They combine the master cylinder, hydraulic booster, and ABS hydraulic circuitry into a single hydraulic assembly.

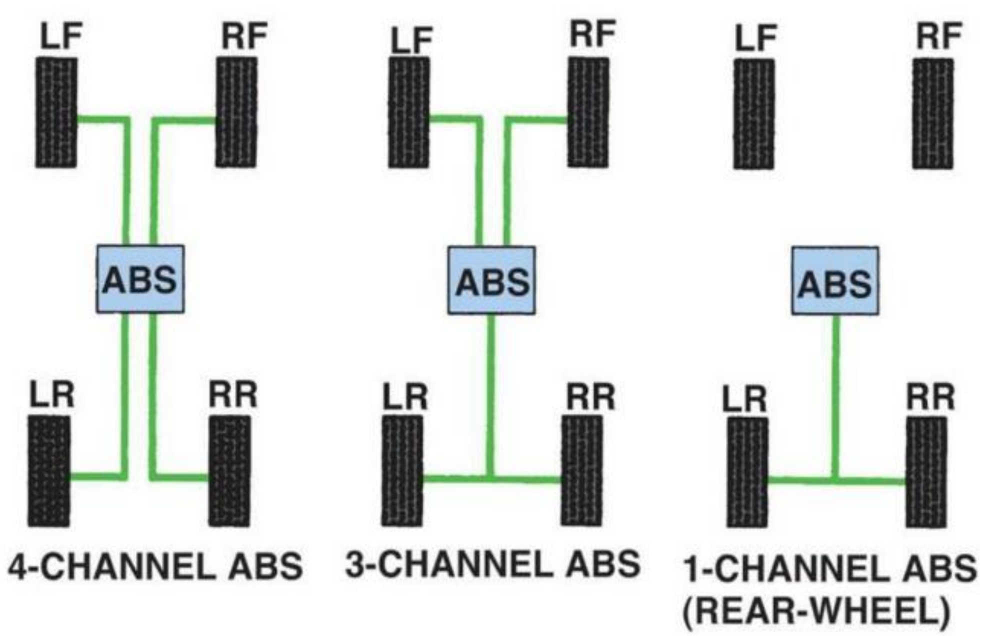
B. Non integral system

Nearly all of today's systems are no integral. They use a conventional vacuum-assist booster and master cylinder. The ABS hydraulic control unit is a separate mechanism. In some nonintegrated systems, the master cylinder supplies brake fluid to the hydraulic unit. Although the hydraulic unit is a separate assembly, it still uses a high-pressure pump/motor, an accumulator, and fast-acting solenoid valves to control hydraulic pressure to the wheels both integral and non-integral systems operate in much the same way; therefore, an understanding of one system will lend itself to the understanding of the other systems. Vacuum power booster and master brake cylinder. But it does not use a high-pressure pump/motor, an accumulator, and fast-acting solenoid valves to control hydraulic pressure. Instead, it uses motors in a hydraulic modulator. In addition to being classified as integral and non-integral ABSs, systems can be broken down into the level of control they provide.

1.9.4 ABS channels

Different schemes of anti-lock braking system use depending upon the types of brakes use. Depending upon the channel (valve) and number of speed sensors the antilock brake are classified

- **Four-channel. Four-sensor ABS**: - This is the best scheme, there is speed sensor and a separated valve for all the four wheels.
- **Three-channel. Three-sensor ABS:** - This scheme is the commonly found on pickup trucks with four wheels ABS has a speed sensor and valve for each of the front wheel with one for both rear wheels.
- **One-channel, One-sensor ABS:** - it has one valve which controls both rear wheels and one speed sensor located in the rear axle.



1.9.5 Operating principles of ABS

Modern antilock brake systems can be thought of as electronic/hydraulic pumping of the brakes for straight-line stopping under panic conditions. Good drivers have always pumped the brake pedal during panic stops to avoid wheel lockup and the loss of steering control. Antilock brake systems simply get the pumping job done much faster and in a much more precise manner than the fastest human foot. Keep in mind that a tire on the verge of slipping produces more friction with respect to the road than one that is locked and skidding. Once a tire loses its grip, friction is reduced and the vehicle takes longer to stop.

When compared to the electronic systems required to manage a transmission or an engine, an ABS is simple. An input circuit is used so that ABS can monitor individual wheel speeds under braking. The wheel sensors use a pulse generator principle. This consists of a toothed ring located at the axle ends (on the wheel assembly) or within the axle. The analog alternating current (AC) voltage output from these sensors is transmitted to an ECU. The ECU ignores the voltage value and, instead, uses the AC frequency to determine wheel speed.

When a vehicle is being driven at a constant speed, the speed of the vehicle and that of the wheels are the same (in other words, the tires are not skidding). However, when the driver steps on the brake pedal in order to slow the vehicle, the speed of the wheels gradually decreases and no longer matches the speed of the vehicle's body which is now traveling along under its own inertia. (That is, a small amount of slippage may occur between the tires and the road surface.)

The difference in ratio between the vehicle's body speed and the speed of the wheels is known as the „slip ratio."

The slip ratio can be determined by the following calculation

$$\text{Slip ratio} = \frac{\text{Vehicle speed} - \text{Wheel speed}}{\text{Vehicle speed}} \times 100\%$$

A slip ratio of 0% reflects a state in which the wheels are turning freely with no resistance. A slip ratio of 100% reflects a state in which the wheels are completely locked up and the tires are skidding along the road's surface. When the difference between the wheel speed and vehicle speed becomes too large, slipping occurs between the tires and the road surface. This also creates friction and may eventually act as a braking force and slow the speed of the vehicle, the range of 10 to 30% at all times. ABS is designed to utilize this slip ratio to maximize brake performance regardless of road conditions.

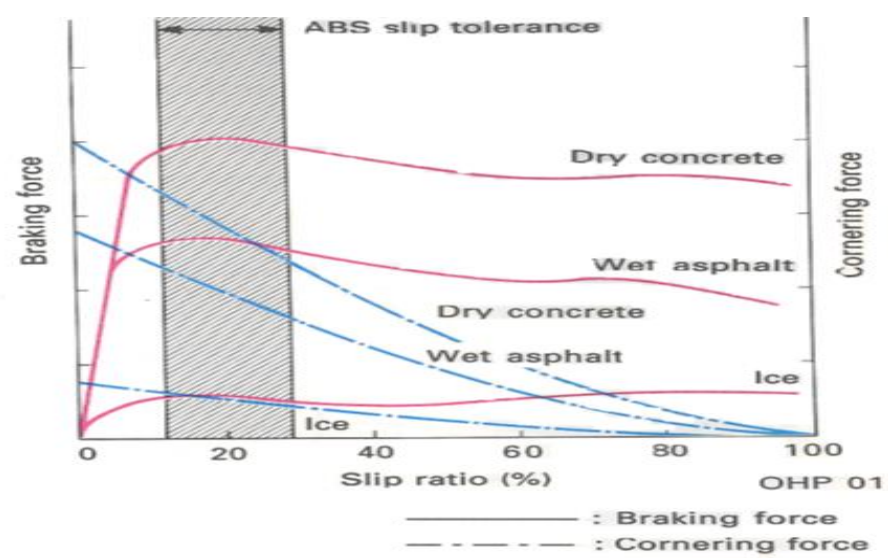


Figure 1.9 Frictional coefficient

NB. On rough roads, or on gravel or snow-covered roads, operation of the ABS may result in a longer stopping distance than for vehicles not fitted with an ABS.

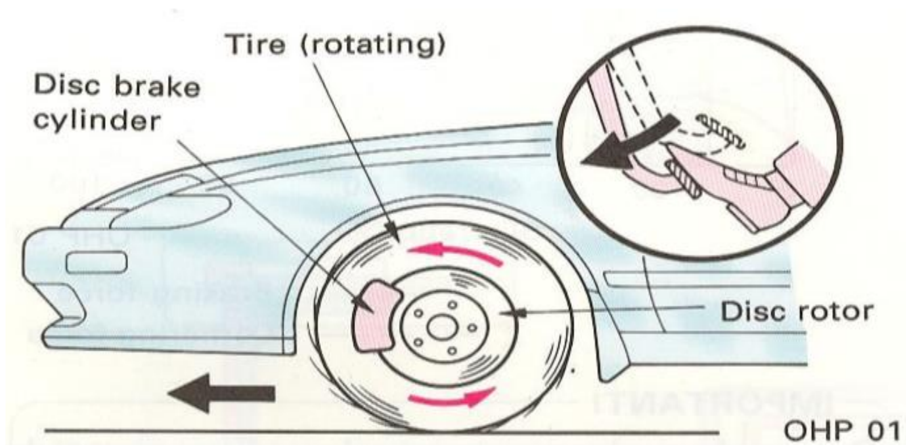
In a panic braking situation, the wheel speed sensors detect any sudden changes in wheel speed.

• The ABS ECU calculates the rotational speed of the wheels and the change in their speed, then calculates the vehicle speed from this. The ECU then instructs the actuators to provide the optimum hydraulic pressure to each brake.

• The brake hydraulic control units operate on commands from the ECU, reducing or increasing the hydraulic pressure, or holding the hydraulic pressure steady as necessary, in order to maintain the optimum slip ratio (10 to 30%) and avoid wheel lock-up

- **Case I**

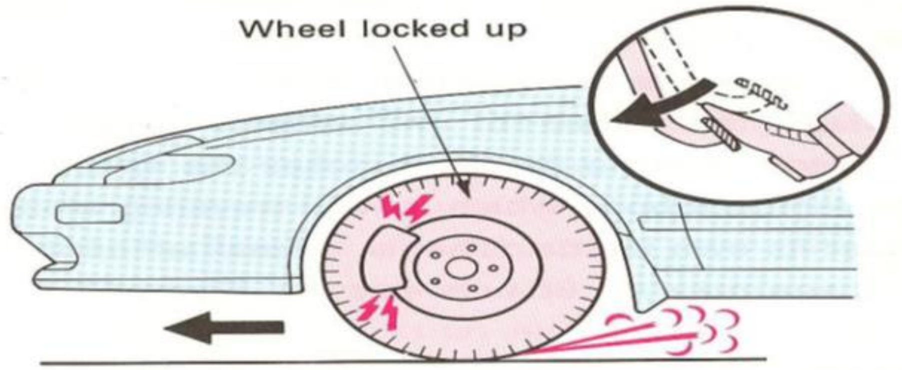
• Brake system resistance < Resistance between tires and road



Ordinary brakes work to slow or stop a vehicle by utilizing two types of resistance. These are the resistance between the brake pads and discs (or brake shoes and drums) and the resistance between the tires and the road surface. Braking can be controlled in a stable manner if the following relationship between the resistance in the brake system and the resistance between the road and tires exists.

- **Case II**

• Brake system resistance > Resistance between tires and road



As a result, if the front wheels lock up, it will become impossible to steer the car. If the rear wheels lock up, the differences in the coefficients of friction (μ) between the left and right sides on the road surface will cause a tire spin to occur. However, if this relationship is reversed, the tires will lock up and the vehicle will begin skidding

1.9.6 Modes of ABS

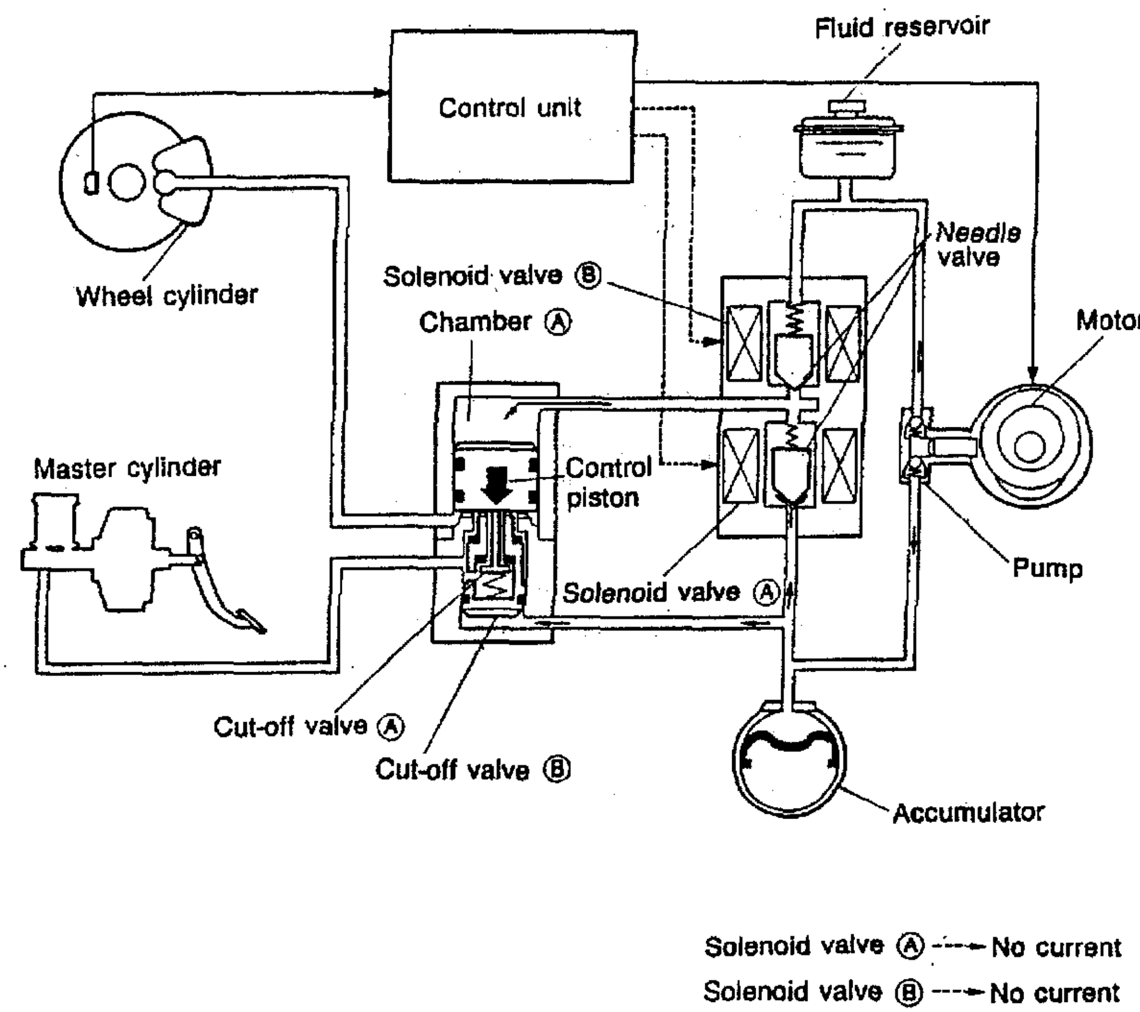
A. Normal Braking

During normal braking, there is no current flow to either solenoid valve A or B. Solenoid valve B needle valve is held closed by spring pressure and solenoid valve A needle valve is pushed open by accumulator pressure.

As a result, accumulator pressure passes through solenoid valve A and flows to chamber A; pushing the control piston downward. In addition, accumulator pressure also pushes against the bottom of cut-off valve B.

