TVET CERTIFICATE IV IN AUTOMOBILE TRANSMISSION AND CONTROL SYSTEMS TECHNOLOGY

MECHANICAL BRAKE SYSTEM REPAIRING

ATCMB401

REPAIR MECHANICAL BRAKE SYSTEM

Competence

RTQF Level: 4

Credits: 9

Learning Hours: 90

Sector: Transports and Logistics

Sub-sector: Automobile Transmission

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Purpose statement

This module will allow the Learner to identify, describe, maintain and repair mechanical brake system. The learner will be able to disassemble, inspect, clean, replace, reassemble and adjust mechanical brake system components. Nevertheless, the learner should be able to test a mechanical brake system.

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Total Number of Pages: 75

Learning Unit 1 – Identify mechanical brake system

Introduction to Mechanical Brakes

Mechanical brakes arrest the energy of a machine or object via force, the force is delivered to a body in rotary or linear motion, such as an axle, shaft, or wheel, to slow or stop motion. There are operated by a various mechanical linkages Friction-based brakes utilize a coarse and rugged material (i.e. brake liner) that is tightened or pressed against a body in motion to decelerate. Friction-based braking generates immense heat and some noise, degrading all of the engaged surface areas. Brake capacity decreases with every cycle and requires inspection and replacement.

Friction-type brakes are heavily used in automotive applications, but mechanical brakes are also essential in material handling, manufacturing, and other power transmission applications.

LO 1.1 – Identify mechanical brake system

- Content/Topic 1 Definition to mechanical brake system

Definition

Mechanical brakes:

The mechanical brakes are assemblies consisting of mechanical elements for the slowing or stopping of shafts in equipment drives. They use levers or linkages to transmit force from one point to another. Braking slows or stops the movement of the coupled shafts.

Brake:

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.

Purposes of mechanical brake system

The brake system has three tasks:

– To reduce the speed of the automobile

– To bring the automobile to a halt (in the case of an emergency stop, as quickly as possible)

– To prevent a still-standing automobile from rolling

- **Content/Topic 2 Identification the types of mechanical brake system**

Classification of Brakes

The following are the classifications of Brakes

- By method of power
  - Mechanical brakes
  - Hydraulic brakes
  - Air brakes
  - Vacuum brakes
  - Power assisted hydraulic brakes
  - Magnetic brakes
  - Electrical brakes
- By method of application:
  - Service or foot brakes
  - Parking or hand brakes
- By method of operation:
  - Manual
  - Servo
  - Power operation
- By method of Braking contact
  - Internal Expanding Brakes
  - External Contracting Brakes
- By Method of Applying Brake force:
  - Single Acting Brakes.
  - Double Acting Brakes.
- **Factors considered when designing a brake system**
  - Energy principles ex: kinetic energy
  - Force principles ex: inertia force
  - Mechanical principles ex: mechanical advantage
  - Friction principles ex: coefficient of friction

Types of Mechanical Service Brakes

According to the operation of braking system there are three types:

- Parking brake
- Service brake
- Exhaust brake

1. **Service Brake**

- This system enables the speed of vehicle to be reduced if necessary until the vehicle is stationary.
- The service brake is operated continuously with the foot operated to reduce wheel speed

The brake system that fulfils the function of the service brake system during malfunction/failure of the service brake system is known as **Auxiliary brake system**. It has less effect considered to the service brake. The auxiliary brake can be performed by means of using steeply and gradually parking brake.

According to the different functions of service braking system, two types of brakes are used in modern cars: Drum brakes and Disc brakes.

2. **Parking brake**

The task of a parking brake (handbrake) is to keep a still-standing automobile in its place. The parking brake must be able to be operated independently from the main brake system (the operating brake). In automobiles with disc brakes in the front and drum brakes in the rear, the parking brake usually operates on the rear wheels.

3. **Exhaust brake**

Exhaust brakes slow light duty, diesel-powered vehicles quickly. They also prevent the brakes from overheating on downhill grades, as this causes brake fade and possibly even failure. Using your exhaust brakes properly can help brakes last up to three times longer.

It is also known as Retarders or continuous or frictionless**.** It can be employed to reduce a vehicle's speed; however, they differ in being unsuitable for actually halting the vehicle. The retarder is suitable for use on extended gradients.
Exhaust brakes retard power in a diesel engine, but in a different way than engine brakes. Engine brakes release compressed air through an exhaust valve, but exhaust brakes hold the compression in the engine and slow the crankshaft's rotation, which reduces vehicle speed.

LO 1.2 – Describe mechanical brake system

- Content/Topic 1 Description of mechanical brake system

Mechanical brake consists of several parts such as Brake pedal, Brake cables, Brake drum and shoes, Brake disc and pads, Rubber booster, Outer cap, Spring, Protector, Screw cap, Inner end, Equalizer, Parking brake strut, Adjuster screw assembly.

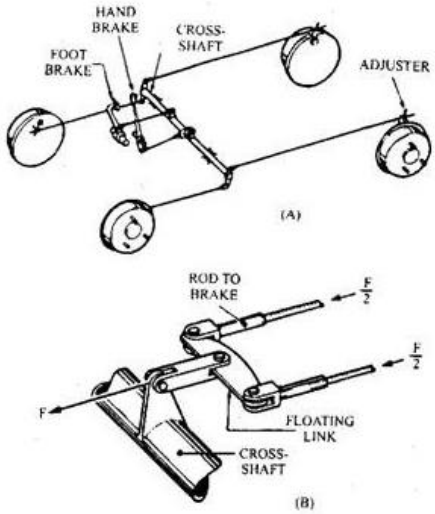


Figure 1 car mechanical braking system

1. **Brake Pedal:** Increase foot pressure by simple mechanical leverage.

2. **Vacuum booster:** A relatively large metal chamber assembly installed between the firewall (bulkhead) and the master cylinder. Uses vacuum to create additional force to the master cylinder, making the stopping process easier on the driver
3. **Hydraulic-booster**: Brake booster that uses the pressure of hydraulic fluid to provide braking assistant.
    - **Hydro-booster:** Also referred to as Hydro-booster II, Hydra booster, or Bendix hydraulic booster. Hydraulic booster unit is powered by the vehicle's power steering pump.
    - **Power master:** Sometimes called an electro hydraulic assist. Hydraulic power brake unit installed on some mid 1980's General Motors vehicles. Uses pressure supplied by an electrically driven hydraulic pump.
4. **Master cylinder**: Brake system device which stores fluid and provides the pressure to operate the other hydraulic components.
5. **Brake lines:** Hydraulic conduits made of steel that connect the stationary parts of the brake hydraulic system.
6. **Hoses:** Hydraulic conduits made of braided rubber that connects to the brake system parts which move in relation to each other.
7. **Multi-circuit brake system:** The multi-circuit brake system embodies a design in which forces are translated through two or more circuits.
8. **Brake fluid:** A special fluid compound used in hydraulic brake systems. It must meet exacting specifications, such as resistance to heating, freezing, and thickening.
9. **Wheel cylinder:** Hydraulic device used in drum brakes to change hydraulic pressure from the master cylinder into mechanical force that applies the brake shoes against the rotating drum.
10. **Disc brake caliper:** Cast iron or aluminum cylinder and piston assembly used to receive, contain, and convert hydraulic pressure from the master cylinder to mechanical force against brake pads.
11. **Disc Brake:** A brake assembly that uses a hydraulic caliper to actuate brake pads against a metal rotor. Used for both front and rear brakes.
12. **Drum brake:** (Internal expanding brakes). It is a brake system that uses a wheel cylinder to force two brake shoes against a rotating drum. Used primarily as rear brakes.
13. **Parking brake:** A hand- or foot- operated brake which prevents vehicle movement while parked by actuating the rear brakes.
14. **Parking brake cable:** Stranded steel wire cable used to apply the parking brakes. Cable thickness is usually around 3/16 (4.76 mm).
15. **Brake-pressure regulating valves:**

a) Metering valve: Used to keep the front brakes from applying before the rear brakes.

b) Proportioning valve: Hydraulic valve used to equalize system pressure between the front and rear brakes to prevent wheel lockup, installed in the rear brake line.

16. **Brake pedal:** The brake pedal is the pedal that you press with your foot in order to make a vehicle go slower or stop. When the driver puts his foot on the brake pedal, the system automatically applies the optimum pressure required to avoid hitting the car in front
17. **Brake cables:** Cables are used for braking on bikes with cable-pull brakes. They consist of two parts: an inner cable of braided stainless steel wire and an outer cable housing, and work by transmitting force using a combination of tension on the inner cable and compression to the housing.

- **Content/topic 2 Description of drum brake**

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.

Features of drum brake

- Self- reinforcement
- Dirt- proof design
- Parking brake easier to use
- Long idle time of brake pads
- Pads replacement and maintenance is costly and time- consuming
- Poor heat dissipation
- Tendency towards facing

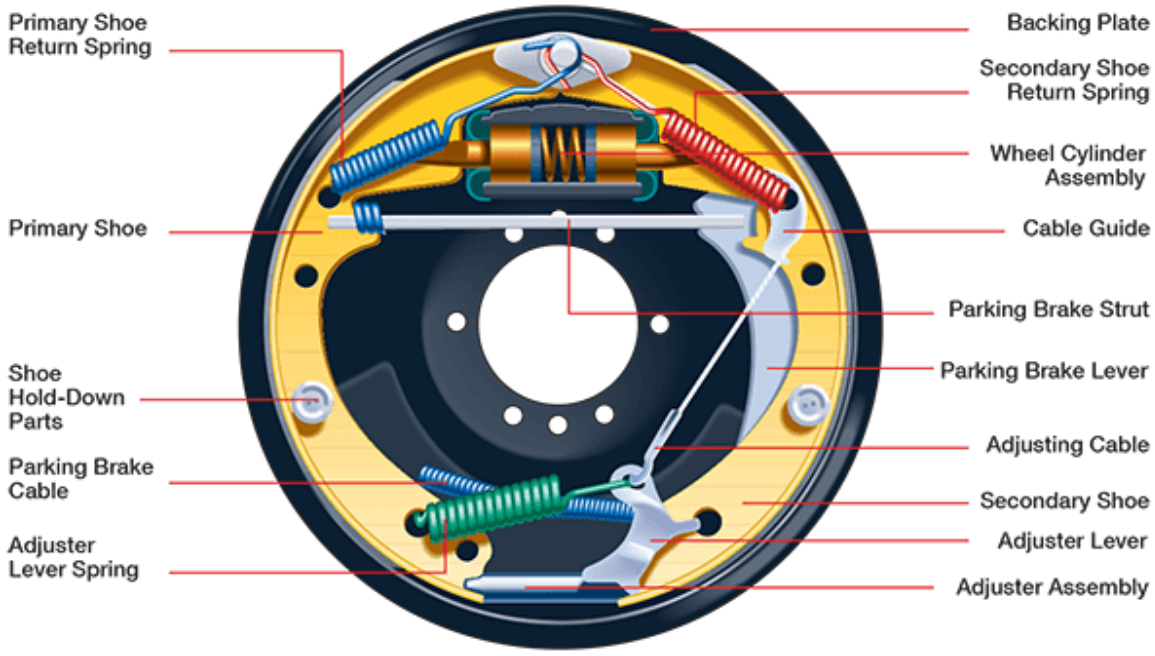


Figure 2 drum brake

The term drum brake usually means a brake in which shoes press on the inner surface of the drum.

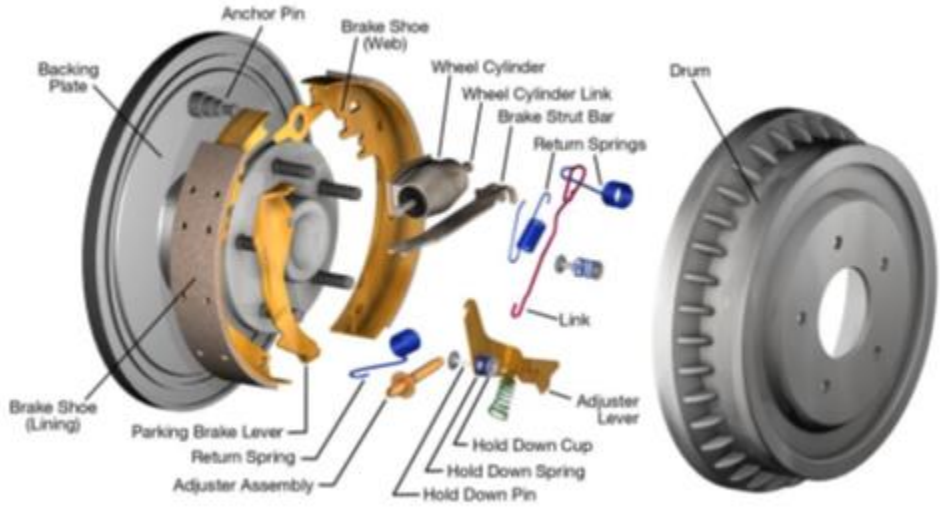


Figure 3 exploded view of drum brake

Backing plates

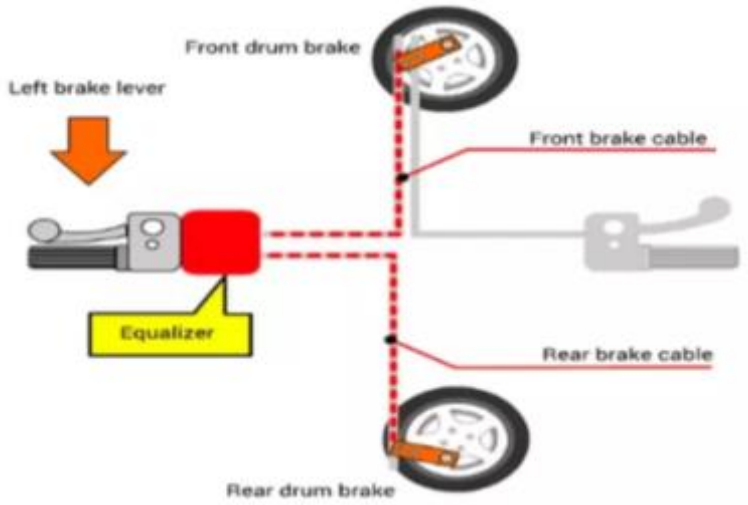
Dust covers or splash guards on disc brake systems can also be referred to as 'backing plates'. These components provide a shield from brake dust and water, reducing corrosion of suspension parts.

Figure 4 backing plate

- **Rubber booster:** This rubber ensures that the driver's foot does not slip off the brake pedal when the brakes are applied, especially when wet. Brake Booster – Giving Drivers Better Braking Control. The function of the brake booster is to give the driver control of the braking system under light pedal effort.

Figure 5 rubber booster

- **Equalizer**: Equalizer is the brain of the system. Pressing the left lever activates the Equalizer, which distributes the braking force between the front and rear wheels simultaneously giving perfect balance to the rider.



- **Parking brake strut:** A cable is attached to the **brake** lever. The lever pushes the rear shoe outward, and the **brake strut** forces the forward shoe into the drum. The secondary shoe faces the rear of the vehicle.

Figure 6 parking brake strut

- **Adjuster screw assembly:** A connection structure of an extensible shaft, wherein an outer shaft is spline-fitted to an inner shaft and an adjusting screw is moved in radial inner direction while being tightened to increase a radial distance between a thread member of a radially expanded member and a receiving member so as to press the inner shaft against the outer shaft in radial outer direction.

Figure 7 adjuster screw assembly

- **Content/Topic 3 Description of disc brake**

Brake disc and pads: A disc brake is a type of brake that uses the calipers to squeeze pairs of pads against a disc or "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary

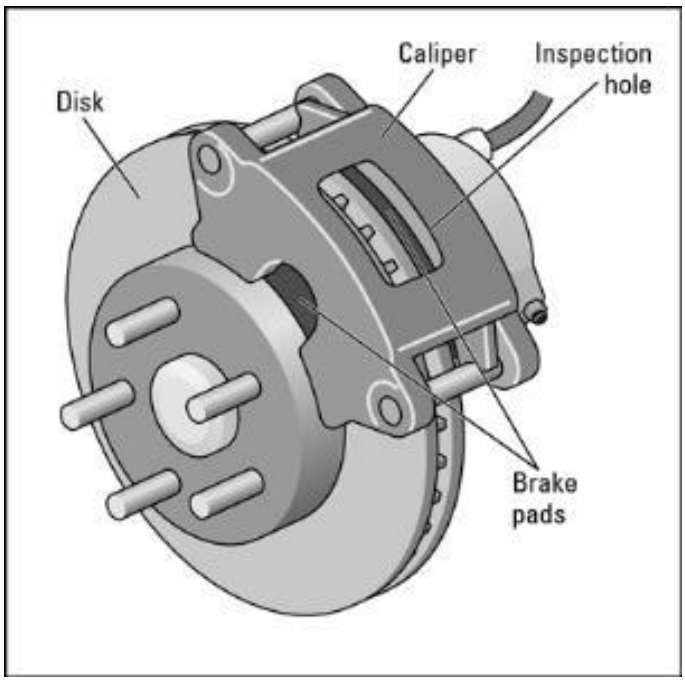


Figure 8 assembly of disc brake

Brake rotors of disc brakes rotate with the wheels, and brake pads, which are fitted to the brake calipers, clamp on these rotors to stop or decelerate the wheels. The brake pads pushing against the rotors generate friction, which transforms kinetic energy into thermal energy.

Advantages of disc brake

- The disc brake loses heat more effectively heat loss is dependent on the amount of air
- The disc brake has the same stopping power in forward or reverse
- Disc brakes are self – adjusting
- Disc brakes pads can be easily checked for wear
- New brake pads are often very easy to far

Disadvantages of brake disc

- Disc brakes are not as effective at slow speed
- The disc brake needs more pressure to work effectively

Parts of disc brake

1) Rotor

Circular disc bolted to the wheel hub that spins with the wheel. Rotors are most commonly made of cast iron or steel; however, some very high-end cars use a carbon ceramic rotor. Rotors can be slotted or drilled for better heat dissipation.

Figure 9 rotor disc

2) Brake pads

- The brake pads are what actually rub against the drums or rotors, the component that pushes into the rotor, creating the friction that slows and stops a car. They feature a metal portion called a shoe and a lining that is attached to the shoe.
- The lining is what actually comes in contact with the rotor and wears away with use. Linings are made of different materials and fall into three categories: organic, semi-metallic and ceramic.
- The lining material chosen will impact the length of brake life, the amount of noise heard when the brakes are applied, and how quickly the brakes bring a car to a halt.