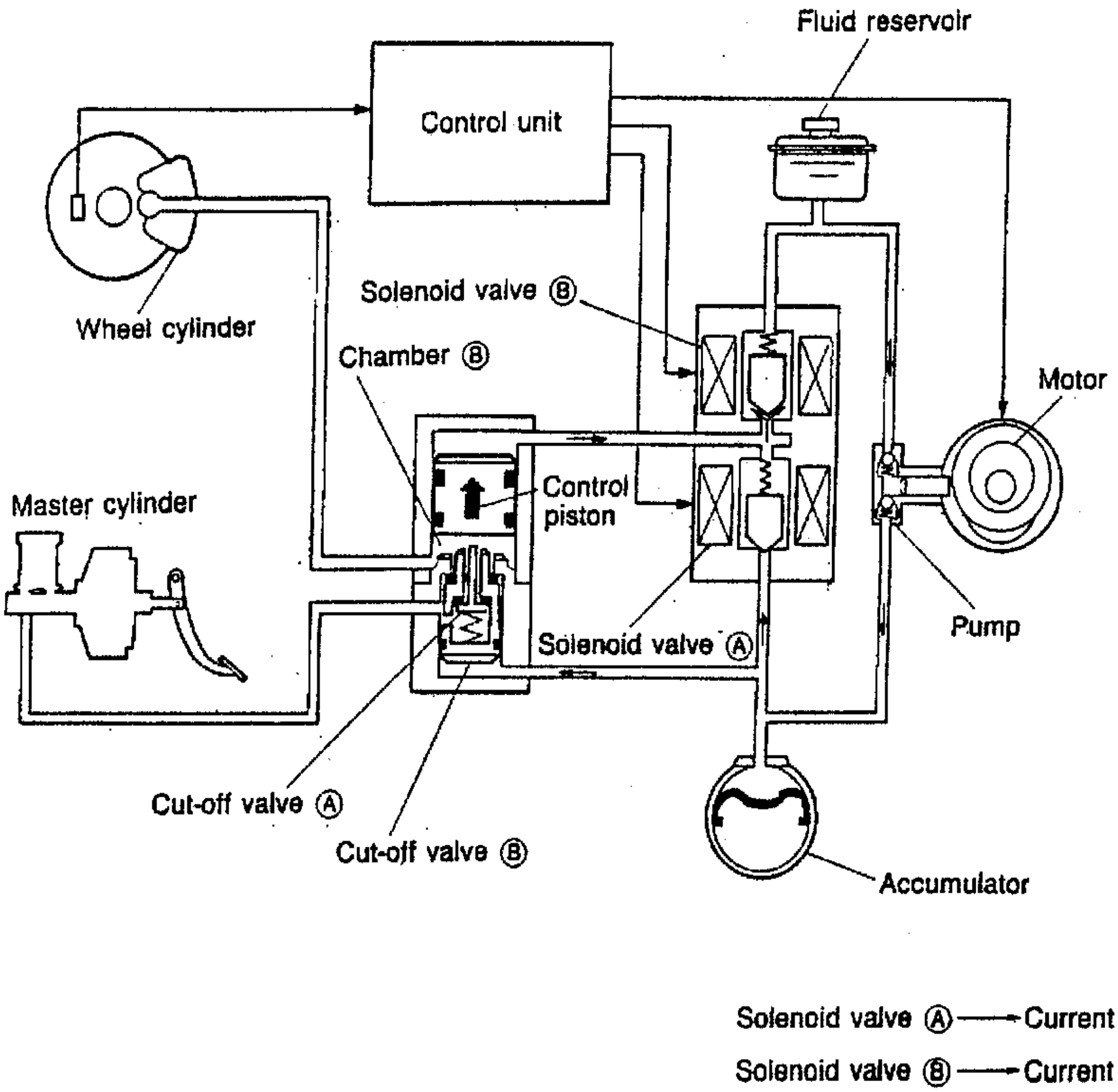
As the surface area of the two pistons to which pressure is applied is different (the control piston has a larger surface area) cut off valve B and the cutoff valve A are held down.

Thus, the hydraulic pressure of the master cylinder passes between cut-off valve B and the body and between cut-off valve B and cut-off valve A, and flows to the wheel cylinder.



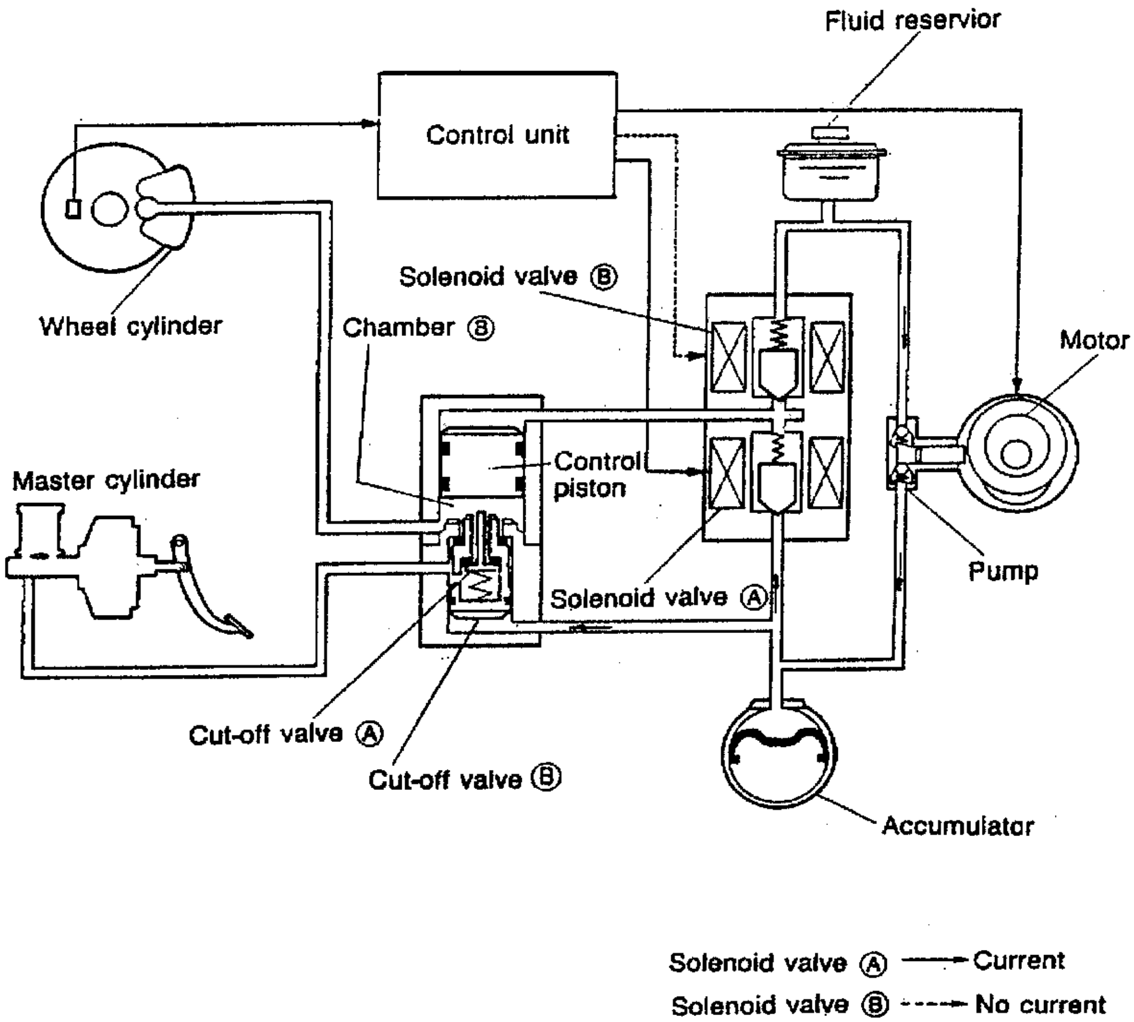
B. Pressure-Reduction

When the wheel cylinder hydraulic pressure increases and the wheel is about to lock, the control unit operates the solenoid valves to reduce pressure. As a result, there is current flaw to bath solenoid valves A and 6; solenoid valve A closes and B opens. Accumulator pressure pushes cut-off valve B upward as accumulator pressure in Chamber A is drained out to the fluid reservoir. Out-off valve B then closes off the passage between it and the body. At the same time valve A closes to cut-off master cylinder pressure to the wheel cylinder. At this time wheel cylinder pressure pushes the control piston further upward, and because of the volume increase of chamber B, the wheel cylinder pressure drops, causing a reduction in wheel braking.



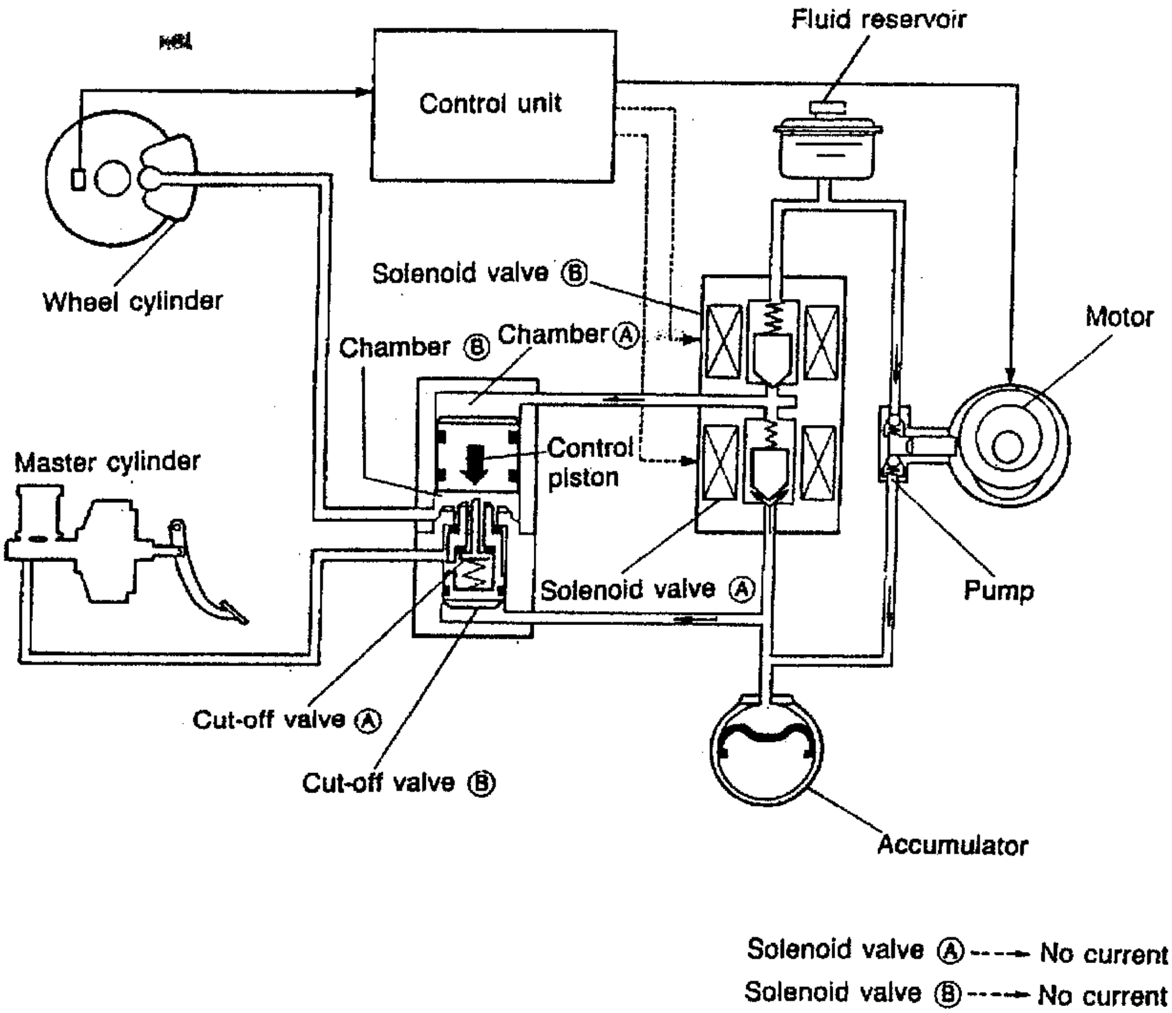
C. **Pressure-Retention**

When pressure retention is required the control unit switches solenoid valve B off and solenoid valve A on. As a result, both valves dose, and the pressure of chamber B is retained. In addition, cut-off valves B and A are held upward by the accumulator pressure; separating the master cylinder and wheel cylinder.



D. Pressure-Increase

When pressure-increase is required, the control unit switches off solenoid valves B or A. As a result, solenoid valve B closes and solenoid valve A opens. Accumulator pressure pushes against the cut-off valve B and the control piston. The control piston receives the greater force and moves down compressing the fluid in chamber B and increasing wheel cylinder pressure.



1.10 Special Service Tools and Equipment

A set, or special service tool, is designed to perform a very specific task. Used to fix a component that isn't easily repaired by a standard tool, SST's are typically developed by engineers during the vehicle design phase to ensure the vehicle can be properly repaired when necessary.

Cleaning, resetting, flanging of the brake line and measuring/assembly. The tools are held in place further tools. For fast work, the tools are organized in the ready for access by means of the soft foam inserts.

Figure 1:38 Brake Service Tools

Another advantage of these inserts is that you notice immediately if a tool is missing. The stable working surface of the cart allows smaller jobs to be done directly at the vehicle.

A. Brake Fluid Test Equipment

Brake fluid is hygroscopic, which means that it absorbswater over the course of time. This cau ses the boilingpoint to drop and the risk of vapor bubble formationincreases. This is why the br ake fluid needs to bechecked regularly in the workshop and replaced ifnecessary.

Brake fluid is hygroscopic, which means that it absorbswater over the course of time, thus caus ing the boilingpoint to drop (risk of vapor lock).

B. Straight Edge

Before a brake disk is mounted, the wheel hub should be checked for flatness (distortion). this is easily done with the ate straight edge, and the light gap method. Its length of 200 mm allows even lager surfaces to be easily checked.

Figure 1:41 Straight edge checking for brake disk flatness

C. Digital Brake Disk Caliper Gauge

The digital brake disk caliper gauge is an indispensable tool for precisely determining brake disk wear. It enables quick and easy measurement of brake disk thickness, i.e., the degree of wear. The measuring range is 125 mm and the length of the measuring jaws is 85 mm. The design of the measuring jaws permits exact measurement even if the disc has a ridge.

Figure 1:42 Digital brake disk caliper gauge

D. Digital Brake Drum Caliper

The digital brake drum caliper gauge is anindispensable instrument for precisely determining t hewear condition of the brake drums. It enables fast andsimple measurement of the brake drum diameter or theamount of wear. The measurement range is 400 mm. Thedesign of the measure ment arm allows for exactmeasurement regardless of burrs in the brake drum.

Figure 1:43 Digital brake drum caliper

E. Magnetic Dial-Gauge Holder

The ate magnetic dialgauge holder, used in conjunctionwith the ate dial gauge, enables lateral a nd adial run-outmeasurements to be taken on brake disks and wheel hubs.
its 70 movable steel pins provide a perfct fit onuneven surfaces.

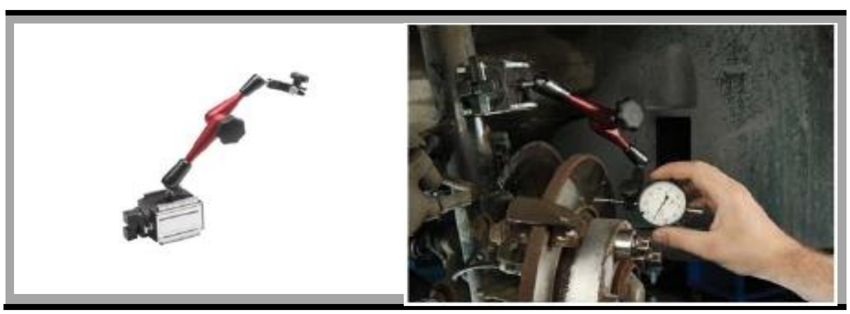


Figure 1:44 Magnetic Dial-Gauge Holder

F. Pneumatic Piston Return Device Set

In order not to destroy the automatic adjustment mechanism of floating calipers with integrated parking brake (combi caliper), the piston must be pressed and turned at the same time when resetting. The Pneumatic Piston Return Device Set is well suited for this job. Due to the infinitely variable pneumatic return of the piston, the device is well suited for brake callipers with right-hand and left-hand return. With the two universal adapters is almost only an application adapter for all vehicles required. The two exchangeable universal adapters fit all conventional vehicle models. The pin spacing can be pre- set by turning the top plate. The precise pin spacing of the turn plate adapts automatically to the holes of the brake piston by turning the base device. With the accessory adapter 03.9314-4990.1, the pistons of normal floating callipers can also be reset.

Figure 1:46 Pneumatic Piston Return Device Set

G. Brake Caliper Guide File

The brake caliper guide file allows the brake pad guide surfaces on brake calipers and holders to be filed to a bright finish. Single-sided cutting ensures that no damage is caused to the dust cap. The special coarse teeth mean that the work is completed quickly and cleanly. Special single-sided cut causes no damage to the dust cap.

Figure 1:47 Brake Caliper Guide File

H. Brake Pad Withdrawal Tool

The brake pad withdrawal tool removes firmly seated disk brake pads with retaining holed from fixed calipers. It prevents damage to brake calipers and disks. The fact that the pulling rod is integrated into the sliding weight means that there is no risk of injury. Pulling rod integrated in the sliding weight, so that there is no risk of injury.

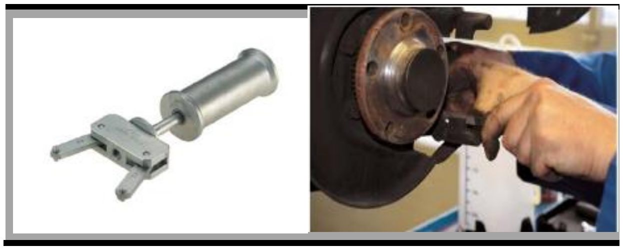


Figure 1:48 Brake Pad Withdrawal Tool

I. **Brake Caliper Wrench**

The brake caliper wrench allows simple loosening or tightening of the rear-axle brake caliper retaining bolts on the Opel Vectra B. It is a sharply cranked 19 mm hexagon wrench with a 1/2" square drive for a socket driver.