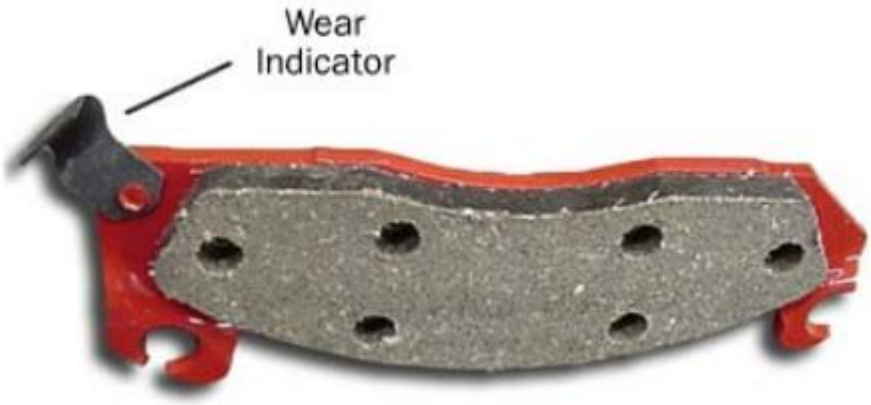


Figure 10 brake pads

3) Piston

Cylinder connected to the brake system hydraulics. The piston is what moves the brake pads into the rotor when the driver presses the brake pedal. Some brake systems have a single piston that moves both pads, while others have two pistons that push the brake pads from each side of the rotor. Others still have four, six, or even eight pistons for higher braking power, at the expense of added cost and complexity.

Figure 11 disc brake piston cylinders

4) Caliper

Housing that fits over the rotor and holds the brake pads and pistons, as well as contains ducting for brake fluid.

There are two types of brake calipers: floating (or sliding) and fixed.

Floating calipers “float” over the rotor, and only have pistons on a single side. When the driver presses the brakes, the pistons press the brake pads on one side into the rotor, which causes the caliper to slide over so that the pads on the non-piston side of the caliper also contact the rotor.

Fixed calipers are bolted in place, and instead, have pistons on both sides of the rotor that move when the driver applies the brakes. Fixed calipers apply brake pressure more evenly and clamp more firmly on the rotor, however floating calipers are found on most cars and are perfectly adequate for everyday driving.

Types of Disc Brakes

There are two types of disc brakes. One is called the "opposed piston type disc brake" which has pistons on both sides of the disc rotor, and the other is the "floating type disc brake" which has a piston on only one side. The floating type disc brakes are also called the sliding pin type disc brakes.

1) Opposed Piston Type Disc Brakes

The opposed piston type is a disc brake which has pistons on both sides of the disc rotors.

The opposed piston type disc brake features stable braking force as well as a high level of controllability.

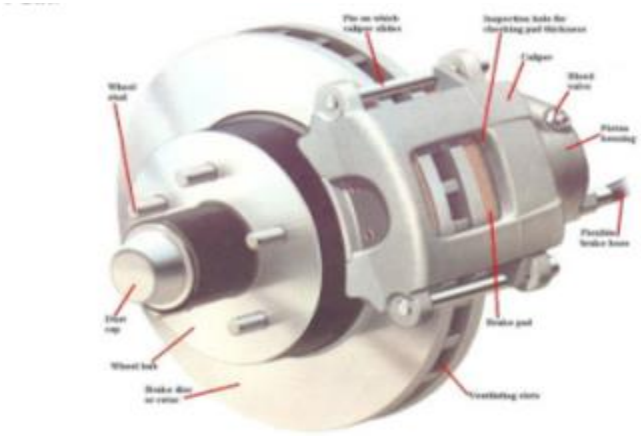


Figure 12 opposed piston type disc brake

2) Floating Type Disc Brakes

Floating type is a disc brake which has a piston on only one side and is also called the sliding type disc brake. On the floating type disc brakes, the piston pushes the inner brake pad against the rotor when the brakes are engaged. This generates a reaction force that moves the caliper itself along with the slide pin, pushing the outer pad against the rotor to clamp it from both sides.

Many passenger car disc brakes are of the floating caliper type since this type has a relatively simple and lightweight construction, which allows for lower manufacturing costs.

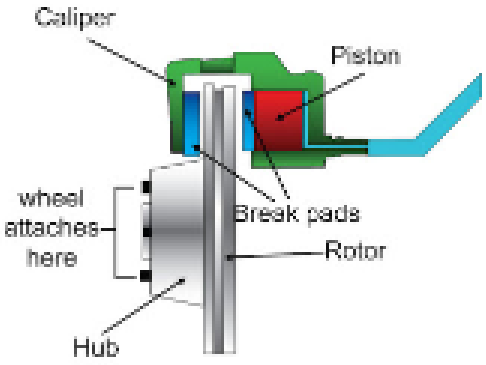


Figure 13 Floating type disc brake

Types of rotor

Smooth Rotors:

Smooth rotors are identified by their flat, smooth surface. For most cars and trucks on the road, smooth rotors are original equipment (OE) because of their versatility for many driving conditions. The main benefit of smooth rotors is that they tend to wear evenly, helping your brake pads last longer. If you want to keep the smooth rotor but still go for the upgrade, look for premium metal that absorbs more heat.

Figure 14 smooth type rotor

2) Drilled or Dimpled Rotors

Drilled rotors are identified by the pattern of holes that have been drilled all the way through the rotor disc. Dimpled rotors are similar, though instead of holes there are dimples that have been drilled to the rotor's minimum thickness level, retaining more structural integrity than a fully drilled rotor. These rotor types help the brake pads to better grip the rotor, giving it more initial bite and increasing stopping power.

Figure 15 drilled or dimpled rotor

Rotor Materials

Brake rotors can be made of six different materials, each with its own advantages. Let's take a look at each.

Cast Iron

This is the very definition of old school when it comes to a brake rotor. It's one or two pieces and gets the job done. In fact, it's the most common material for brake rotors. The right design (usually two-piece) can even work well in a performance vehicle. However, it's also the heaviest option, which affects the overall weight of your car and its handling, since that weight is right up there with your front wheels.

Steel

Steel has been the racer's choice for years because a steel brake rotor is thinner, weighs less and handles heat better. The downside: Steel rotors aren't as durable as some others, and warped rotors can cause noise and a pulsating pedal when you brake.

Layered Steel

Layering sheets of steel together and laminating them makes them resistant to the warping you might find in a straight steel brake rotor. It's a favourite of racers, who don't want frequent brake rotor replacement and repair, but manufacturers are currently only targeting professional racers and production is limited, so it's not terribly common in passenger vehicle applications.

Aluminium

Aluminium brake rotors dissipate heat quickly, but they also melt at a lower temperature than other options. Aluminium is a favourite for motorcycles, which weigh less and are easier on the rotors when braking than a heavy car, truck or SUV.

High Carbon

These are iron, but with a lot of carbon mixed in. They can take a lot of heat and dissipate it quickly. The metallic content helps the rotor avoid cracking under high stress, and brake noise and vibration are reduced as well. The only downside is the price, which is significantly higher than straight iron or aluminium.

Ceramic

They offer the highest heat capacity (85 per cent higher than cast iron) and superior dissipation, and they maintain a more consistent force and pressure as the temperature of the rotors rises. Ceramic is the highest-performance brake rotor available today. They are used in super-fast cars like Ferrari, Porsche, Lamborghini...

The figure below represents a vehicle deceleration process

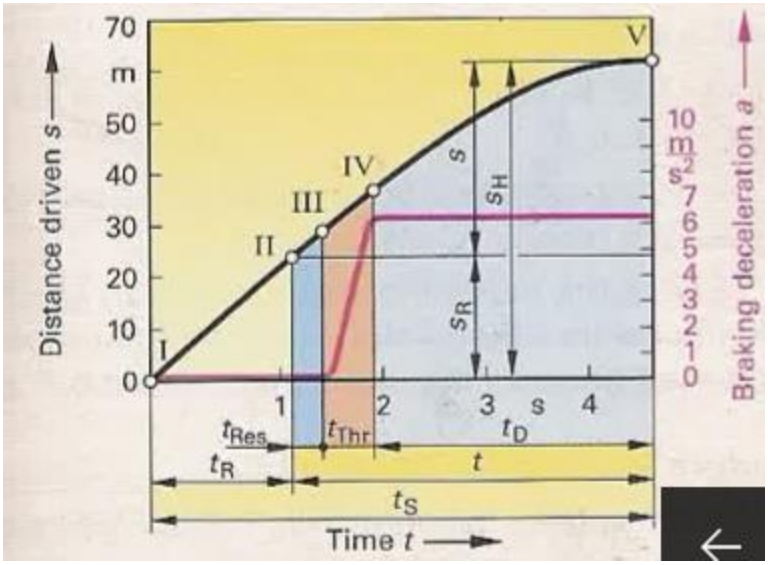


Figure 16 vehicle deceleration process

I: detection of damper
II: start of braking by driver
III: start of braking action
IV: full braking action
V: vehicle stopped

- **Reaction time** (t_R): this time needed by the driver between recognizing a hazard and operating the brake pedal.
- **Braking time** (t) : the sum of the response, threshold and delay times .
- **Response time** (t_{res}): this is generated by the clearance in the brake system. Eg: pedal idle travel, clearance
- **Threshold time** (t_{th}): the pressure in the brake system is increased during the threshold time and the desired braking deceleration is achieved
- **Delay period** (t_D): the braking deceleration remains constant until the vehicle comes to a halt.

Advantages of disc brake

1. It is lighter than drum brakes.
2. It has better cooling (because the braking surface is directly exposed to the air(
3. It offers better resistance to fade.
4. It provides uniform pressure distribution
5. Replacement of brake pads is easy.
6. By design, they are self-adjusting brakes.

Disadvantages of disc brake

1. It is costlier than drum brakes.
2. Higher pedal pressure is required for stopping the vehicle. This brake system is installed with vacuum booster.
3. No servo action is present. It is difficult to attach a suitable parking attachment

LO 1.3 – Differentiate mechanical service brake, parking brake and exhaust brake

- **Content/Topic 1 operation of mechanical brakes**

Operation of mechanical brakes

Mechanical brake systems are going to bring the vehicle to a stop; the mechanical brake just does it more efficiently. With mechanical brakes, a tensioned steel cable activates pistons that make the brake pads compress against the rotor.

Brakes absorb energy and convert it to heat. Thus, prime concerns in a brake are:

1. Generating a force capable of retarding a rotating shaft.

2. Dissipating or absorbing the heat generated in the process.

Mechanical brakes all act by generating frictional forces as two surfaces rub against each other. The stopping power or capacity of a brake depends largely on the surface area of frictional surfaces as well as on the actuation force applied. The friction and wear encountered by the working surfaces are severe. Thus, the durability of a brake or service life between maintenance depends heavily on the type of material used to line the shoe or pad.

- **Content/Topic 1 Differentiation of mechanical service brake, parking brake and exhaust brake**

Comparison among the types of brakes

Mechanical service brake

The service brake is the system that is designed to slow down the vehicle and bring it to a stop. Parking brakes are also referred to as "**emergency**" brakes although; in an emergency they would never slow down a vehicle in a safe manner.

The service brake is activated every time you step on the brake pedal and it distributes the braking force hydraulically to the front and rear wheels. 75% front and 25% rear, on average.

The parking brake is typically cable operated and applies force to either dedicated brake shoes inside the rear rotor or, through the piston in the caliper. It can be operated by a seperate pedal or a hand lever, usually located between the front seats.

Electric parking brakes have a switch as in newer vehicles with electric actuators on the rear wheels. Some SAAB models of the eighties and nineties had the parking brakes acting on the front wheels.

The Parking Brake

- The parking brake is the brake that is designed to "hold" the vehicle stationary.
- A parking brake, also called an emergency brake or e-brake, is a mechanical hand lever or foot-operated brake that is a backup braking system.
- It is located either between the front two seats or to the left of your gas and brake pedal.
- A parking brake controls the rear brakes and is a completely separate device from your vehicle's regular hydraulic brakes. It is in charge of keeping a parked vehicle stationary; it will prevent the car from rolling down a hill or moving.
- The emergency brake name comes from the brake's ability to stop the car if the regular hydraulic brakes totally fail.

Operation

- Parking brakes are completely mechanical and use only cables and levers to operate.
- When a parking brake lever is pulled (or when a parking brake pedal is pushed), these cables transmit the necessary force to keep your vehicle in place or to stop the vehicle.
- The steel cables are attached to the parking brake, and when the parking brake is pulled, the steel cables are tightened.
- Most vehicles have drum brakes on their rear wheels; so, when the parking brake is pulled, the cables will pull a lever that compress the brake shoes to stop the vehicle.

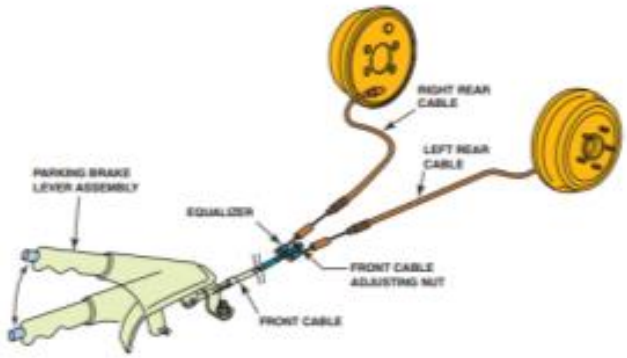


Figure 17 Hand brake diagram

- If your vehicle has rear disc brakes and you pull the parking brake, then the cables engage a corkscrew device that pushes a piston into the brake pads, which stop the vehicle. In both instances, the parking brake bypasses the regular hydraulic brakes to stop the vehicle. Parking brakes also have a self-locking system, which means that the brake won't be released unless the lever or foot brake is released.
- In road vehicles, the **parking brake**, also called **hand brake**, **emergency brake**, or **e-brake**, is used to keep the vehicle stationary and in many cases also perform an emergency stop. Parking brakes on older vehicles often consist of a cable connected to two wheel brakes at one end and the other end to a pulling mechanism which is operated with the driver's hand or foot. The mechanism may be a hand-operated lever at floor level beside the driver, or a straight pull handle located near the steering column, or a (foot operated) pedal located beside the driver leg. In most automobiles the

parking brake operates only on the rear wheels, which have reduced traction while braking. Some automobiles have the parking brake operate on the front wheels.

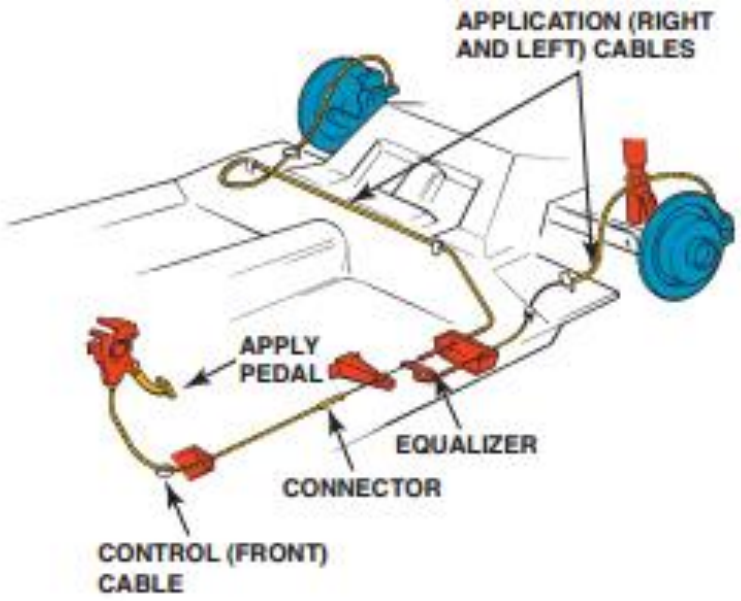


Figure 18 mechanical service brake circuit

- The parking brake cable may have an adjustment bolt to allow for loosening or tightening the cables as needed. Some parking brakes are self-adjusting and any slack is taken up in the pedal or handle assembly. In the drum brake assembly, the cable attaches to the parking brake lever. The lever is attached to one of the brake shoes with a pin or a hook. The parking brake strut or self-adjuster screw is placed over the lever.

Figure 19 parking brake cables mounting

Operation

When a hand-operated parking brake is pulled, a latch moves along a gear. Once the brake is set, the driver releases the handle and the latch locks into place on a notch in the gear. To release the brake, the lever must be raised slightly and the release button pressed. This allows the latch to release from the gear and remain retracted so that it does not lock into another gear position

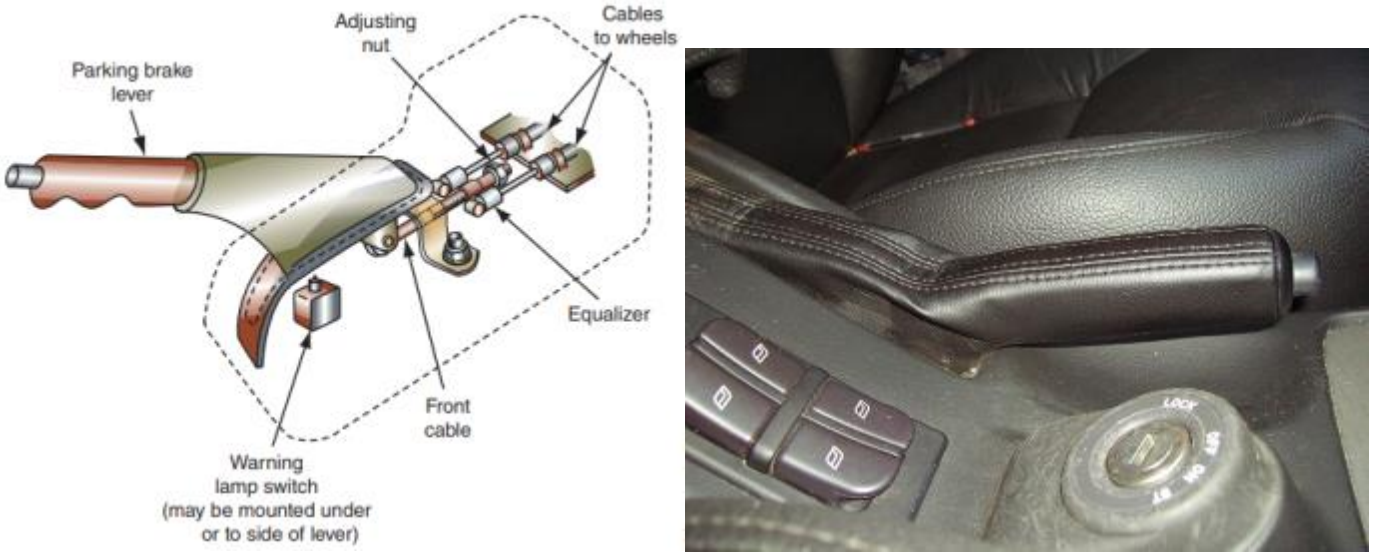


Figure 20 shifting lever hand brake

Foot-operated parking brakes are set the same way as hand-operated systems, but instead of using a release button, a handle is used to release the latch An example of a foot-operated assembly.