Figure 1:49 Brake Caliper Wrench

J. **Parking Brake Cable Spring Pliers**

The parking brake cable spring pliers allow simple and safe attachment of the parking brake cable to the brake shoe lever on drum brakes. It is particularly useful for mounting the top kit.

Figure 1:50 Parking brake cable spring pliers

K. **11 Mm Reamerfor ABS Sensor Mount**

Before installing a new ABS wheel speed sensor, this fixture hole must be thoroughly cleaned and brought back to nominal dimension. The ATE reamer is the ideal tool for this. The reamer enables precise cleaning of the fixture hole with an 11 mm diameter for the ABS wheel speed sensor, without expanding the diameter of the hole or damaging the sensor wheel. This ensures correct reinstallation of the wheel speed sensor.

Figure 1:51 ABS sensor mount

Self-check 1.1

Directions: Answer all the questions listed below.

Part I: Give short answers for the following questions

1. What is the difference between hydraulics and pneumatics brake system?
2. Write classification of brake by application and operation.
3. List out auxiliary brake system.
4. Explain principles of hydraulic and pneumatic systems.
5. List at least five separate types of wear and distortion to look for when inspecting brake drums.
6. What is the job of wheel cylinder stops?
7. Explain the operation of an integral drum brake parking brake.

Part II: Choose the correct answer from the given alternatives.

1. Brake linings should be replaced when.
   a) linings are worn to within 1⁄32 inch of a rivet head
   b) linings are contaminated with oil or grease
   c) linings are contaminated with brake fluid
   d) all of the above

2.In the unapplied position, drum brake shoes are held against the anchor pin by the .

a) Hold own springs
b) star wheel adjuster
c) shoe hold down
d) return springs

3. Duo-servo drum brakes are also known as what type of brake assembly?

a) leading-trailing brakes
b) self-energizing brakes
c) nonservo brakes
d) none of the abov

Unit Two: Inspecting Brake system components

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Common Brake System problems
- Visual inspection
- Road test

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify Common Brake System problems
- Inspect Visually the brake system
- Perform Road test

2.1 Common Brake System Problems

In order to make a good diagnosis and be able to properly identify the problem.

A. Basic brake problems

Remind your customers of the importance of regular brake inspections. Most drivers will only have their brakes inspected when they run into a problem; hence many rotors, pads and other components are kept beyond their proper and safe use-by dates. Regular inspection provides greater safety for motorists, greater replacement trade for workshops, and the real opportunity for you to up-sell to higher quality components.

Here’s a quick review of some of the more common brake problems:

B. Low Brake Fluid

Usually indicates a leak in the brake system, which poses a serious safety hazard. The calipers, wheel cylinders, brake hoses, brake lines, and master cylinder all need to be inspected. If a leak is found, the defective component must be replaced. The vehicle should not be driven until the repairs can be made because a leak may lead to brake failure.

C. **Low Brake Pedal**

Can result if shoe adjusters on drum brakes stick and fail to compensate for normal friction material wear. Adjusting them may restore a full pedal, but unless the adjusters are cleaned or replaced the problem will return as the friction linings wear. Other causes include worn friction material ora fluid leak.

D. Spongy Or Soft Pedal

Means there’s air in the brake system either as a result of improper bleeding, fluid loss or a very low fluid level. The cure is to bleed the brakes using the sequence recommended for the specific vehicle. Another possible cause is a rubber brake hose that is “ballooning” when the brakes are applied.

E. EXCESSIVE PEDAL TRAVEL

Possible causes include worn friction material, misadjusted drum brakes, and air in the brake lines. Potentially dangerous because the system may run out of pedal before the vehicle can be safely stopped.

F. Pedal Sinks To Floor

A dangerous condition caused by worn internal rubber seals in the master cylinder or a leak in the hydraulic system will not allow the brakes to hold pressure.

G. Pedal Pulsation

A jerking or pulsing brake pedal indicates DTV (Disc Thickness Variation), and the brake rotor needs to be resurfaced or replaced. The faces of a rotor must be parallel (within 0.0005inch / 0.0127mm on most cars) and flat (no more than about 0.002 inches or 0.050 mm of runout). Don't forget the wheel bearings (if serviceable) - they will need to be cleaned, inspected, and repacked with grease. New grease seals will also be needed.

H. Steering Wheel Vibration

Indicates a torque variation in the brakes. This is commonly associated with friction material deposits on the brake rotors causing a grab and release motion. The intermittent torquefrom left to right pulls on the steering rack and transfers to the steering wheel. Steering wheel vibration can also indicate DTV when combined with a pedal pulsation. Check for friction material deposits (dark patches) first for friction material deposits (dark patches) first.

I. Chatter

Vibrations and noise through the brake pedal and/or steering wheel under braking. Commonly caused by rotors that have been machined incorrectly.

K. Scraping Noise

Commonly caused by vibrations between the brake pads and caliper, which may be cured by resurfacing or replacing the rotors, installing new pads and pad shims, or applying brake grease or noise compound to the back of the pads.

L. Squeals

Commonly caused by vibrations between the brake pads and caliper, which may be cured by resurfacing or replacing the rotors, installing new pads and pad shims, or applying brake grease or noise compound to the back of the pads.

M. Grabby Brakes

Oil, grease or brake fluid on the friction surface will cause them to grab. The cure is to identify and eliminate the source of contamination, and then replace the linings. Badly scored drums or rotors can also grab. Resurfacing or replacement may be needed.

N. Dragging Brakes

May create a steering pull and/or increased fuel consumption. Caused by weak or broken retracting springs on drum brakes, a jammed or corroded caliper piston, a floating caliper with badly corroded mounting pins or bushings. Brake calipers should be overhauled or replaced every 60,000 kms. Dragging brakes cause extreme wear, excessive temperature and can mean lower performance in emergencies.

O. Brakes Pull To One Side

Can be caused by contaminated friction surfaces, misadjusted brakes, a bad wheel cylinder or caliper, dragging brakes on one side, or loose wheel bearings. Can also be caused by a side-to side mismatch of friction materials on the front brakes, or differences into thickness, type or condition.

P. 'Hard' Pedal

Lack of power assist may be due to low engine vacuum, a leaky vacuum hose or a defective booster. Sometimes a faulty check valve will allow air to enter the vacuum in the booster, causing a hard pedal when the brakes are applied.

- **The car pulls to one side during braking:**

Possible causes:

- ➢ Incorrect tire pressure or unequal tires.
- ➢ Wheel out of alignment
- ➢ Restricted brake hose
- ➢ Caliper stuck, seized or loose
- ➢ Damaged or contaminated friction material (with grease or brake fluid)
- ➢ Loose suspension parts

- **"Roughness" or vibration of the brake pedal.**

Possible causes:

- ➢ Parallelism between disc faces out of specification
- ➢ Wheel bearings damaged or out of adjustment
- ➢ Pad material worn down to steel support
- ➢ Worn, damaged (grooving) or cracked brake discs.

- **Excessive pedal travel:**

Possible causes:

- ➢ Air in the brake fluid circuit
- ➢ Insufficient liquid
- ➢ Liquid contaminated with water (if it occurs at high temperature)
- ➢ Brake fluid leak at any point in the circuit or component (pump or caliper)

- Bent brake pad.

- **Brake system with residual braking torque (dragging brakes).**

Possible causes:

- Pressure “trapped” in the braking circuit due to some obstruction
- Brake caliper seized or with un lubricated guides
- Damaged brake piston seal

- **High sensitivity of the braking system in low load braking (disproportionate response).**

Possible causes:

- Defective dosing valve
- Inadequate friction material. ICER Brakes recommends mounting its pads to avoid this problem.
- Improper disc friction surface finish

- **Loss of braking efficiency at high temperature or high speed.**

Possible causes:

- Inadequate friction material or no "scorching" process. The "scorching" is a productive process in which the pad is subjected to a high temperature on the friction surface, thus managing to burn part of the surface organic components.
- Improper brake disc. ICER Brakes recommends
- mounting its discs to avoid this problem

- **Noise while braking.**

Possible causes:

- Discs and pads contaminated with some type of external agent
- Ungreased braking system (guides)
- Inadequate friction material.
- Improper or worn brake disc.
- Excessively worn disc
- Loose or deteriorated suspension components
- Loose or damaged wheel bearing

2.2 Visual Inspection

- **Brake discs**

Visual inspection

- Droplet formation
- Traces of corrosion
- Formation of ridges
- Raised bridge at the edge
- Hot spots
- Blue colouring
- Structural changes
- Partial wear of the friction surface
- Corrosive pad impression

Figure 2:1 Embosed Stamp

- **Checking the lateral runout of a brake rotor**

Excessive lateral runout is the wobbling of a rotor from side to side when it rotates. This wobble knocks the pads farther back than normal, causing the pedal to pulse and vibrate during braking. Chatter can also result. Lateral runout also causes excessive pedal travel because the pistons have farther to travel to reach the rotor. If runout exceeds specifications, the rotor must be turned or replaced.

For the best braking performance, lateral runout should be less than 0.003 inch (0.08 mm) for most vehicles. Some manufacturers, however, specify runout limits as small as 0.002 inch (0.05 mm) or as great as 0.008 inch (0.20 mm).

Runout measurements are taken only on the outboard surface of the rotor, using a dial indicator and suitable mounting adapters. If the rotor is mounted on adjustable wheel bearings, readjust the bearings to remove bearing end play. Do not overtighten the bearings. On rotors bolted solidly to the axles of FWD vehicles, bearing end play is not a factor in rotor runout measurement. If there is excessive bearing end play, the bearing assembly must be replaced. Bearing end play is best checked with a dial indicator.

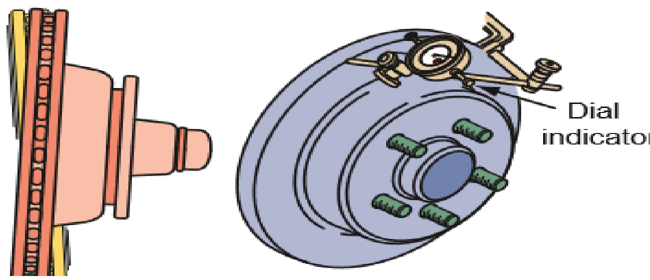


Figure 2:2 Checking The Lateral Run Out Of A Brake Rotor.

Clamp the dial indicator support to the steering knuckle or other suspension part that will hold it securely as you turn the rotor. Position the dial indicator so that its tip contacts the rotor at 90 degrees. Place the indicator tip on the friction surface about 1 inch in from the outer edge of the rotor. Do not place the dial indicator on a dirty, rusted, grooved, or scored area. Rotate the rotor until the lowest reading appears on the dial indicator; then set the indicator to zero. Turn the rotor through one complete revolution and compare the lowest to the highest reading. This is the maximum runout of the rotor.

- **Additional Checks For Brake Rotor**

The following are some of the typical rotor conditions that warrant disc replacement or machining.

a) Grooves and Scoring

Inspect both rotor surfaces for scoring and grooving. Scoring or small grooves up to 0.010 inch (0.25 mm) deep are usually acceptable for proper braking performance. Scoring can be caused by linings that are worn through to the rivets or backing plate or by friction material that is harsh or unkind to the mating surface. Rust, road dirt, and other contamination could also cause rotor scoring. Any rotor having score marks more than 0.15 inch should be refinished or replaced.

b) Cracks

Check the rotor thoroughly for cracks or broken edges. Replace any rotor that is cracked or chipped, but do not mistake small surface checks in the rotor for structural cracks. Surface checks will normally disappear when a rotor is resurfaced. Structural cracks, however, will be more visible when surrounded by a freshly turned rotor surface.

c) Bluing or Heat Checking

Inspect the rotor surfaces for heat checking and hard spots Heat checking appears as many small interlaced cracks on the surface. Heat checking lowers the heat dissipation ability and friction coefficient of the rotor surface. Heat checking does not disappear with resurfacing.

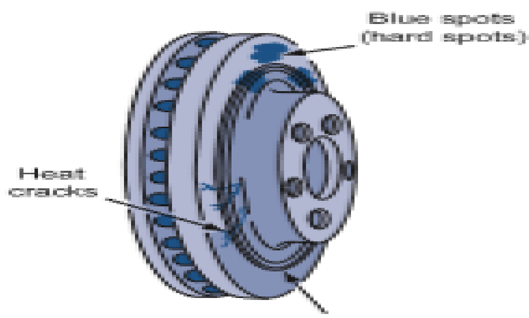


Figure 2:3 Conditions That Should Be Looked For On A Brake

- **Brake pads**

Visual inspection

- Paper/Protective foil
- Uneven wear
- Wear on piston side/outer side
- Deposits linked with direction
- Thickness of residual deposit
- Other causes of brake noise

Figure 2:4 Traces of Corrosion Rotor

A raised bridge at the edge of the friction ring surface always signifies the existence of material erosion, which is either due to an advanced service run or to an extreme sports driving technique of the end user. This leads to an increased deposit of brake dust in the disc cup. In any event, the pads must also be inspected.

Figure 2:5 A raised bridge at the edge of the friction ring surface

If the brake band is only worn in the center or if the inner and outer brake band is corroded, there may be a number of reasons for this:

– Low brake torque due to low brake effort of the rear axle

– The brake pad is not completely fitted

– The wrong brake pads have been used

– Part of the friction material of the brake pads has been lost.

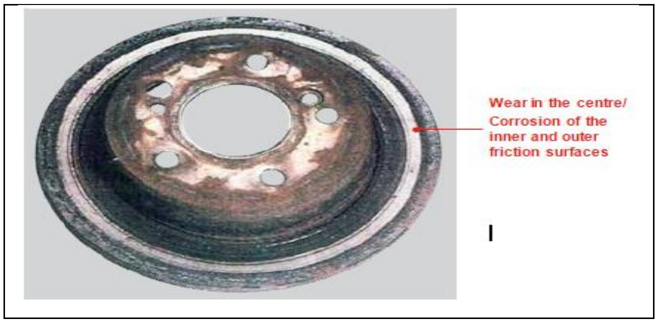


Figure 2:6 worn brake band

To check the lateral impact of the brake disc please proceed as follows:

- If the brake disc is only fastened with one screw, secure it with two additional screws at the wheel hub.
- Attach the dial gauge with the aid of the magnet at the strut.

Figure 2:7 To Check The Lateral Impact Of The

- Place the sensor 1 cm from the outer diameter and read the oscillation value on the dial gauge during a full rotation.
- The reading at the disc must be below 0.08 mm and at the hub below 0.02 mm.
- If the figure is not within the tolerance, adjust the position of the disc to the wheel hub by 45 ° and check again.
- Also check the concentricity of the wheel hub.
- N.B.: The hub impact approximately doubles the disc impact.

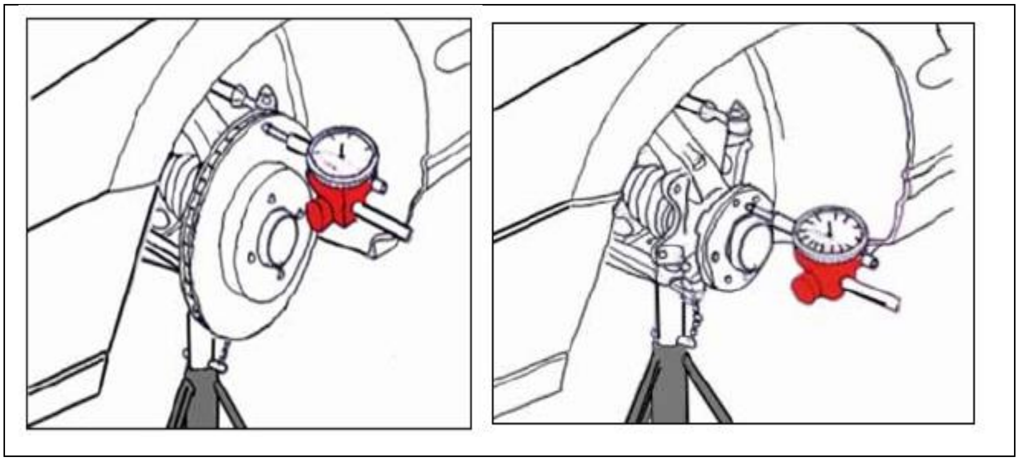
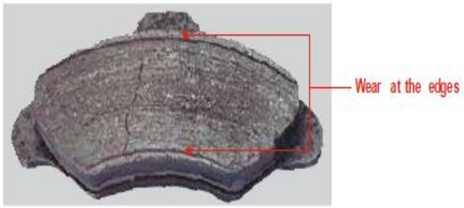
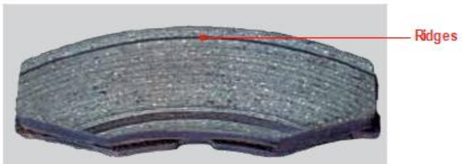
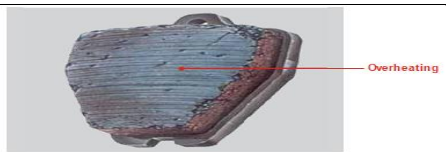
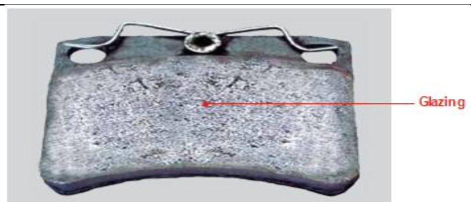


Figure 2:8 To Check The Concentricity Of The Wheel Hub

If the brake pad shows wear at the upper and lower edge of the friction surface, an old ‘run-in brake disc has been used.