- On some vehicles, to release the parking brake you press the parking brake pedal down and it disengages. Many foot-operated systems now use automatic brake releases.
- These systems release when the vehicle is shifted out of Park. Vehicles with electric parking brakes simply have a Parking Brake button on the dash. The driver presses the button, and the brake applies. To release the parking brake, the driver presses the parking brake button. Some vehicles will automatically release the parking brake once the vehicle starts driving. The components of a manually released foot-operated parking brake pedal.

Some more points

- In cars with disc brakes on all four wheels, an emergency brake has to be actuated by a separate mechanism than the primary brakes in case of a total primary break failure.
- Most cars use a cable to actuate the emergency brake.
- Some cars with four wheel disc brake have a separate drum brake integrated into the hub of the rear wheels.

- This drum brake is only for emergency brake system, andis actuated only by the cable. It has no hydraulics.

Figure 21 Brake warning light and ISO symbol used to indicate that the parking brake is applied

Electric parking brake

- The emergency brake was originally intended for one particular emergency and that was "no other way to stop", as was the case when the footbrake suddenly failed due to a loss of hydraulic pressure or other issue. Drivers had to respond when brakes failed, so they were expected to learn how to stop a speeding vehicle using the emergency brake alone.
- Safety regulations became almost universal by 1980, so modern brake systems are very reliable, using dual-circuit hydraulics and more recently low-brake-fluid sensors. As modern brakes no longer cause emergencies in normal contexts (a brake warning light comes on after the first sign of trouble),It is no longer necessary for the average driver to learn to use this brake for emergencies.
- Some drivers benefiting from the "park" function on their automatic transmissions do not use this brake at all (daily use of the parking brake is recommended, to ensure it does not seize up). After a lack of recent braking emergencies, automakers stopped using the term and started referring it by its other use, the "parking brake", even though the ability to function at a high speed was still there. On an increasing number of modern vehicles, the parking brake can only be engaged when the vehicle is at a stop, and they no longer have an emergency brake.
- The emergency brake in some cars is completely mechanical; that is, by pulling the lever, the driver pulls a cable, which in turn causes the brake shoes inside a drum brake to press against the cylinder. In a car with a completely mechanical emergency brake, the driver would be able to apply the brake even in if there was a complete loss of hydraulic pressure and a stopped engine (which would mean that there would be no power braking

Figure 22 Electric park brake switch

Advantages of parking brake

- It is used to keep the vehicle stationary
- Perform an emergency stop
- Pulling mechanism which is operated with the driver's hand or foot
- It operates only on rear wheels and sometimes on propeller shaft
- It reduces traction while braking

Exhaust brakes

- Exhaust brakes slow light duty, diesel-powered vehicles quickly. They also prevent the brakes from overheating on downhill grades, as this causes brake fade and possibly even failure. Using your exhaust brakes properly can help brakes last up to three times longer.
- Exhaust brakes retard power in a diesel engine, but in an different way than engine brakes. Engine brakes release compressed air through an exhaust valve, but exhaust brakes hold the compression in the engine and slow the crankshaft's rotation, which reduces vehicle speed.
- An exhaust brake is typically mounted on the outlet side of the turbocharger and retards the engine's ability to push out or exhaust compression. A butterfly valve in the exhaust brake stays open until it's activated. Then it closes and restricts exhaust flow by keeping it in the cylinder. This causes the piston to force the compression into the exhaust brake, which absorbs the energy.

- **Content/Topic 3 Description of advantages and disadvantages of mechanical brake**

Advantage of mechanical brake

- More straight forward to set up and maintain mechanically
- Less expensive than hydraulic disc brakes
- Mechanical brakes are simpler and cheaper.
- They're also extremely reliable,
- Simple in construction and maintenance

- More affordable contrasted with water driven brake
- They are useful for crisis and stopping brakes

Disadvantages of mechanical brakes

- Mileage occurs at brake surfaces
- They are not as successful than water driven brake
- Warmth scattering isn't uniform
- They are less effective compared to hydraulic brake
- It require greater force to stop a running vehicle
- Brake materials do not last longer

Learning Unit 2 – Disassemble and inspect mechanical brake components

LO 2.1 – Select tools, materials and equipment

- Content/Topic 1 classification of tools needed in disassembling mechanical brake components

Classification of tools:

Hand tools selection

A. Hand tools

Most service procedures require the use of hand tools. Therefore, technicians need a wide assortment of these tools. Each has a specific job and should be used in a specific way. Most service departments and garages require their technicians to buy their own hand tools.

A1.Wrenches

The word *wrench* means twist. A wrench is a tool for twisting and/or holding bolt heads or nuts. Nearly all bolt heads and nuts have six sides; the jaw of a wrench fits around these sides to turn the bolt or nut. All technicians should have a complete collection of wrenches. This includes both metric and SAE wrenches in a variety of sizes and styles

Figure 23 wrench spanners

The following is a brief discussion of the types of wrenches used by automotive technicians.

A.1.1.**Open-End Wrench** The jaws of the open-end wrench allow the wrench to slide around two sides of a bolt or nut head where there might be insufficient clearance above or on one side of the nut to accept a

box wrench.

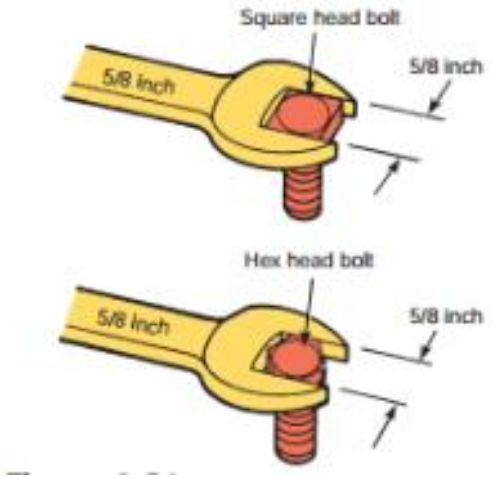


Figure 24 open end wrench spanner

A1.2.Box-End Wrench The end of the box-end wrench is boxed or closed rather than open. The jaws of the wrench fit completely around a bolt or nut, gripping each point on the fastener. The box-end wrench is not likely to slip off a nut or bolt. It is safer than an open-end wrench. Box-end wrenches are available as 6 point and 12 point**)**. The 6-point box end grips the screw more securely than a 12-point box-end wrench can and avoids damage to the bolt head.

Figure 24 box end spanner

A1.3.Allen Wrench Setscrews are used to fasten door handles, instrument panel knobs, engine parts, and even brake callipers. A set of fractional and metric hex head wrenches, or Allen wrenches, should be in every technician's toolbox. An Allen wrench can be L-shaped or can be mounted in a socket driver and used with a ratchet.

Figure 25 allen wrench

A.2.Sockets and Ratchets

A set of Imperial and metric sockets combined with a ratchet handle and a few extensions should be the top side of a socket has a square hole that accepts a square lug on the socket handle.

This square hole is the drive hole. One handle fits all the sockets in a set. On better-quality handles, a spring loaded ball in the square drive lug fits into a depression in the socket. This ball holds the socket to the handle. An assortment of socket (ratchet) handles is shown.

Figure 26 sockets and ratchets

A2.1.Special Sockets Screwdriver and Allen wrench attachments are also available for use with a socket wrench.

Figure 27 special sockets

A.3.Torque Wrenches

Torque wrenches measure how tight a nut or bolt is. Many of a car's nuts and bolts should be tightened to a certain amount and have a torque specification that is expressed in foot-pounds (U.S.)

Figure 28 torque wrenches

A.4.Extensions: An extension is commonly used to separate the socket from the ratchet or handle. The extension moves the handle away from the bolt and makes the use of a ratchet more feasible. Extensions are available in all common drive sizes and in a variety of lengths.

Figure 29 extension

A.5.Screwdrivers

A screwdriver drives a variety of threaded fasteners used in the automotive industry. You also should have an assortment of special screwdrivers, such as those with a head design

Figure 30 screw driver

A.5.1.Impact Screwdriver

An impact screwdriver is used to loosen stubborn screws. Impact screwdrivers have interchangeable heads and bits that allow the handles of the tools to be used with various screw head designs.