Inspect brake pads

If the brake pad shows wear at the upper and lower edge of the friction surface, an old ‘run-in‘ brake disc has been used.	
Ridges on the brake pad are a mirror image of the brake disc (see page 4 for scoring of the face surface)	
Overheating of the brake pads is caused if the brake caliper is stuck or not moving freely.	
Glazing of the brake pads is a consequence of repeated light braking (bad parking), which polishes the pad surface blank. Heavy braking can cause the braking effect to weaken.	

If the pad has broken away, this is a result of the pad being wrongly fitted.	

Figure 2:9 Inspect Brake Pads

Possible causes of brake noises:

- Low braking pressure
- New pads mounted with old discs
- Old or hardened brake caliper cups
- Piston shoulder not set at 20 º
- Foreign bodies (dirt, lubricating gel)in the pad surface.
- Brake caliper and pads not moving freely (surrounding area of braking system must be cleaned (suspension system)

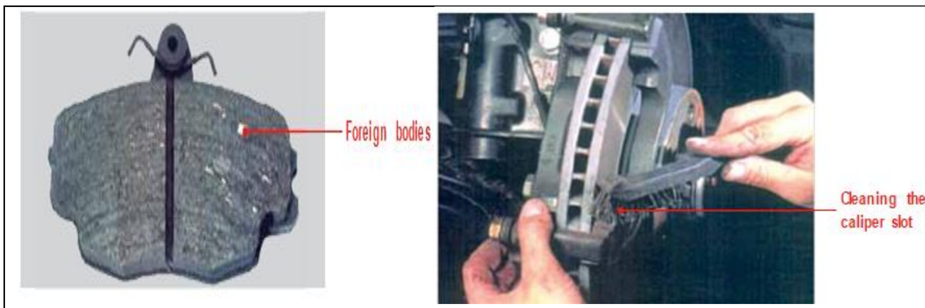


Figure 2:10 Movement of Brake Caliper And Pads

Inspection Procedure

- Inspect the function of brake indicator lamp(s).

a. With the engine stopped (ignition off), have the driver turn the ignition to the “on” or “ru n”position.

b. Observe the location and operation of all brake indicators.

c. Have the driver start the engine, leave the key in the “on” position and release the park brak e.

d. Observe the brake indicator(s). All brake indicator lamps should go off.

e. Have the driver apply the park brake while you observe the brake indicators. An indicat orlamp must turn on to show that the park brake is applied.

- Determine pedal reserve height and inspect the brake power-assist unit or brake power unit function.

a. With the engine running, have the driver firmly apply the brake pedal (about 50 lbs of f orceand hold it for approximately 10 seconds. Observe the brake indicator(s) and obs erve theheight of the brake pedal above the floor.
b. Inspect the operation of the brake power-assist unit or the brake power unit based on the specific procedure for the system being inspected.

- Inspect the parking brake.

a) Ask the driver to apply the parking brake and attempt to move the vehicle in low forward gear without applying the throttle. The vehicle should not roll.
b) Repeat with the driver using reverse gear and no throttle. The vehicle should not roll.
c) NOTE: For manual transmissions, have the driver put the vehicle in low forward or reverse gear and have the driver let out the clutch until it begins to engage. The throttle should not be applied.
d) If the parking brake actuator utilizes air or hydraulic fluid to release the brake, inspect for leaks at the unit.

External Brake System Check

1. Brake Actuators

a) Visually check the front and rear brake actuators for any abrasions, bulges, cuts, loose parts, broken or cracked air hoses or damaged components.
b) Check that brake hoses and cables are properly secured, but allow the caliper full movement during normal operation.
c) On parking brake chambers ensure that caging bolt plugs/covers are present and fully installed.
d) Examine the entire pneumatic circuit, including connections, hoses and piping conditions for evidence of any heavy leakage.
e) If heavy leakage is present or audible then immediate repair is recommended.

Figure 2:11 Brake Rotors

- If possible, visually check the rotors for large cracks, heavy grooves, heavy scoring, hot spots, or oil contamination. See below for examples of visual rotor conditions requiring further inspection.

Rotor Condition Inspection

Figure 2:12 Rotor Condition Inspection

- Check rotor for cracks, condition of rubbing surfaces and maximum wear dimension.

a) Glazing = permissible
b) Radial cracks max 0.019 inch / 0.5 mm = permissible
c) Unevenness under 0.059 inch / 1.5 mm = permissible
d) Cracks across outer surface = not permissible
e) Outer surface

Visual Inspection

a) Visually inspect the caliper for corrosion, leaking hydraulic fluid, cracks or visible damage.
b) Check back plate tie bolts to ensure that they are properly torqued,

safety wired and have not worked loose.

c) Visually check torque plate for corrosion, cracks and loose bolts that attach the torque plate to the axle.

d) Visually check brake linings (pads) for wear. Linings worn to less than 0.100” must be replaced.

e) Check brake line and brake line fittings for signs of damage or leakage. If the linings have been contaminated with fluid, they should be replaced.

2.3 Road test

Testing of material friction characteristics demands delicate procedure, because their features cannot be estimated based on their chemical structure, configuration or on other data used for estimation of metals and alloys, but exclusively based on experimental methods. Friction properties of brake pads depend on several parameters of operating conditions, first of all on temperature, surface pressure and sliding speed at friction surfaces.

Data required for the accurate characterization of friction materials is acquired under controlled conditions in the laboratory and on the vehicle. In order to effectively interpret the acquired data, engineers must be familiar with both the procedures and equipment utilized. Many variables, such as timing, cost, sample availability and data obtained from a particular test, are considered when selecting a testing methodology appropriate to the engineer scope of work. To reduce preliminary material qualification costs and to facilitate research, a variety of laboratory-scale test machines has been developed. These range from massive, inertial dynamometers with electronic controls and sensors to small, rub-shoe machines that can sit on a bench-top. Some off-vehicle test systems involve instrumented skid pads onto which a fully loaded vehicle can drive and apply the brakes. Instrumented roll-on-type systems can test one set of vehicle axles at a time. The amount of data obtained from this wide range of tests varies greatly, and friction data from one type of brake test may not directly correlate with that from another type. Added to this concern is the fact that many of the larger dynamometer units are custom, one-of-a-kind units. Therefore, data for different materials are usually ranked in relative terms within the cones of the given test method, and can agree between one method and another.

The following summarizes the various levels of brake material testing:

I. Vehicle road tests,
II. Vehicle skid-pad tests,
III. Vehicle drive-on dynamometers (in-ground or portable)
IV. Inertial dynamometers (full-scale hardware)
V. Inertial dynamometers (sub-scale hardware)
VI. Laboratory tribometers.

While vehicle tests are expensive, time-consuming and subject to road conditions and weather variability, brake dynamometer testing in the laboratory is faster and less costly to screen or verify friction material characteristics.

The two major types of brake dynamometers are commonly used: the inertial dynamometer which evaluates a full-size brake or a brake system and simulates vehicle braking well, but is time consuming and expensive, or a smaller Chase dynamometer that features low capital expenditure and shorter test time using a small friction material sample against a large drum. The Chase dynamometer does not simulate brake conditions as well as the inertial dynamometer, and therefore is used primarily for rapid screening and/or for quality control only.

Vehicle brake simulations are conducted on an inertial dynamometer (Fig. 1). To simulate the kinetic energy of the vehicle mass moving, the dynamometer utilizes mechanical mass fixed in increments to a rotating shaft. An electric motor is responsible for bringing the rotating mass up to a speed set point.

Once the set point is reached, the motor releases control, and the braking system is responsible for bringing the rotating mass to a stop. The energy dissipated during braking can be equated to the energy dissipated during braking in a vehicle. To accommodate multiple vehicle platforms, dynamometers utilize a stepped shaft that accepts fixed increments of inertia. To prepare a vehicle for testing, the following equipment is required: transducers (torque, pressure, temperature, speed, acceleration.

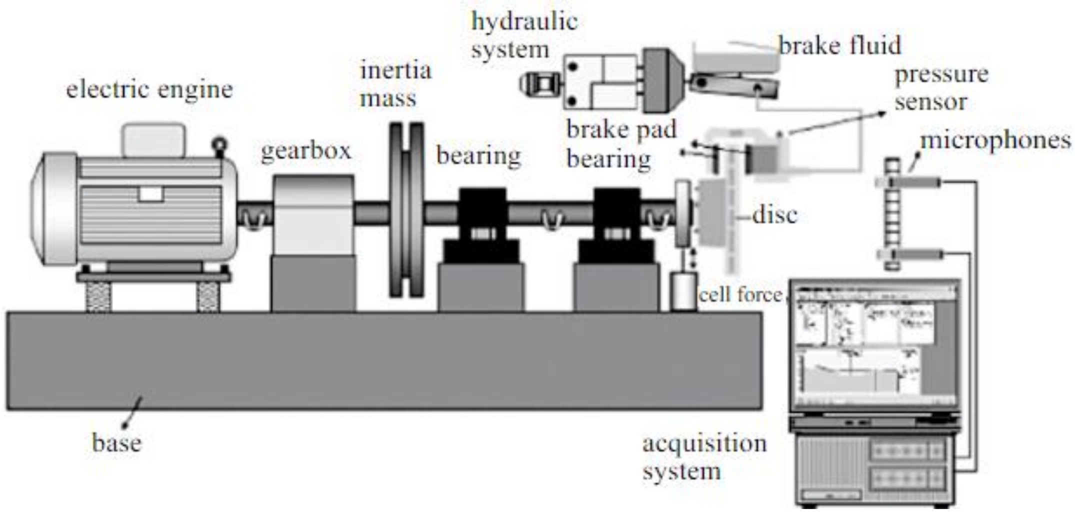


Figure 2:13 Brake inertial dynamometer

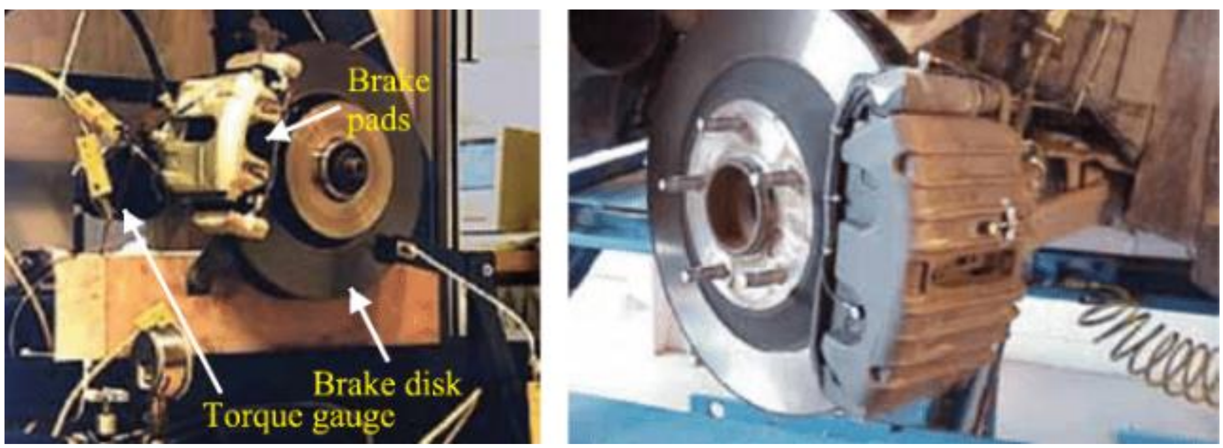


Figure 2:14 Laboratory test stand for testing of disc brake friction characteristics

Vehicleroad Testing Of Brake Pad Friction characteristics

Vehicle testing procedures vary as widely as dynamometer procedures. Examples of vehicle procedure test objectives include: certification testing, durability testing, and product development. Performing vehicle testing is more complicated and expensive than dynamometer testing. In order to prepare for a vehicle test, the following must be considered:

- **timing** – vehicle testing typically takes longer than dynamometer testing (the dynamometer can be run unattended, the vehicle cannot)
- **staffing** – scheduling test drivers with appropriate skill levels in a manner that maximizes efficiency in vehicle run-time is difficult

- **facilities** – facilities for the installation of test hardware, installation of transducers, signal conditioning and data acquisition are extremely specialized and require the coordination of multiple disciplines
- **inspection** – inspections typically occur at kilometer intervals and frequently must be performed outside of 'normally' scheduled shifts to maximize vehicle run-time.

Self-check 2.1

Directions: Answer all the questions listed below.

Part I: Give short answers for the following questions

1. Name the three major assemblies that make up a disc brake.
2. Name the three types of calipers used on disc brakes.
3. What type of brake uses the inside of each rear wheel hub and rotor assembly as a parking brake drum?
4. True or False? Disc brakes are not as likely to fade during heavy braking as are drum brakes.
5. What are the two basic types of brake rotors used on today's vehicles?
6. True or False? All calipers have at least one piston that pushes the brake pad against the rotor?
7. What is the difference between floating and sliding calipers?

Part II:Choose the correct answer from the given alternatives.

1. Which term refers to variations in thickness of the rotor?
   a) torque
   b) lateral run out
   c) parallelism
   d) pedal pulsation
2. Which of the following is not likely to cause a pulsating brake pedal?
   a) loose wheel bearings
   b) worn brake pad linings
   c) excessive lateral runout
   d) nonparallel rotors

Operation Sheet 2.1

Operation Title: Brake Pedal Check & Adjustment

Purpose: Every learner should know how to check & adjust pedal clearance.

Conditions or situations for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Steel rule

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

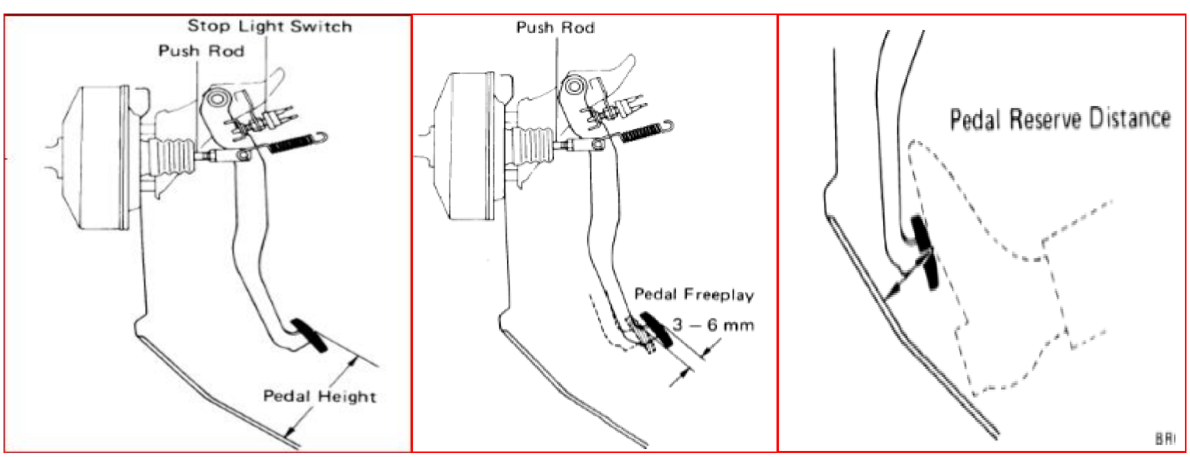
PROCEDURE:

Steps in doing the task

1. CHECK THAT PEDAL HEIGHT IS CORRECT.

Pedal height from asphalt sheet: 151.5 — 161.5 mm (5.96 — 6.36 in.)

If incorrect, adjust the pedal height.



2. If necessary, adjust pedal height.

a. If necessary, remove the instrument lower finish panel and air duct.

b. Loosen the stop light switch lock nut.

c. Sufficiently loosen the stop light switch.

d. Loosen the push rod lock nut.

e. Adjust the pedal height by turning the pedal push rod.

f. Return the stop light switch until it lightly contacts the pedal stopper.

g. Tighten the two lock nuts.

h. Check that the stop lights light when the brake pedal depressed.

i. After adjusting the pedal height, check and adjust the pedal free play.

3. CHECK THAT PEDAL FREEPLAY IS CORRECT.

(a) Stop the engine and depress the brake pedal several times until there is no more vacuum left in the booster.

(b) Push in the pedal by hand until the beginning of the second resistance is felt, measure the distance, as shown. Pedal freeplay: 3 — 6 mm (0.12 — 0.24 in.) HINT: The freeplay to the first resistance is due to the play between the clevis and pin. And it is 1 — 3 mm (0.04 — 0.12 in.) on the pedal.

4 IF NECESSARY, ADJUST PEDAL FREEPLAY.

(a) If incorrect, adjust the pedal freeplay by turning the pedal push rod.

(b) Start the engine and confirm that pedal freeplay exists.

(c) After adjusting the pedal freeplay, check the pedal height.

(d) Install the air duct and instrument lower finish panel.

5. CHECK THAT PEDAL RESERVE DISTANCE IS CORRECT.

Release the parking brake. With engine running, depress the pedal and measure the pedal reserve distance, as shown.

Pedal reserve distance from asphalt sheet:at 50 kg (110.2 lb, 490N): More than 80 mm (3.15 in.) If incorrect, troubleshoot the brake system.

Operation Sheet 2.2

Operation Title: Operational Test of Brake Booster

Purpose: Every learner should know how to test a brake booster.

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

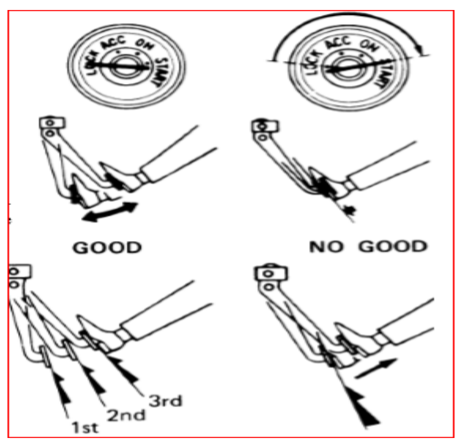
- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

Procedure:

HINT: If there is leakage or lack of vacuum, repair before testing. If available, use a brake booster tester to check the booster operating condition.

Operating Check



(a) Depress the brake pedal several times with the engine stopped, and check that is no change in the pedal reserve distance.

(b) Depress the brake pedal and start the engine. If the pedal goes down slightly, operation is normal.

Air Tightness Check

(a) Start the engine and stop it after one or two minutes. Depress the brake pedal several times slowly. If the pedal goes down furthers the first time, but gradually rises after the second or third time, the booster is air tight.

(b) Depress the brake pedal while the engine is running, and stop it with the pedal depressed. If there is no change in pedal reserve travel after holding the pedal for thirty seconds, the booster is air tight.

Operation Sheet 2.3

Operation Title: Bleeding of Brake System

Purpose: Every learner should know how to bleed an airlock of brake system.

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

PROCEDURE:

HINT: If any work is done on the brake system or if air is suspected in the brake lines, bleed the system of air. NOTICE: Do not let brake fluid remain on a painted surface. Wash it off immediately.

1. Fill Brake Reservoir with Brake Fluid

Check the fluid level in the reservoir. If necessary, add brake fluid.

2. Bleed Master Cylinder

HINT: If the master cylinder was disassembled or if the reservoir becomes empty, bleed the air from the master cylinder.

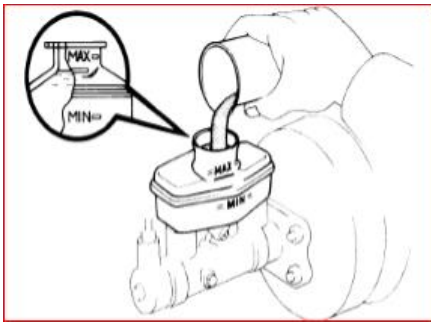
(a) Disconnect the brake tubes from the master cylinder. Use a container to catch the brake fluid.

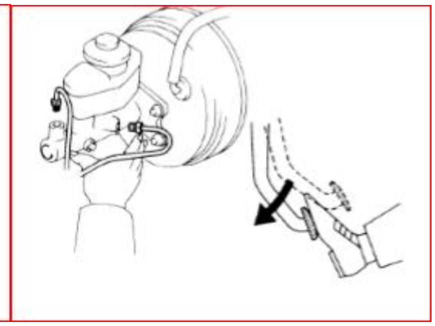
(b) Slowly depress the brake pedal and hold it.

c) Block off the outer holes with your fingers, and release the brake pedal.

(d) Repeat (b) and (c) three or four times.

(e) Connect the brake tubes to the master cylinder.





3. Begin Bleeding Air From Brake Or Wheel Cylinder With Longest Hydraulic Line.

(a) Connect the vinyl tube to the brake or wheel cylinder bleeder plug, and insert the other end of tube in a half full container of brake fluid.

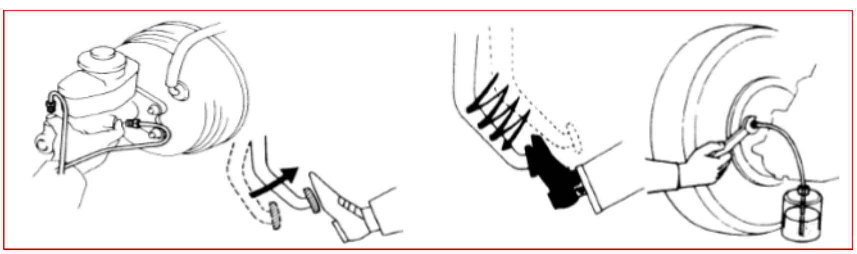
(b) Slowly depress the brake pedal several times.

(c) While having an assistant press on the pedal, loosen the bleeder plug until fluid starts to runout. Then close the bleeder plug.

(d) Repeat (b) and (c) until there are no more air bubbles in the fluid.

(e) Tighten the bleeder plug.

4. Repeat Procedure For Each Wheel.



Operation Sheet 2.4

Operation Title: Check and Adjustment of Parking Brake

Purpose: Every learner should know how to check & adjust a parking brake.

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

PROCEDURE:

CHECK THAT PARKING BRAKE LEVER TRAVEL IS CORRECT

Pull the parking brake lever all the way up, and count the number of clicks. Parking brake lever travel at 20 kg (44.1 lb, 196 NI): 5 — 8 clicks If incorrect, adjust the parking brake.

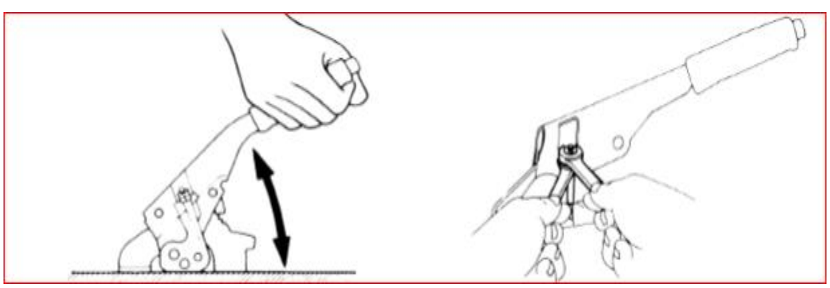
IF NECESSARY, ADJUST PARKING BRAKE LEVER TRAVEL HINT: Before adjusting the parking brake, make sure that the rear brake shoe clearance has been adjusted.

(a) Remove the console box.

(b) Loosen the lock nut and turn the adjusting nut until the lever travel is correct.

(c) Tighten the lock nut.

(d) Install the console box.



Unit Three: Overhauling Brake system components

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Removing and disassembling brake system components
- Assembling and Testing Brake System
- Post Repair Test

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Removal of the brake system from the vehicle.
- Perform Brake System assembly and testing
- Conduct Post Repair Test

3.1 Removing and disassembling brake system component

3.1.1 Overhauling Master Cylinder

This section describes how I overhauled the front master cylinder and PDWA brakes for my '70 TR6. As mentioned in other notes, the car is completely disassembled so I didn't have to deal with removing them from the car. However, I thought it appropriate to include a description of how I remove them.

A. Draining the system

Most of the fluid must be removed from the system before either the master cylinder or the PDWA can be removed. You can either remove the fluid intentionally or it'll leak out when you open the pipes. Normal DOT3/4 brake fluid is a very effective paint remover so it is wise to avoid getting it all over the engine compartment and to clean up any spills.

The DOT3/4 fluid absorbs moisture so it's a good idea to get completely drain the system and install new fluid whenever the system is opened. To completely drain the system I connect a 3-foot length of 1/4 inch ID plastic hose from one of the caliper bleed nipples to an old radiator overflow bottle. I then open the bleed screw and gently pump the brakes until the large (back) part of the reservoir is empty. I've always had trouble with the bottle falling over, hose coming out, etc so this is a good opportunity to get the significant other or bleed nipple. (If she pumps and nothing comes out, I suggest she pump the other middle pedal.) Once the reservoir for the front has been drained I move the hose and bottle to one of the rear cylinders and repeat the process to drain the other reservoir. (One can also use the pressure tool described in the bleeding and adjusting note to blow all the fluid out of the system.)one of the kids to lend a foot.

Figure 3:1 Master Cylinder

The helper pumps the brake while I deal with the hose, bottle and opening the Removing the

MC: The photo on right is of my '76 TR6.

To remove the MC, I first disconnect the two brake lines from the side of the cylinder. Fluid will likely drip from the pipes so it's a good idea to wrap the pipes with a large rag or towel. The two nuts and lock washers are then removed from the studs that secure the MC to the servo and the MC can be lifted off. If I plan to remove the PDWA and/or plan to drain the entire system, I open one wheel caliper/cylinder bleed nipple at a time, drape a large rag or towel over the nipple and then use an air gun to apply ~10 psi air to the associated brake line fitting previously disconnected from the MC

Figure 3:2 Two Brake Lines from the Side of the Cylinder

Removing the PDWA: The photo on right shows the PDWA on my '76TR6. Before removing the PDWA I blow the fluid out of the system as described above. Next, I disconnect the electrical connector to the switch on the top and then disconnect the two pipes from the engine side of the PDWA and then remove the bolt securing the PDWA to thbody. The PDWA will then lift off with the pipes that connect between the MC and PDWA still attached to the PDWA. I then seal the ends of the two pipes still attached to the frame with tape and scrub everything down with soapy water and hose it off.

Disassembling the MC: As with any TR project, a couple special tools will come in handy here. The1/2 inch hex wrench shown in photo below is to remove the nut that retains the tip over valve in the MC. The little part to the left of the wrench is an old tip over valve with the end cut off so it won't tip over. The lower tool is a bow gun with an old rear brake hose screwed into it.

Figure 3:3 A Bow Gun With An Old Rear Brake Hose Screwed

The photos below show disassembling the MC. The reservoir is being removed on the left and the nut (hollow plug) that holds the tip over valve in place is being removed in the center photo. The tip over valve with nut is shown in the right photo. The first time I disassembled one of these I discovered I didn't have the correct hex wrench at like 3 AM. I shoved the hex head of an old 5/16-inch bolt into the retaining nut and used a small pipe wrench on the shaft of the bolt. (Pipe wrenches are really handy ---- one step above vise grips.)

Figure 3:4 Disassembling The Master Cylinder

The next task is to remove the two pistons. With a little luck they'll come out when the cylinder is shook. However, we have other methods for the difficult ones. The scheme is to blow out the pistons with compressed air. However, for this to work all the openings except the end must be sealed. The tip over valve with the end cut off mentioned earlier can be installed to seal that opening. The tip over valve just removed can be used (with end sawed off) since there is a new one in the rebuild kit. The front brake port is plugged with a 7/16 -20 bolt and the air connection hose & gun pictured above is attached to the rear brake line port. The port to the rear brake reservoir can be covered with a finger. I pointed the end in a trashcan with some impact absorbing material (loose trash) in the bottom.

Figure 3:5 Master Cylinder Piston and spring

I was really careful here because the pistons usually leave the cylinder with some dispatch. If the pistons don't come out I disconnect the air and then use a hammer and punch to drive the pistons into the cylinder a little to break them free --- then the air again. The pistons and springs are shown below. This stuff was set aside till later.

Checking the MC Bore Size: The standard MC bore is of two sizes; the rear slightly smaller than the front. If you shine a light down the bore you should see a small but definite reduction in bore size just beyond the front brake port, about two thirds of the way into the bore. I measured the bore on this MC and found the smaller inner part to be 0.774 inches diameter and the larger part to be 0.812 inches diameter. I've heard that some master cylinders have been bored oversized and possibly to one diameter throughout. If there is not a clear step near the closed end of the cylinder or if the diameters differ greatly from those measured here, the standard MC replacement seals will likely not work properly.

Cleaning up the MC casting: The master cylinder casting has a yellow cast when new; I think due to a chromium or cadmium plating. This usually starts to disappear after a couple years and areas of the surface then start to corrode. If one is satisfied with this appearance one merely has to give the inside a quick inspection and run a hone down the cylinder if it is rough then go on to replacing the seals. I prefer to clean the casting and coat the outer surface so that it looks nice -- at least for a while. In the past I've used clear coat and aluminum paint finishes.

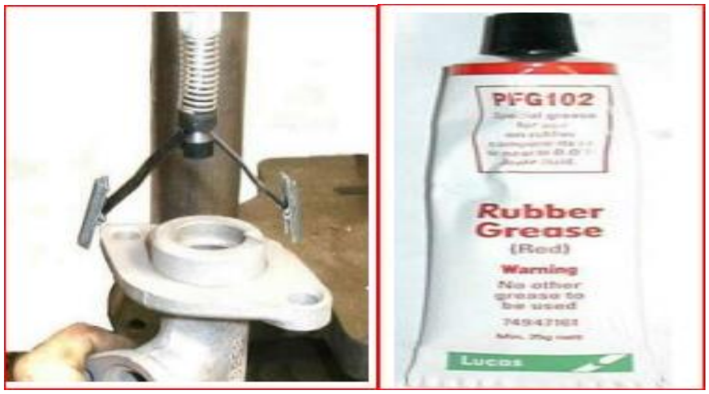


Figure 3:6 Cleaning up the master cylinder casting

Rubber Grease: I think one of the keys to a lasting brake job is the use of grease on all threads, rubber seals and exposed unfinished metal such as the exposed ends of the cylinders. Greasing the pipe and bleed nipple threads often eliminates problems 10 to 20 years hence at the next rebuild. Greasing the exposed metal prevents the corrosion and pitting that sometimes destroys the components. Girling and Lockheed sell red rubber grease that is compatible with the rubber seals and brake fluid for just this purpose. Unfortunately, I had a hard time securing the grease recently.

Replacing the MC Seals: The parts of the rebuild kit are shown on the right. The tip over valve seal is easy to deal with --- you get a new valve in the rebuild kit.

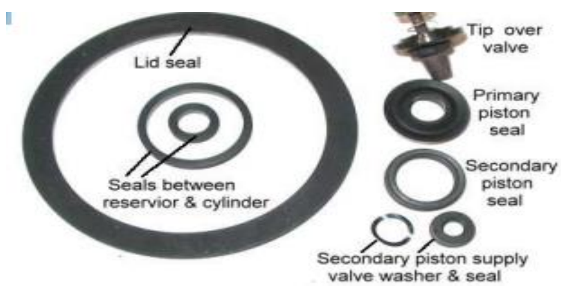


Figure 3:7 Replacing the master cylinder Seals

The secondary piston must be disassembled to get at the supply valve seal and wavy washer. I wore eye protection for this procedure. I used a small screwdriver to lift the thimble tab over the lip on the piston. The spring usually propels the pieces in all directions if they are not secured --- a rag over the whole mess sometimes helps. Once apart, the old wavy washer and seal were removed and discarded and new parts installed. The lip on the outside of the seal is positioned toward the end of the cylinder. It looks like it may be position in the other direction in the photo below.

Figure 3:8 Disassembled the master cylinder piston

The next step is to put the secondary piston back together. I used the vise to squeeze the spring (I held the parts with one hand as shown in photo) and then used a small screwdriver in the other hand to push the thimble over the end of the piston and pressed the tab down behind the lip.

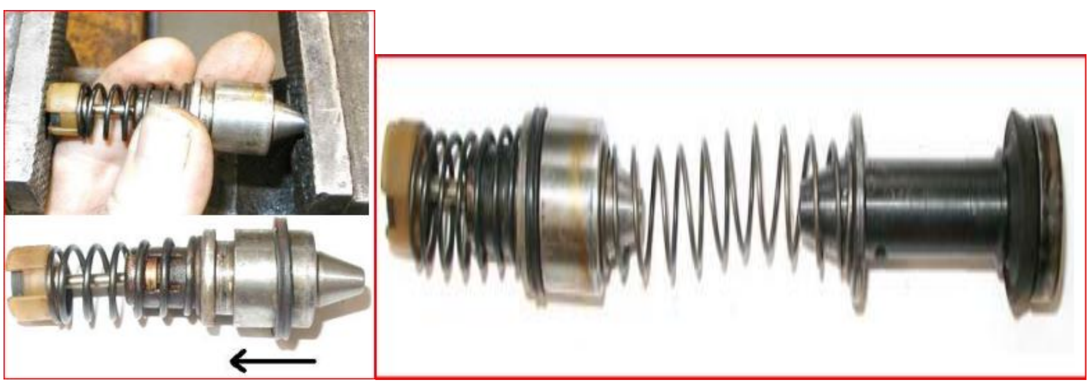


Figure 3:9 Disassembled the master cylinder spring

PWDA Disassembly: The major task with the PDWA was to get the piston out so that I could replace the seals. I used compressed air as shown in the photo on the right. I removed the switch and end plug and then plugged the ports for the front brakes with 7/16" bolts and the switch hole and one of the ports for the rear brakes with 3/8 bolts. The airline connects to the last rear brake port. I pointed it in the trashcan and fireed. (If the local dogooders saw me doing this, they'd make me get a permit and register this thing.) If it doesn't let go, I disconnect the air, use a punch drive the piston in to break it free and then hook up the air and fire again.