Figure 31 impact screw driver

To use an impact screwdriver select the correct bit and insert it into the driver's head.
Then hold the bit against the screw slot while firmly twisting the handle in the desired direction. Strike the handle with a hammer. The force of the hammer will exert a downward force on the screw and, at the same time, exert a twisting force on the screw.

A.6.Pliers

Pliers are gripping tools used for working with wires, clips, and pins. At a minimum, an auto technician should own several types: standard pliers for common parts and wires, needle nose for small parts, and large, adjustable pliers for large items and heavy-duty work.

Figure 32 different types of pliers

A brief discussion on the different types of pliers follows:

A.6.1. Combination pliers are the most common type of pliers and are frequently used in many kinds of automotive repair. The jaws have both flat and curved surfaces for holding flat or round objects. Also called slip-joint pliers, the combination pliers have many jaw-opening sizes. One jaw can be moved up or down on a pin attached to the other jaw to change the size of the opening.

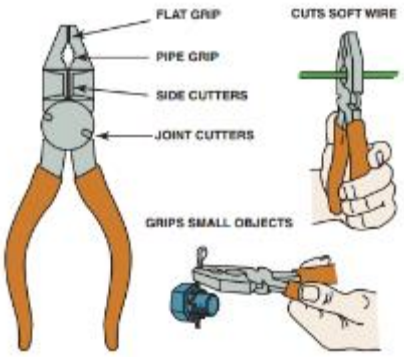


Figure 33 combination pliers

A.6.2. Adjustable pliers, commonly called *channel locks,* have a multi-position slip joint that allows for many jaw-opening sizes.

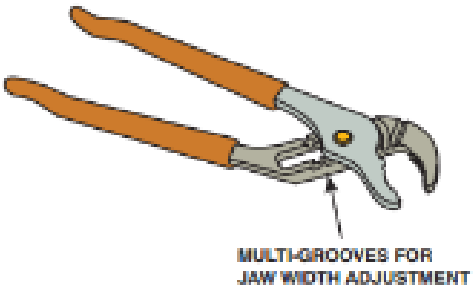


Figure 34 adjustable pliers

A.6.3.Needle nose pliers

They have long, tapered jaws. They are great for holding small parts or for reaching into tight spots. Many needle nose pliers also have wire-cutting edges and a wire stripper. Curved needle nose pliers allow you to work on a small object around a corner.

Figure 35 needle nose plier

A.6.4.Locking pliers, or vise grips, are similar to the standard pliers, except they can be tightly locked around an object. They are extremely useful for holding parts together. They are also useful for getting a firm grip on a badly rounded fastener that is impossible to turn with a wrench or socket. Locking pliers come in several sizes and jaw configurations for use in many auto repair jobs.

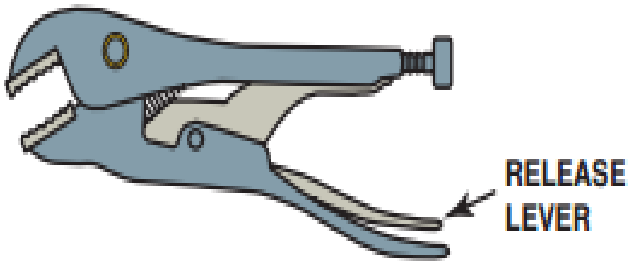


Figure 36 locking plier

A.6.5. Snap- or lock ring pliers are made with a linkage that allows the movable jaw to stay parallel throughout the range of opening. The jaw surface is usually notched or toothed to prevent slipping.

Figure 37 snap ring plier

A.6.7.Retaining ring pliers are identified by their pointed tips that fit into holes in retaining rings. Retaining ring pliers come in fixed sizes but are also available in sets with interchangeable jaws.

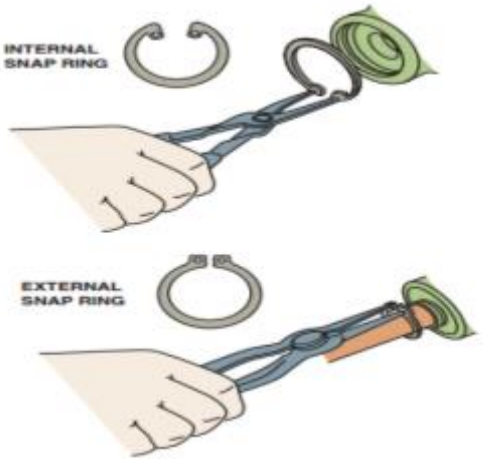


Figure 38 Retaining ring plier

A.7.Hammers

Hammers are identified by the material and weight of the head. There are two groups of hammer heads, steel and soft faced your tool set should include at least three hammers: two

A.7.1.ball-peen hammers,

The heads of steel-faced hammers are made from high-grade alloy steel. The steel is deep forged and heat treated to a suitable degree of hardness.

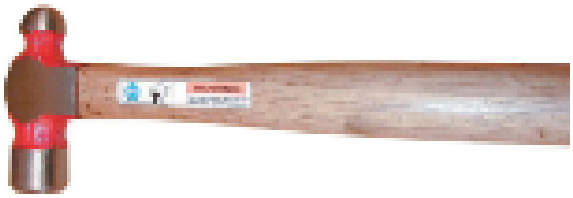


Figure 39 ball pein hammer

A.7.2.Soft Hammer

Soft-faced hammers have a surface that yields when it strikes an object. Soft-faced hammers should be used on machined surfaces and when marring a finish is undesirable. For example, a brass hammer should be used to strike gears or shafts because it will not damage them.

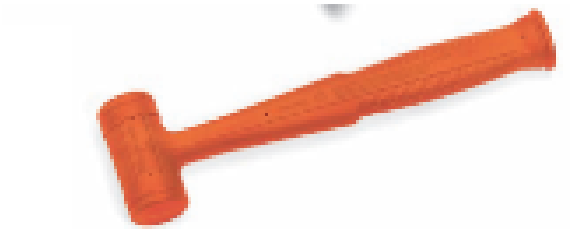


Figure 40 soft hammer

A.8.Chisels

Chisels are used to cut metal by driving them with a hammer. Automotive technicians use a variety of chisels for cutting sheet metal, shearing off rivet and bolt heads, splitting rusted nuts, and chipping metal. A variety of chisels are available, each with a specific purpose, including flat, cape, round-nose cape, and diamond point chisels.

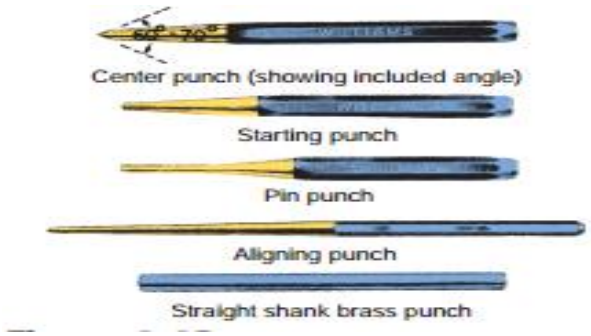


Figure 41 types of chisels

Safety precaution when using hand tools

- The following safety tips should be kept in mind whenever you are working with hand tools: Always *pull* a wrench toward you for best control and safety.
- Never push a wrench.
- Keep wrenches and all hand tools clean to help prevent rust and to allow for a better, firmer grip.
- Always use a 6-point socket or a box-end wrench to break loose a tight bolt or nut. Use a box-end wrench for torque and an open-end wrench for speed.
- Never use a pipe extension on a wrench or ratchet handle.
- If more force is required, use a larger tool or use penetrating oil and/or heat on the frozen fastener. (If heat is used on a bolt or nut to remove it, always replace it with a new part.)
- Always use the proper tool for the job. If a specialized tool is required, use the proper tool and do not try to use another tool improperly.
- Never expose any tool to excessive heat. High temperatures can reduce the strength ("draw the temper") of metal tools.
- Never use a hammer on any wrench or socket handle unless you are using a special "staking face" wrench designed to be used with a hammer.
- Replace any tools that are damaged or worn

B.Measuring tools

Measuring tools are precise and delicate instruments. In fact, the more precise they are, the more delicate they are. They should be handled with great care. Never pry, strike, drop, or force these instruments, They may be permanently damaged.

B.1.Ruler and T-square: it is used when taking metric measurement and in technical drawing. Measuring edge is divided into increments based on a different scale, Metric or inch measures.

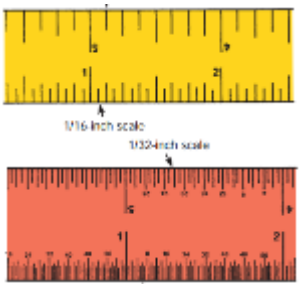


Figure 42 ruler

B.2.Micrometer

A micrometer is the most used measuring instrument used to take cylinder rod diameter it can be used in service and repair.

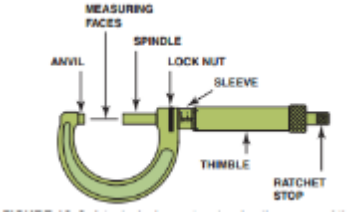


Figure 43 micrometer

B.3.Feeler gauge

A **feeler gauge** (also known as a **thickness gauge**) is an accurately manufactured strip of metal that is used to determine the gap or clearance between two components.