Figure 3:9 Reassembled the master cylinder

PDWA Reassembly: I coated the piston with rubber grease and slid two new O-Rings into position on the piston. I then poured a little silicone fluid into the PDWA bore and then slid the piston into position. I looked down into the hole for the switch and positioned the piston such that the narrow part is exactly under the middle of the hole. I used the sharp end of a scribe (a nail would work as well) through the switch hole to work the piston into the exact middle. I then installed and tightened the plug, making sure that there was a copper washer under the head of the plug. The ready to assemble parts are shown in the next photo.

Figure 3:10 coated the piston with rubber grease

Before installing the switch I tested it by pressing the switch plunger in and verified operation by measuring the resistance between one of the switch terminals and the plunger with an ohmmeter. (Note: the two terminals at the top of the switch are wired together. When the plunger is pushed up it connects ground from the plunger via the piston and PDWA housing to the terminals.) In this case the resistance went to less than 1ohm between the plunger and the switch terminals when the plunger was pushed in, indicating that the switch was good. The switch exerts considerable force on the piston requiring that there be a considerable difference in pressure between the two sides of the PDWA before the piston moves operating the switch. This allows for normal bleeding of the brakes with light brake pressure.

Figure 3:11 tested it by pressing the switch plunger

The assembled master cylinder with PDWA and connecting pipes are shown on the right. The final step is to install the components in the car, which for this stuff is at least a year away. I will use stainless steel nuts and lock washers to connect the MC to the servo. I'll also use a stainless steel bolt with lock washer to secure the PDWA. Filling the reservoir is described in the note on bleeding the system.

Figure 3:12 tested it by pressing the switch plunger

Removing disc brake

Procedure

1. Unbolt the end of the steering rack and pinion.

2. Unbolt and remove thecalipers.

3. Crimp the oil hoses, if necessary.
4. Unscrew or cut the oil hoses from the brakes.

5. Remove the caliper bracket.

6. Unscrew (if necessary) and remove the disc.

7. Measure the diameter of the disc andrecord the information in the appropriate location.

3.1.2 Removing drum brake system.

Procedure

1. Remove the drum screws, if necessary.
2. Remove the drums.
3. Measure the diameter of the brakes andrecord the information in the appropriatelocation.

Figure 3:13 removal of drum brake

3.1.3 Removing Master Cylinder

1. Loosen the bolt and block the brake lines, or crimp and cut them.
2. Disconnect or cut the electrical wiring.
3. Loose the bolt and remove the master cylinder

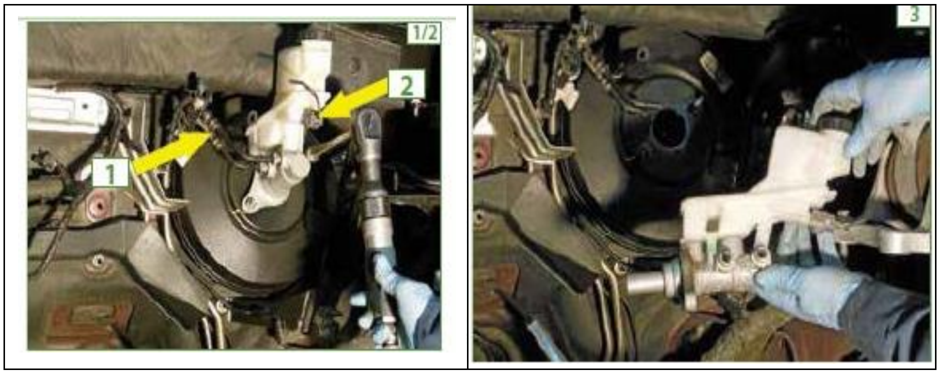


Figure 3:14 Removal of master cylinder

3.1.4 Removal of Power Brakes (Assisted brakes or brake "booster")

Procedure

1. Dismantle the cover on the steering column.
2. Remove the lock (clip) from the power brake lever.
3. Unbolt the power brake or, if required, unlock it by turning.
4. Vacuum model; secure the pin with tap to avoid looing it.

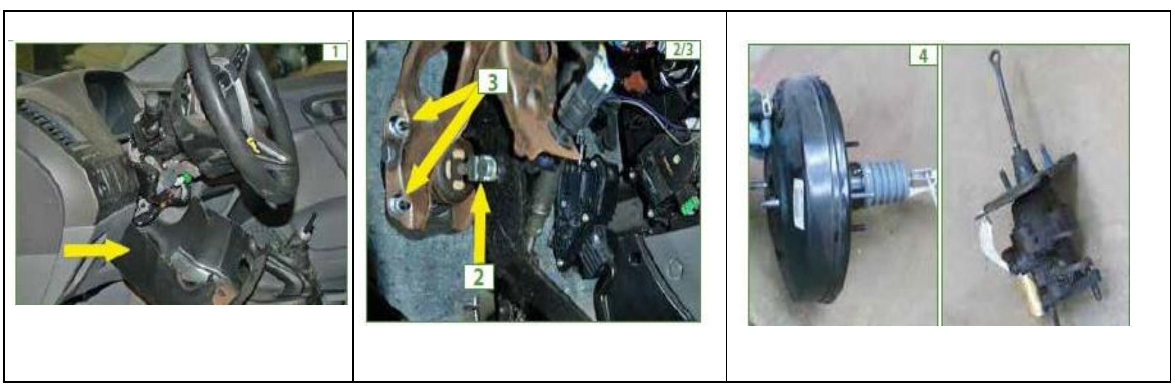


Figure 3:15 Removal of Power Brakes

3.1.5 Removing of ABS

Steps

1. Loosen the bolt and block the brake lines, or crimp and cut them.
2. Disconnect or cut the electrical wiring.
3. Loosen the bolt and remove the ABS module.

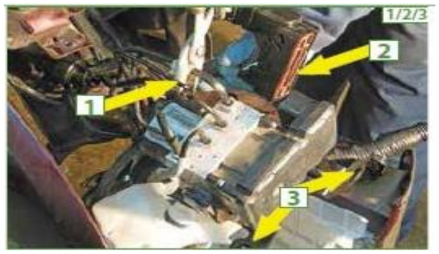


Figure 3:16 ABS removal

- **Master Cylinder Replacement**

To remove a master cylinder, disconnect the brake lines at the master cylinder. Install plugs in the brake lines and master cylinder to prevent dirt from entering. Remove the nuts that attach the master cylinder to the fire wall power brake unit and remove the cylinder. Reassemble, install, and bleed the master cylinder according to the manufacturer's directions.

- **Brake Shoe Replacement**

Brake linings that are worn to within 1/32 inch (0.79 mm) of a rivet head or that have been contaminated with brake fluid, grease, or oil must be replaced. Failure to replace worn linings results in a scored drum. When it is necessary to replace brake shoes, they must also be replaced on the wheel on the opposite side of the vehicle. Inspect brake shoes for distortion, cracks, or looseness. If these conditions exist, the shoe must be discarded. Do not let brake fluid, oil, or grease touch the brake lining.

- **Selecting Replacement Linings**

Identification codes, called the automotive friction material edge codes, are printed on the edges of drum brake linings and disc brake pads. The letters and numbers identify the manufacturer of thelining material and the material used, and the last two letters identify the cold and hot coefficients of friction.

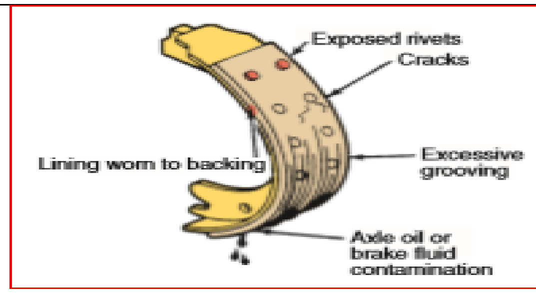


Figure 3:17 Potential brake shoe problems

Figure 3:18 Identification codes are printed on the edges

Replacing Wheel Cylinders

Wheel cylinder leaks reveal themselves in several ways:

(1) Fluid can be found when the dust boot is peeled back.

(2) The cylinder, linings, and backing plate, or the inside of a tire might be wet

(3) There might be a drop in the level of fluid in the master cylinder reservoir. Such leaks can

cause the brakes to grab or fail and should be immediately corrected.

Figure 3:19 check for internal wheel cylinder leaks of drum brake

Replacing a Wheel Cylinder

Procedure.

1. Remove the brake shoe assemblies from the backing plate before proceeding.
2. Use the appropriate tubing wrench and disconnect the hydraulic line where it enters the wheel cylinder.
3. Remove the plates, shims, and bolts that hold the wheel cylinder to the backing plate.
4. Remove the wheel cylinder from the backing plate and clean the area with a proper cleaning solvent.
5. Install the new wheel cylinder.
6. Thread the brake line into the cylinder before attaching the wheel cylinder to the backing plate. Once the cylinder's mounting bolts are tightened to specifications, tighten the brake line. Then reassemble the brake unit and bleed the system.

Removing and Replacing Brake Pads

1. Front brake pad replacement begins with removing brake fluid from the master cylinder reservoir.
2. Raise the car. Make sure it is safely positioned on the lift. Remove its wheel assemblies.
3. Inspect the brake assembly. Look for signs of fluid leaks, broken or cracked lines, or a damaged brake rotor. If any problem is found, correct it before installing the new brake pads.
4. Loosen the bolts and remove the pad locator pins.
5. Lift and rotate the caliper assembly from the rotor.
6. Remove the brake pads from the caliper assembly.

1	2
	

3	4
	
5	6
	

7. Fasten a piece of wire to the car’s frame and support the caliper with the wire.
8. Check the condition of the locating pin insulators and sleeves.
9. Place a piece of wood over the caliper’s piston and install a C-clamp over the wood and caliper. Tighten the clamp to force the piston back into its bore.
10. Remove the clamp and install new locating pin insulators and sleeves, if necessary.
11. Install the new pads into the caliper.
12. Tighten the caliper bolt.

7	8

	
9	10
	
11	12
	

Caliper Removal

To be able to replace brake pads, service the rotor, or to replace the caliper, the caliper must be removed. The procedure for doing this varies according to caliper design. Always follow the specific procedures given in a service manual. Use the following as an example of these

procedures:

1. Remove the brake fluid from the master cylinder.
2. Raise the vehicle and remove the wheel and tire assembly.
3. On a sliding or floating caliper, install a C-clamp with the solid end of the clamp on the caliper housing and the screw end on the metal portion of the outboard brake pad. Tighten the clamp until the piston bottoms in the caliper bore. then remove the clamp. Bottoming the

piston allows room for the brake pad to slide over the ridge of rust that accumulates on the edge of the rotor.

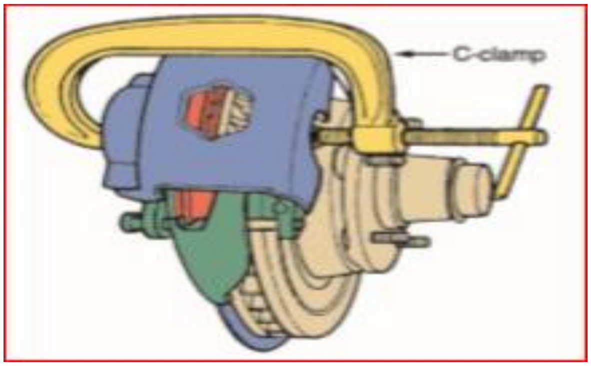


Figure 3:20 Bottoming the piston in the caliper's

4. On threaded-type rear calipers, the piston must be rotated to depress it, which requires a special tool.

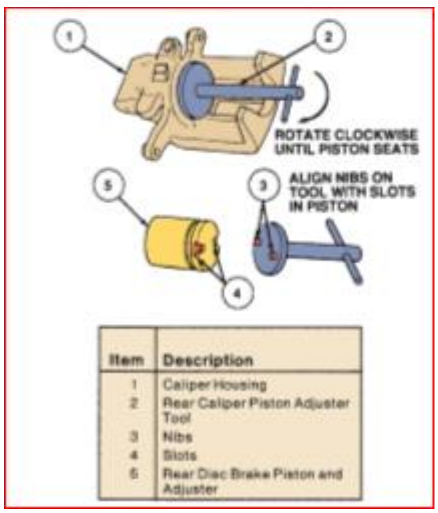


Figure 3:21 A special tool is required to move a threaded piston into its bore

5. Disconnect the brake hose from the caliper and remove the copper gaskets or washer and cap the end of the brake hose. If only the brake pads are to be replaced, do not disconnect the brake hose.
6. Remove the two mounting brackets to the steering knuckle bolts. Support the caliper when removing the second bolt to prevent the caliper from falling.
7. On a sliding caliper, remove the top bolts, retainer clip, and antirattle springs. On a floating caliper, remove the two special pins that hold the caliper to the anchor plate (Figure 50–21). On a fixed caliper, remove the bolts holding it to the steering knuckle. On

all three types, get the caliper off by prying it straight up and lifting it clear of the rotor.

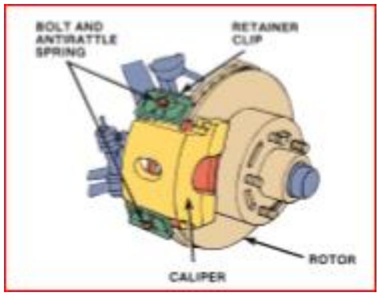


Figure 3:22 Sliding caliper removal

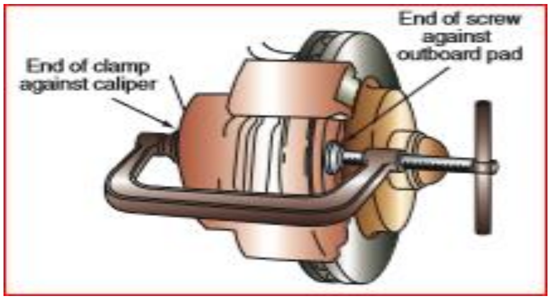
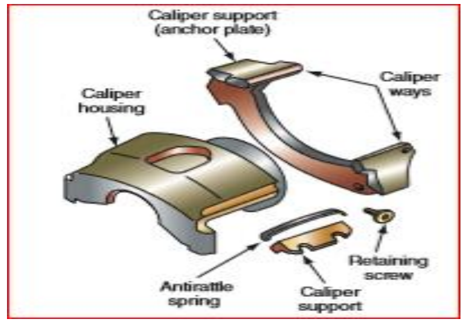
- **Caliper Disassembly**

If the caliper must be rebuilt, it should be taken to the workbench for servicing. Drain any brake fluid from the caliper by way of bleeder screws. Remove the bleeder valve protector, if so equipped. On a floating caliper, examine the mounting pins for rust that could limit travel. Most manufacturers recommend that these pins and their bushings be replaced each time the caliper is removed. This is a good idea because the pins are inexpensive and a good insurance against costly comebacks. On a fixed caliper, check the pistons for sticking and rebuild the caliper if this problem is found. To disassemble the caliper, the piston and dust boot must first be removed.

Insert the used outer pad or a block of wood into the caliper. Place a folded shop towel on the face of the lining to cushion the piston. Apply low air pressure (NEVER MORE THAN 30 PSI) to the fluid inlet port of the caliper to force the piston from the caliper housing.

- **Rotor Service**

If the thickness of the rotor is below or close to the minimal allowable thickness or is badly distorted, it must be replaced. If the thickness is greater than the minimum specifications, it can be trued and smoothened with a brake lathe. Rotors that have minor imperfections or are slightly unparallel can be turned true and smooth with a brake lathe.

<table>
<tr>
<td>1,Use a C-clamp to retract the piston into the bore of the caliper.

</td>
<td>2,To remove a sliding caliper, remove the support retaining screws, antirattle springs and then the supports.

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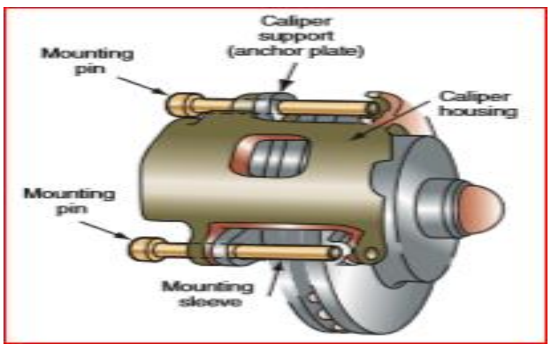
</tr>
<tr>
<td>3. To remove a floating caliper, remove the pins holding it to the steering knuckle or bracket.

</td>
<td>4. Some calipers can be rotated up on its upper mounting pin to replace the brake pads.
</td>
</tr>
</table>

Figure 3:23 Place the caliper face down on a

Removing a Rotor

To remove a rotor, raise the vehicle and remove the wheel. Then remove the caliper from the rotor and suspend it with wire from the suspension of the vehicle. Before you remove a rotor, mark it "L" or "R" for left or right so that it gets reinstalled on the same side of the vehicle from which it was removed.

If the rotor is a two-piece floating rotor, remove it from the hub by pulling it off the hub studs. If you cannot pull the rotor off by hand, apply penetrating oil on the front and rear rotor-to-hub mating surfaces. Strike the rotor between the studs using a ball-peen hammer. If this does not free the rotor, attach a three-jaw puller to the rotor and pull it off. Whenever you separate a floating rotor from the hub flange, clean any rust or dirt from the mating surfaces of the hub and rotor. Neglecting to clean rust and dirt from the rotor and hub mounting surfaces before installing the rotor will result in increased rotor lateral runout, leading to premature brake pulsation and other problems. If the rotor and hub are a one-piece assembly, remove the outer wheel bearing and lift the rotor and hub off the spindle.

- **Brake Lathes**

A brake lathe cuts metal away to achieve the desired surface finish. There are basically two types of brake disc lathes used by the industry. The first one, a bench brake lathe, has the capability of resurfacing brake drums and brake discs after they have been removed from the vehicle. The lathe rotates the disc as cutting tools work their way across the braking surface of the disc. The second type is an onvehicle brake lathe. This type of brake lathe is a time saver because the rotor does not need to be removed from the vehicle. Special fixtures are used to straddle the rotor so the cutting tools can precisely cut both sides of the rotor. An electric motor is used to rotate the disc and hub assembly during cutting. Whenever you refinish a rotor, remove the least amount of metal possible to achieve the proper finish. This helps to ensure the longest service life from the rotor. Never turn the rotor on one side of the vehicle without turning the rotor on the other side. Left- and right-side rotors should be the same thickness, generally within 0.002 inch to 0.003 inch. Similarly, equal amounts of metal should be cut off both surfaces of a rotor.

- **Bench Lathes**

On a bench, off-vehicle lathe, the rotor is mounted on the lathe's arbor and turned at a controlled speed while a cutting bit passes across the rotor surface to remove a few thousandths of an inch of metal The lathe turns the rotor perpendicularly to the cutting bits so that the entire rotor surface is refinished. Most rotor cutting assemblies have two cutting bits. The rotor mounts between the bits and is pinched between them. As the cut is made, the same amount of surface material should be cut from both sides of the rotor.

- **Bench Lathes**

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Figure 3:24 A typical bench lathe for resurfacing brake rotor

- **On-Vehicle Brake Lathes**

The advantage of an on vehicle lathe is that the rotor does not need to be removed. On-vehicle lathes also are ideal for rotors with excessive run-out problems. To install the lathe, remove the wheel and then remove the caliper. If any end play is present in an adjustable tapered roller bearing, carefully tighten the adjusting nut by hand just enough to remove the end play before installing the lathe. After turning the rotor, readjust the bearing. To hold a two-piece floating rotor to its hub, reinstall the wheel nuts with flat washers or adapters against the rotor. Carefully follow the manufacturer's mounting instructions andattach the lathe to the rotor. Some on-vehicle lathes mount on the caliper support; others are supported on a separate stand attach the lathe to the rotor.

Figure 3:25 An on-the-vehicle brake lathe

Some on-vehicle lathes mount on the caliper support;

others are supported on a separate stand. Some on-vehicle lathes use the vehicle’s power to rotate the rotor; others use an electric motor. If the engine is used to turn the rotor, the lathe can be used only on drive wheels. However, this presents a problem because the differential gearing in the transaxle transmits the power to the opposite wheel, not to the rotor to be resurfaced. To prevent that opposite wheel from turning, that wheel can be lowered to the floor or the brake on the opposite side can be applied. This is done by removing and plugging the brake hose to the caliper on the rotor you are refinishing. Apply the brakes; this will lock the other wheel. Self-powered on-vehicle lathes are more popular. These have the advantage of being able to machine on nondriving wheels, and rotor speed can be controlled more exactly. An on-car lathe may be mounted on the brake caliper support or on its own stand and indexed to the hub and the wheel studs. Each lathe has its own operating instructions, which you must follow carefully.

Installing a Rotor If the rotor is a two-piece floating rotor, make sure all mounting surfaces are clean. Apply a small amount of antiseize compound to the pilot diameter of the disc brake rotor before installing the rotor on the hub. Reinstall the caliper. If the rotor is a fixed, one-piece assembly with the hub that contains the wheel bearings, clean and repack the bearings and install the rotor. Install the wheel and tire on the rotor and torque the wheel nuts to specifications, following the recommended tightening pattern. Failure to tighten in the correct pattern may result in increased lateral run-out,brake roughness, or pulsation as well as damage to the wheels. After lowering the vehicle to the ground, pump the brake pedal several times before moving the vehicle. This positions the brake linings against the rotor.

3.2 Assembling and Testing Brake System

3.2.1. Assemble Wheel Cylinder

a) Before the cylinder is assembled, lubricate the new cups and the piston with the correct brake fluid.

b) If the boots are deteriorated, or do not fit tightly on the push rods and the cylinder housing, replace the boots.

c) Wash the wheel cylinder with brake fluid.

d) Install the spring in the cylinder.

e) Install the cups in each end of the cylinder with the open ends of the cups toward each other.

f) Install the pistons in each end of the cylinder with the recessed end of the pistons toward the open ends of the cylinder.

g) Install dry boots over each end of the cylinder.

3.2.2. Assemble of Hydraulic Brake

1. Before assembly, apply a thin layer of Meritor specification 0-616 brake lubricant such as Texaco Thermatex EP-2 grease or equivalent to the following parts:
   a. Adjustment bolt assemblies.
   b. Anchor pins, anchor pin holes and anchor pin slots.
   c. Push rod ends of the wheel cylinders.
   d. The surfaces of the guide washers that slide against the brake shoes.
2. Install the wheel cylinder to the spider. Tighten the wheel cylinder capscrews to 15-20 lb. ft. (20-27 N•m).
3. Install the two adjustment bolt and star wheel assemblies into their threaded holes. The end of each adjustment bolt must extend into the slot for the shoe approximately 0.125 inch (3.175 mm). Install each star wheel clip with its screw and lock washer.
4. Install the two anchor pins, with their slots in position to engage the shoes, in the anchor pin holes.
5. Install both shoe guide bolts into their holes from the back of the spider and assemble one spacer and one washer on each bolt.
6. Place one shoe in position to engage the anchor pin slot, the adjustment bolt slot and the wheel cylinder push rod. Install a shoe guide washer and nut to the shoe guide bolt.

7. Put the other shoe in position to engage the opposite anchor pin slot, adjustment bolt and wheel cylinder push rod. Install a shoe guide washer and nut to the shoe guide bolt.
8. Tighten the shoe guide nut on each shoe guide bolt until there is no clearance between the washer and the shoe. Loosen the nut 1/2 turn and install the cotter pins.
9. Install the four shoe return springs.

NOTE: The bleeder cylinder can be installed at either the top or bottom positions on the brake. In either installation the bleeder outlet MUST be installed at the top of the cylinder.

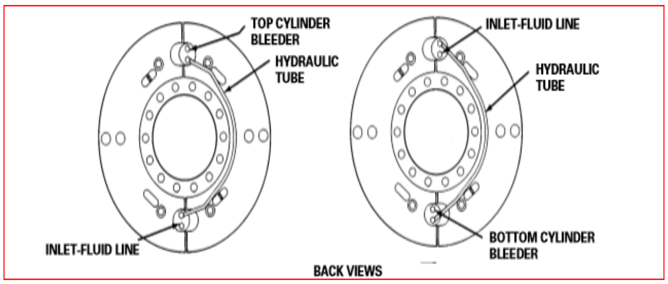


Figure 3:26 Install the four shoe return springs

10. Install the hydraulic brake tube assembly to the two wheel cylinders.
11. Connect the hydraulic line and install the brake drum and wheel.
12. Bleed the hydraulic system after all brakes are assembled and adjusted.

3.2.3. Assemble DLM Brake

1. Before assembly, apply a thin layer of Meritor specification 0-616 brake lubricant such as Texaco Thermatex EP-2 grease or equivalent (listed on page 31) to the following parts:
   a. The sides of the brake lever and shoes that slide against each other.
   b. The ends of the shoe webs.
   c. The surfaces of the wear pads and actuating pawls.
2. If it was removed, install the brake backing plate in the same position as marked in Step 10 of the Disassembly Section. Tighten the capscrews to the specifications set by the vehicle builder.
3. Put the roller(s) in position on the actuator pawl pin at the lever opening on the backing plate.

4. Install the brake actuator lever with the large hole in the tab over the pawl pin that is opposite the actuator pawl. Set the lever arm in the backing plate opening with the outer edge of the lever next to the roller.
5. Install the brake shoes with the webs against the actuator lever and the pawl pins through the web slots.
6. Use a brake shoe return spring installation tool to connect the shoe return springs to the brake shoes in the slots nearest the backing plate.
7. Assemble the brake drum and drive shaft using standard procedures.

3.3 Post Repair Test

3.3.1 Inspect Parts

It is important that you carefully inspect all parts before assembly starts. Check all parts for wear or damage and repair or replace them as required. Replacement of these parts now can prevent problems with the assembly later.

- Check all castings and backing plates for cracks, loose rivets and correct alignment. Replace all damaged parts.
- Check all adjusting bolts, guide pins and pawl pins for corrosion and wear. Replace or repair damage parts.
- If the brake has automatic adjuster pawls, check the pawl breakaway torque with a torque wrench to verify that the torque is between 120-240 lb. in. (13-27 N•m).
- Check brake shoes for rust, expanded rivet holes, broken welds and correct alignment. Replace damaged shoes.
- Check anchors, anchor pins and shoe bushings for wear or damage. Replace as necessary.
- Replace all shoe return springs at time of brake overhaul.
- Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting and distortion. Replace damaged brake drums.
- Inspect wheel cylinders for leaks and smooth action.

3.3.2 General Test Conditions

- For the approval or assessment of any vehicle, the braking performance shall be measured during road tests conducted following these rules:

- The vehicle's condition as regards mass must be as prescribed for each type of test and be specified in the test report;
- The test must be carried out at the speeds prescribed for each type of test; if the maximum design speed of a vehicle is lower than the speed prescribed for a test, the test shall be performed at a speed that is set at a multiple of 5 km/h that is 4 to 8 km/h less the vehicle's maximum speed. The stopping distance achieved shall be no greater than specified by the formula given for the particular requirement.
- During the tests, the force applied to the brake control in order to obtain the prescribed performance must not exceed the maximum force laid down;
- The road must be dry and have a surface affording an adhesion coefficient (PFC) in the range 0.8 - 0.9, unless specified otherwise in the relevant stages of the test sequence.
- The tests must be performed when there is no wind liable to affect the results
- Temperatures at the start of the tests.
- Ambient; The ambient temperature shall be lie between 0 and 45oC.
- Tyres; These must be cold and at the pressure prescribed for the load actually borne by the wheels when the vehicle is stationary
- Brakes; The average initial brake temperature (IBT) of the wheel brakes on the hottest axle must be between 65 and 100oC. Temperatures may be measured as outlined in ISO PAS 12158.

3.3.3. Behavior of the vehicle during braking

- In braking tests, and in particular in those at high speed, minor steering correction is allowed but the general behavior of the vehicle during braking must be checked.
- Behavior of the vehicle when braking on a road on with reduced adhesion must meet the relevant Braking Distribution or ABS requirements.
- In the case of a Regenerative Braking System of Category B, where the braking for a particular axle (or axles) is comprised of more than one source of braking torque.

3.3.4. Preparation of Brake Linings.

If tests are to be made on a new production vehicle, the burnish sequence below shall be undertaken before brake performance tests are commenced.

If testing a manufacturer submitted vehicle which, by bedding and conditioning the linings in a similar manner to the procedure explained below, has been made ready for brake performance testing, the following procedure may be omitted.

General information.

The burnish procedure is a series of stops which also provides the opportunity for vehicle familiarization and final adjustment and checking of the instrumentation. There is no end requirement to this initialization procedure other than brake readiness.

- **Vehicle conditions**.
  a) Vehicle laden.
  b) In the normal gear for the test speed.
  c) Conducted on a normal dry asphalt road surface or equivalent.

3.3.5 Test conditions and procedure.

a) **IBT:** No greater than 100oC at the commencement of each stop.
b) Test speed 80 km/h.
c) Braking rate: Maintain a constant 3.0 m/s2 during each stop.
d) Pedal force: Adjust as necessary to maintain the 3 m/s2 braking rate.
e) There shall be no wheel locking for any period longer than 0.1 s at speeds above 15 km/h.
f) Make 200 stops as above allowing a time interval between the commencement of each such as to allow brake temperatures to cool to 100oC or the distance interval of 2 km, whichever occurs first.
g) Accelerate, after each stop back to 80 km/h and maintain that speed until making the next stop.
h) After completing the burnish procedure, allow the brakes to cool and then adjust all the brakes in accordance with the manufacturers specification.

Self-check 3.1

Directions: Answer all the questions listed below.

Part I: Give short answer for the following questions.

1. What is the primary difference between an automatic traction control system and a stability control system?
2. Briefly describe the proper steps and testing needed to accurately diagnose antilock braking systems.
3. An ABS modulates brake pressure. What does this mean?
4. Explain the difference between oversteer and understeer.
5. List the various methods used by traction control systems to eliminate wheel spin.

Part II:Choose the correct answer from the given alternatives.

1. W hich of the following could cause an extremely hard brake pedal?

   a. air in the system

   b. excessively worn brake pads

   c. use of the wrong fl uid

   d. a leaking diaphragm in the vacuum power booster
2. Which of the following is not a factor in determining the effectiveness of a brake system? a. heat dissipation

   b. lubricant

   c. pressure

   d. frictional contact area
3. While bleeding a brake system: Technician A loosens the brake line fi tting at the master cylinder to bleed the system if a bleeder screw is seized cannot be loosened. Technician B uses shop air to push the fl uid and air from the wheel units to the master cylinder. Who is correct?

   a. Technician A b. Technician B

   c. Both A and B d. Neither A nor B

Operation Sheet 3.1

Operation Title: Master Cylinder Overhaul

Purpose: Every learner should know how to overhaul a master cylinder..

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

1. REMOVE RESERVOIR
   (a) Remove the set screw and pull out the reservoir.
   (b) Remove the cap and strainer from the reservoir.
2. REMOVE TWO GROMMETS
3. PLACE CYLINDER IN VISE
4. REMOVE PISTON STOPPER BOLT
   Using a screwdriver, push the pistons in all the way and remove the piston stopper bolt and gasket. HINT: Tape the screwdriver tip before use.

5. REMOVE TWO PISTONS AND SPRINGS

(a) Push in the piston with a screwdriver and remove the snap ring with snap ring pliers.

(b) Remove the No.1 piston and spring by hand, pulling straight out, not at an angle.

NOTICE: If pulled out at an angle, there is possibility of damaging the cylinder bore.

(c) Place a rag and two wooden blocks on the work table, and lightly tap the cylinder flange against the block edges until the No.2 piston drops out of cylinder.

HINT: Make sure the distance (A) from the rag to the top of blocks is at least 100 mm (3.94 in.).

Inspection of Master Cylinder Components Hint: Clean the disassembled parts with compressed air.

1. Inspect Cylinder Bore for Rust or Scoring
2. Inspect Cylinder for Wear or Damage If necessary, clean or replace the cylinder.