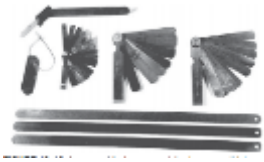


Figure 44 feller gauge

B.4.Vernier Calliper

A **vernier calliper** is a measuring tool that can make inside, outside, or depth measurements. It is marked in both British Imperial and metric divisions called a vernier scale. A vernier scale consists of a stationary scale and a movable scale, in this case the vernier bar to the vernier plate. The length is read from the vernier scale.

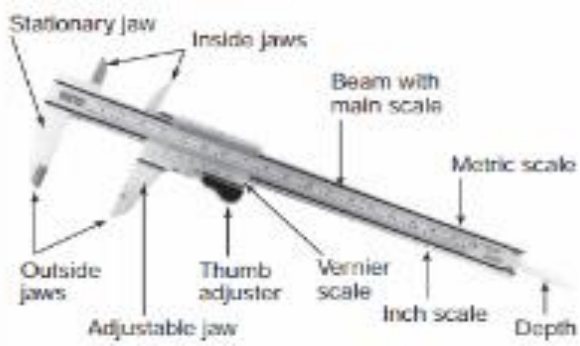


Figure 45 vernier caliper

A vernier calliper has a movable scale that is parallel to a fixed scale. These precision measuring instruments are capable of measuring outside and inside diameters and most will even measure depth. Vernier callipers are available in both Imperial and metric scales. The main scale of the calliper is divided into inches; most measure up to 6 inches.

C.Testing tools

C.1.Digital multi-meter

It is an electrical device used to measure multiple units such as resistance, current, voltage, and capacitance to test electronic components. Typical digital multi-meter, the black meter lead always is placed in the COM terminal. The red meter test lead should be in the volt-ohm terminal except when measuring current in amperes.

Figure 46 digital multimeter

C.2.Dial indicator

Dial indicators are one of the primary measuring tools used in precision engine building it is typically used to measure deck clearances, multi-plate clutch clearance.

Figure 47 dial indicator

C.3.Circuit Tester

Circuit testers are used to check for voltage in an electrical circuit. A circuit tester, commonly called a **test light**, looks like a stubby ice pick.

Figure 48 circuit tester

Its handle is transparent and contains a light bulb. A probe extends from one end of the handle and a ground clip and wire from the other end. When the ground clip is attached to a good ground and the probe touched to a live connector, the bulb in the handle will light up. If the bulb does not light, voltage is not available at the connector.

D.Power tools

D.1.Impact wrench

An **impact wrench**, either air (pneumatic) or electrically powered, is a tool that is used to remove and install fasteners. The air-operated 1/2 in. drive impact wrench is the most commonly used unit

Figure 49 impact wrench

The direction of rotation is controlled by a switch.

Battery-powered units: This type of impact wrench is very useful, especially if compressed air is not readily available.

Figure 50 battery powered (portable impact wrench)

D.2.Air ratchet

An air ratchet is a very useful tool that allows fast removal and installation of fasteners, especially in areas that are difficult to reach or do not have room enough to move a hand ratchet wrench.

Figure 51 air wrench

An **air ratchet** is used to remove and install fasteners that would normally be removed or installed using a ratchet and a socket. An air ratchet is much faster, yet has an air hose attached, which reduces accessibility to certain places.

Content/Topic 2 Selecting Materials and consumables to be used when repairing mechanical brake system

A.Grease

Greases are made from oil blended with thickening agents. There are a few synthetic greases available that meet the same standards as petroleum greases. The thickening agent increases the viscosity of the grease. Grease is forced between two surfaces that move or rub against each other.

The grease reduces the friction produced by the movement of the parts. During a chassis lube, grease is forced into a pivot point or joint through a grease fitting. Grease fittings are found on steering and suspension parts, which need lubrication to prevent wear and noise caused by their action during vehicle operation. A grease gun forces lubrication into a joint.

Figure 52 greasing

Most vehicle manufacturers recommend the use of grease meeting the NLGI #2 and "GC" for wheel bearings and "LB" for chassis lubrication. Many types of grease have both designations and therefore can be used for wheel bearings or chassis lubrication

Types of Grease

- Greases are categorized by a **National Lubricating Grease Institute (NLGI)** number and by the thickeners and additives that are in the grease, such as lithium, molybdenum disulphide, calcium, aluminium, barium, or sodium.
- Some grease is also labelled with an "EP," which means they have extreme pressure additives. The number assigned by the NLGI is based on test results and the specifications set by the American Society for Testing Materials (ASTM). The ASTM specifies the consistency of grease using a penetration test.
- The **American Society for Testing Materials (ASTM)** specifies the consistency of grease using a **penetration test.**
- The **National Lubricating Grease Institute (NLGI)** uses the penetration test as a guide to assign the grease a number. Low numbers are very fluid and higher numbers are more firm or hard. Most vehicle manufacturers specify NLGI #2 for wheel bearing and chassis lubrication.

- During this test, the grease is heated to 77°F (25°C) and placed below the tip of the test cone. The cone is dropped into the grease. The distance the cone is able to penetrate the grease is measured. The cone will penetrate deeper into soft grease. The NLGI number represents the amount of penetration

NLGI Grade	Worked Penetration after 60 strokes at 77°F(25°C)	Appearance
000	44.5–47.5 mm	fluid
00	4.00–4.30 mm	fluid
0	3.55–3.85 mm	very soft
1	3.10–3.40 mm	soft
2	2.65–2.95 mm	moderately soft
3	2.20–2.50 mm	semifluid
4	1.75–2.05 mm	semihard
5	1.30–1.60 mm	hard
6	0.85–1.15 mm	very hard

- The higher the NLGI number, the thicker the grease is. NLGI #2 is typically specified for wheel bearings and chassis lubrication. The NLGI also specifies grease by its use and has established two categories for automotive use.
- Chassis lubricants are identified with the prefix “L,” and wheel bearing lubricants have a prefix of “G.” Greases are further defined within those groups by their overall performance.
- Chassis greases are classified as either LA or LB, and there are three classifications for wheel bearing greases (GA, GB, and GC). LB and GC have the highest performance ratings and are the greases specified for chassis and wheel bearing lubrication.
- Many types of greases are labelled as both GC and LB and are acceptable for both. These are often referred to as multipurpose greases

Class	Purpose
GA	Mild duty—wheel bearings
GB	Mild to moderate duty—wheel bearings
GC	Mild to severe duty—wheel bearings
LA	Mild duty—chassis parts and universal joints
LB	Mild to severe duty—chassis parts and universal joints

The NLGI certification mark is included on the grease’s container. Here are NLGI identification symbols.

B.Brake pads

Brake pads are a component of disc brakes used in automotive and other applications. Brake pads are composed of steel backing plates with friction material bound to the surface that faces the disc brake rotor.

Figure 53 brake pad

B.1.Types of Brake Pads

Typically, the regular vehicles have four common brake pad types:

No	Brake pad type	Main features
1	Semi-Metallic 	- Being used widely in different vehicles - Made of steel wire or wool, graphite or copper, and friction modifiers - Long- term durability and excellent heat transfer capability - More noises, wear down rotors faster, underperforms at low temperatures
2	Non-Asbestos Organic 	- Made of fibers, high-temperature resins, and filler materials - Softer and create less noise than Semi - Metallic - Deteriorate faster and create more dust
3	Low-Metallic NAO 	- Made of organic materials with 10%-30% metal - Excellent braking and heat transfer capabilities
4	Ceramic 	- Made of ceramic fibers, bonding agents, nonferrous filler materials - Less noise, wear down slowly, create less dust - Expensive than other brake pads

There are numerous types of brake pads, depending on the intended use of the vehicle, from very soft and aggressive (such as racing applications) to harder, more durable and less aggressive compounds.

Most vehicle manufacturers recommend a specific kind of brake pad for their vehicle, but compounds can be changed (by either buying a different make of pad or upgrading to a performance pad in a manufacturer's range) according to personal tastes and driving styles.

C.Brake shoe

A **brake shoe** is the part of a braking system which carries the brake lining in the drum brakes used on automobiles, or the brake block in train brakes and bicycle brakes. A device that is put on a track to slow down railroad cars is also called brake shoe.

Figure 54 brake shoes

Content/Topic 2 Selection of equipment to be used when repairing mechanical brake system

Equipment to be selected when you are going to repair or service mechanical brake system, the following are important components to choose:

A.Car lifter

Lift

A lift is used to raise a vehicle so the technician can work under the vehicle. The lift arms must be placed under the car manufacturer's recommended lifting points prior to raising a vehicle. There are three basic types of lifts: frame contact wheel contact, and axle engaging.

These categories define where the frame contact points align with the vehicle.

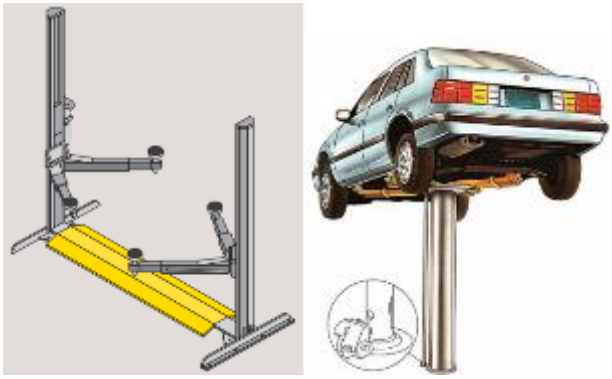


Figure 55 car lift

B.Jack and Jack Stand Safety

A vehicle can be raised off the ground by a hydraulic jack, A handle on the jack is moved up and down to raise part of a vehicle and a valve is turned to release the hydraulic pressure in the jack to lower the part. At the end of the jack is a lifting pad.