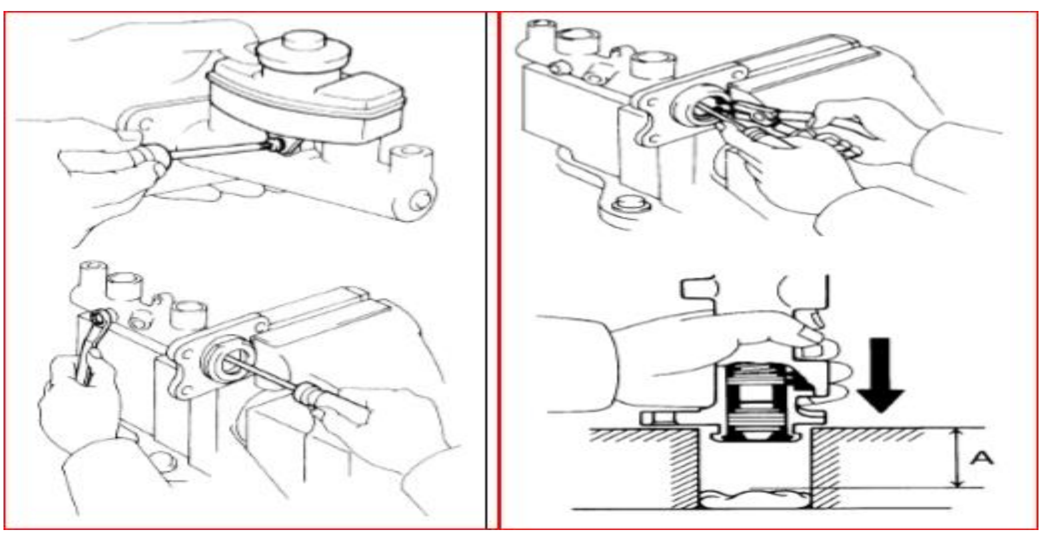
Assembly of Master Cylinder

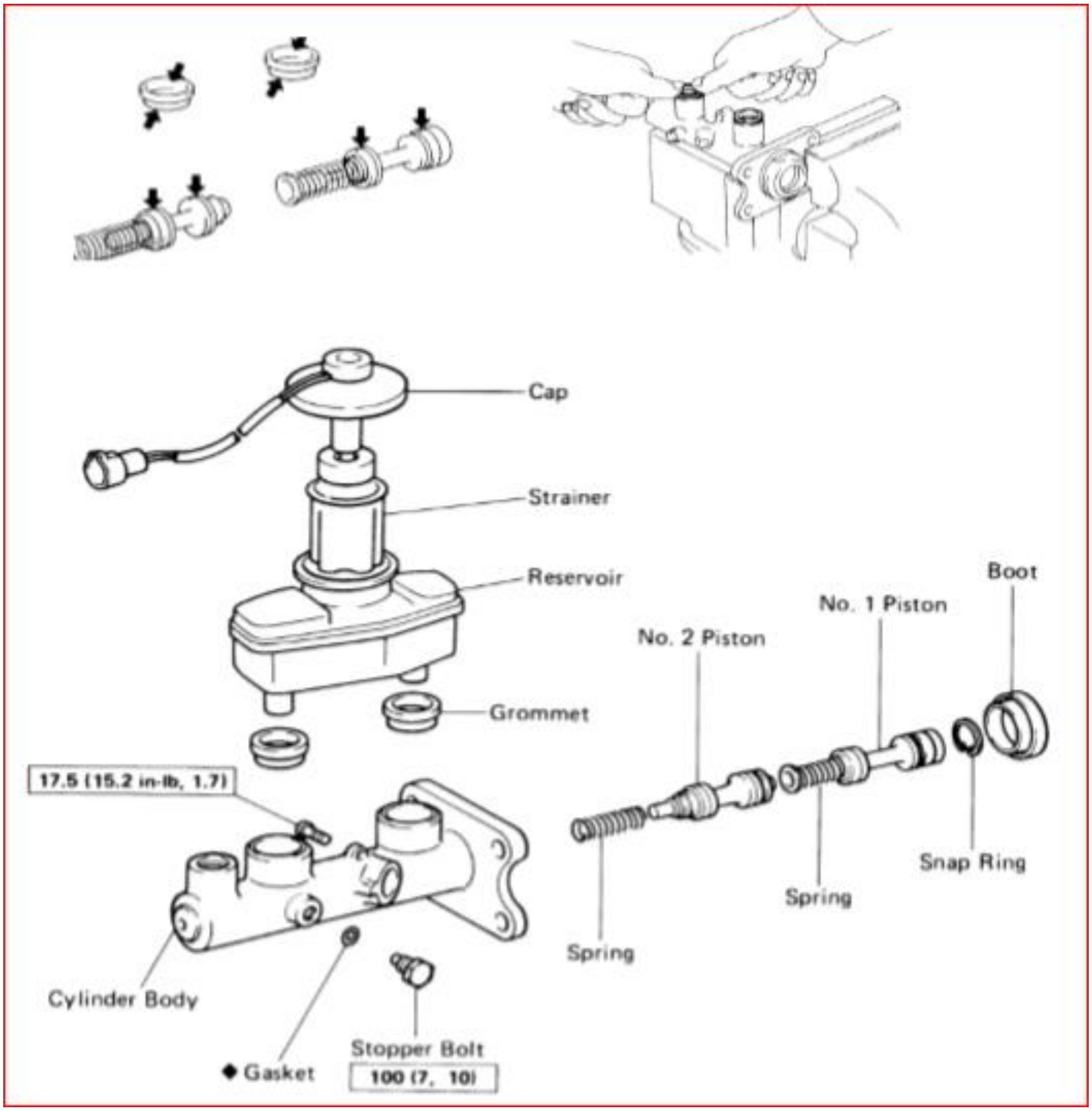
1. Apply Lithium Soap Base Glycol Grease to Rubber Parts Indicated By Arrows
2. Install Two Springs and Pistons Notice: Be careful not to damage the rubber lips on the pistons.

a) Insert the two springs and pistons straight in, not at an angle. NOTICE: If inserted at an angle, there is a possibility of damaging the cylinder bore.

(b) Push in the piston with a screwdriver and install the snap ring with snap ring pliers.
HINT: Tape the screwdriver tip before use.

3. Install Piston Stopper Bolt Using a screwdriver, push the piston in all the way and install the piston stopper bolt over the gasket. Torque the bolt.
4. Install Two Grommets
5. Install Reservoir




Cap
Strainer
Reservoir
Grommet
17.5 (15.2 in-lb, 1.7)
Cylinder Body
◆ Gasket
Stopper Bolt
100 (7, 10)
Boot
No. 1 Piston
No. 2 Piston
Snap Ring
Spring
Spring

Operation Sheet 3.2

Operation Title: Servicing Disc Brake

Purpose: Every learner should know how to service a disc brake.

Conditions for the operations:

- ✓ Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Different types of wrench

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

Replacement of Brake Pads

If a squealing noise occurs while braking, inspect the brake pads.

1. **Remove front wheel**

Remove the wheel and temporarily fasten the rotor disc with the hub nuts.

2. **Inspect pad lining thickness**

Check the pad thickness through the cylinder inspection hole and replace pads if not within specification. Minimum thickness: 1.0 mm (0.039 in.)

3. Remove brake hose bracket Remove the two bolts and remove the bracket.

4. Remove cylinder from torque plate

(a) Remove the installation bolt from the torque plate. (

b) Remove the brake cylinder and suspend it so the hose is not stretched. HINT: Do not disconnect the brake hose.

5. Remove following parts

(a) Two anti-squeal springs

(b) Two brake pads

(c) Four anti-squeal shims

(d) Two pad support plates

6. Check rotor disc thickness

7. Check rotor disc runout

8. Install two pad support plates Install the two pad support plates to the torque plate.

9. Install new pads

(a) Install anti-squeal shim No.1 to the pad.

(b) Install the pads onto each support plate. HINT: Install the pads so the wear indicator is at the bottom side.

(c) Install the anti-squeal shim No.2 over shim No.1.

(d) Install the two anti-squeal springs. NOTICE: Do not allow oil or grease to get on the rubbing face.

10. Install cylinder

(a) Draw out a small amount of brake fluid from the reservoir.

(b) Press in piston with a hammer handle or an equivalent. HINT: Always change the pad on one wheel at a time as there is a possibility of the opposite piston flying out.

(c) Insert the brake cylinder carefully so the boot is not wedged. Install and torque the installation bolt.

11. Install brake hose bracket Install the brake hose bracket and torque the two bolts.

12. Install front wheel

13. Check that fluid level is at max line

Disassembly of Cylinder

1. Remove sliding bushing and dust boot

2. Remove main pin boot Pull out the main pin boot.

3. Remove cylinder boot set ring and cylinder boot

Using a screwdriver, remove the cylinder boot set ring and cylinder boot.

4. Remove piston from cylinder

(a) Put a piece of cloth or an equivalent as shown.

(b) Use compressed air to remove the piston from the cylinder. CAUTION: Do not place your fingers in front of the piston when using compressed air.

5. Remove piston seal from brake cylinder

Using a screwdriver, remove the piston seal.

Assembly of Cylinder

1. Apply lithium soap base glycol grease to following parts

(a) Main pin boot

(b) Sliding bushing and boot

(c) Piston, piston seal and cylinder boot

2. Install piston seal and piston in cylinder

3. Install cylinder boot and set ring in cylinder

4. Install main pin boot Push in the main pin boot.

5. Install sliding bushing and dust boot

(a) Install the sliding bushing and dust boot into the brake cylinder.

(b) Insure that the boot is secured firmly to the brake cylinder groove.

Installation of Cylinder

1. Install pads

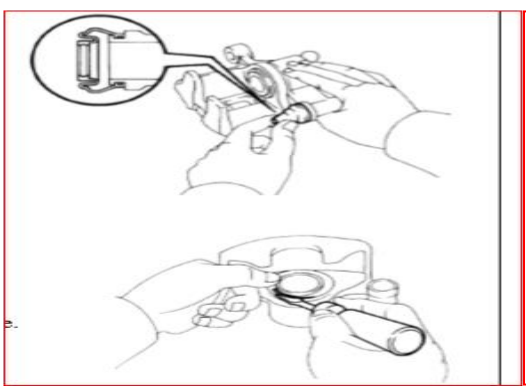
2. Install cylinder

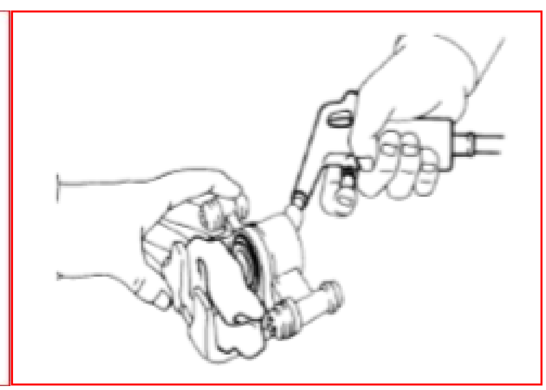
3. Install flexible hose to brake cylinder set the flexible hose and new gaskets in position and install the union bolt.

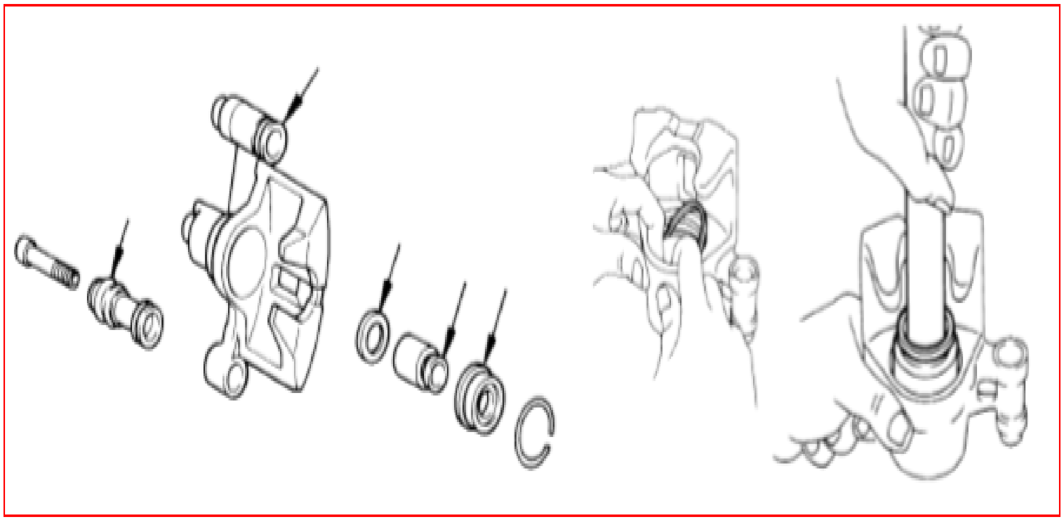
4. Install brake hose bracket Install the brake hose bracket and tighten the two bolts.

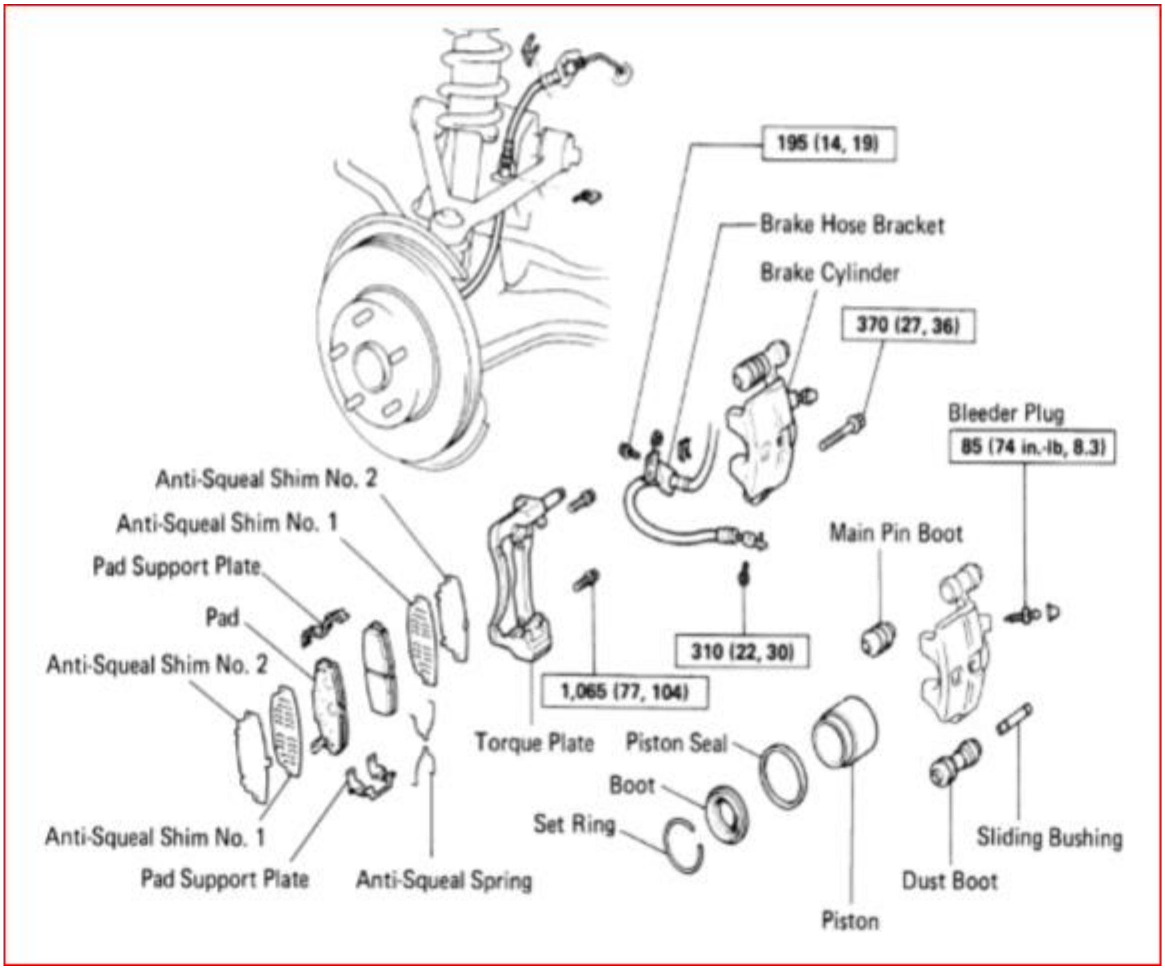
5. Fill brake reservoir with brake fluid and bleed brake system

6. Check for leaks








195 (14, 19)
Brake Hose Bracket
Brake Cylinder
370 (27, 36)
Bleeder Plug
85 (74 in.-lb, 8.3)
Main Pin Boot
Anti-Squeal Shim No. 2
Anti-Squeal Shim No. 1
Pad Support Plate
Pad
Anti-Squeal Shim No. 2
310 (22, 30)
1,065 (77, 104)
Torque Plate
Piston Seal
Boot
Set Ring
Anti-Squeal Shim No. 1
Pad Support Plate
Anti-Squeal Spring
Piston
Dust Boot
Sliding Bushing

LAP Test 1

Practical Demonstration

Name: ___________________________ Date: _____________

Time started: _____________________ Time finished: ________________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: Inspecting brake system components**.**

Task 2: Adjusting brake linkages

Task 3: Bleeding hydraulic system

Task 4: Overhauling braking system and subassemblies

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