Jack stands should be used to support the vehicle after it has been raised by a jack.

Figure 56 various types of jacks

The pad must be positioned under an area of the vehicle's frame or at one of the manufacturer's recommended lift points. Never place the pad under the floor pan or under steering and suspension components, because they can easily be damaged by the weight of the vehicle. Always position the jack so that the wheels of the vehicle can roll as the vehicle is being raised.

B. Air Compressor

A shop air compressor is usually located in a separate room or an area away from the customer area of a shop. An **air compressor** is powered by a 220 V AC electric motor and includes a storage tank and the compressor itself, as well as the pressure switches, which are used to maintain a certain minimum level of air pressure in the system. The larger the storage tank, expressed in gallons, the longer an air tool can be operated in the shop without having the compressor start operating.

Figure 57 air compressor

D. Service bay/pit

It is a hole in the floor of a garage from which the underside of a vehicle can be examined and serviced.

Figure 58 service bay

LO 2.2 – Disassemble mechanical brake components

- **Content/Topic 1 Disassembling mechanical brake component**

A.Wheels and tires removal

Step 1: Prepare the workplace

- Cleaning of work place
- Check Availability of tool, materials and equipment
- Preparing the car includes Lift the vehicle and Stand the vehicle
- Refer to your vehicle owner's manual if you need assistance locating the designated jack points.

Step 2: Chock the wheels and release the emergency brake.

- Park your vehicle on level ground and release the emergency brake, placing wheel chocks behind the front wheels.

Step 3: Loosen the lugs nuts.

- Loosen the lug nuts but do not remove them while the wheel is still on the ground so it does not turn.
- The lug nuts will be on tight; use the tire iron that came with your vehicle or a long breaker bar to loosen them.

Step 4: Jack up the vehicle and remove the wheels and Place the jack under a sturdy portion of the frame.

- If you have any questions as to where to place the jack on your particular vehicle, consult the repair manual. After you have the vehicle in the air, place jack stands under the frame and lower the jack.

Step 5: Remove the lug nuts completely and remove the wheel

B. Arrangement of mechanical brake component

B.1.Arrangement of brake pad

Step 1: Remove Old Brake Pads and Open Piston

Step 2: open the brake calliper and arrange brake pad


B.2.Arrangement of brake shoes

Step 1: Remove the brake drum. Remove the drum by pulling it straight out towards you. If it does not come off easily, hit the front of it with a hammer to loosen it.

Step 2: Remove the hold down spring assemblies.


Step 3: Remove the shoes and emergency brake cable clip if required.

Step 4: arrangement of brake shoes

B3.arrangement of Engine brake

Step 1: dismount the exhaust manifold mounting

Step 2: Remove engine brake

Step 3: Arrangement of engine brake on the work bench

LO 2.3 – Machine mechanical brake components Inspect

- Content/Topic 1 Inspection of Mechanical brake components

A) Inspection of Cable movement

- Parking brake cables are subject to damage from water, dirt, and other debris thrown up under the vehicle by the tires.
- Most parking brake cables do not require lubrication because they are lined with nylon or Teflon, and any cable housing ends located under the vehicle are protected by rubber or nylon seals.

Typical hand operated parking brake.

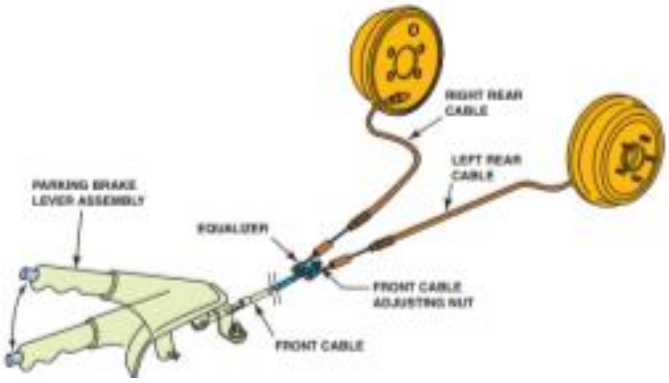


Figure 59 typical hand operated parking brake

Note that the adjustment for the cable is underneath the vehicle at the equalizer

- **Look for Swollen Parking Brake Cables**
- Always inspect parking brake cables for proper operation.
- A cable that is larger in diameter in one section indicates that it is rusting inside and has swollen.

Figure 60 swollen parking cable

- A rusting parking brake cable can keep the rear brake applied even though the parking brake lever has been released. This can cause dragging brakes, reduced fuel economy, and possible vehicle damage due to overheated brakes.

B) Inspection Rubber booster

The indicators below show that rubber booster is failing inspect that:

- Hard to press brake pedal
- Longer stopping distance
- Engine stalls when brake pedal is applied
- Difficult the brake pedal to release and return in initial place
- Housing for damages and leaks

C) Inspection Brake pads wear

- Some brake pads have worn sensing indicators. The three most common design wear sensors are audible, visual, and tactile.
- Inspect A glazed pad
- Inspect the brake pad and rotors have matching wear patterns

Note: if the brake pad need to be replace then the rotor must be machined

D) Brake shoes wear

- Inspect the linings for uneven wear,
- Inspect brake shoes for distortion, cracks, or looseness
- Inspect embedded foreign material,
- inspect loose rivets, and
- Check if they are oil soaked or grease.

Notes:

(A) If linings are oil soaked, replace them.
If linings are otherwise serviceable, tighten or replace loose rivets, remove imbedded foreign material, and clean the rivet counter bores.

(B) If linings at any wheel show a spotty wear pattern or an uneven contact with the brake drum, it is an indication that the linings are not centred in the drums. Linings should be circle ground to provide better contact with the drum.

E) Inspection of Spring tension

- All springs should be checked for distortion and damage.

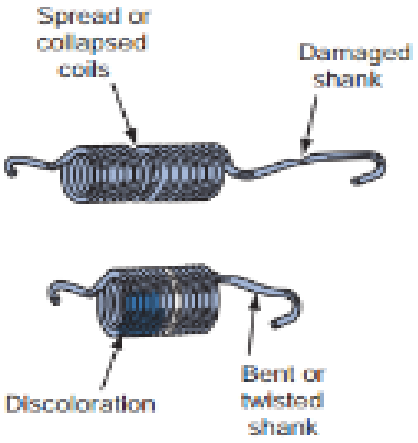


Figure 61 return spring

Learning Unit 3 – Maintain and repair Mechanical brake components

LO 3.1 – Detect mechanical brake system faults

- Content/Topic 1 Detection faults of mechanical brake system

Fault detection methods

a) Visual inspection

- Visual inspection or visual testing is the most basic method of inspection, it is the process of looking over a piece of mechanical brake circuit using the naked eye to look for defect, and it requires no equipment except the eyes of an inspector.
- Visual inspection is simple and can detect most signs of damage of mechanical brake system.
- Visual inspection involves removing the brake drum and making a thorough visual inspection of the entire brake instead of just looking at the thickness of the remaining lining. If a riveted brake lining is cracked between rivets, the lining should be replaced.

b) Measurement

By using measuring equipment such as dial indicator, it is necessary to measure the outer surface of brake disc rotor or brake drum.

Drum Measurements

Measure every drum with a drum micrometer, even if the drum passed a visual inspection, to make sure that it is within the safe oversize limits.

- If the drum is within safe limits, even though the surface appears smooth, it should be turned to ensure a true drum surface and to remove any possible contamination in the surface from previous brake linings, road dust, and so forth.
- Remember that if too much metal is removed from a drum, unsafe conditions can result.

Figure 62 drum diameter measurement

- Take measurements at the open and closed edges of the friction surface and at right angles to each other.
- Drums with taper or out-of-roundness exceeding 0.006 inch (0.152 mm) are unfit for service and should be turned or replaced.
- If the maximum diameter reading (measured from the bottom of any grooves that might be present) exceeds the new drum diameter by more than 0.060 inch (1.5 mm), the drum cannot be reworked.

- If the drums are smooth and true but exceed the new diameter by 0.090 inch (2.2 mm) or more, they must be replaced.

- **Content/Topic 1 Checking faults of brake components**

Checking brake components

Drum Inspection

one of the most important parts that need to be inspected is the brake drum. Thoroughly clean the drums with a water-dampened cloth or a water-based solution. If the drums have been exposed to leaking oil or grease, thoroughly clean them with a non-oil base solvent after washing to remove dust and dirt.

- Carefully check the inside surface of the brake drum.

- It is important to determine the source of the oil or grease leak and correct the problem before reinstalling the drums. Brake drums act as a heat sink.
- They absorb heat and dissipate it into the air. As drums wear from normal use or are machined, their cooling surface area is reduced and their operating temperatures increase.

- Their structural strength is also reduced. This leads to distortion, which causes some of the drum conditions Also take a look at the brake shoes while they are still mounted.
- Their condition can often reveal defects in the drums.
- If the linings on one wheel are worn more than the others, it might indicate a rough drum. Uneven wear from side to side on any one set of shoes can be caused by a tapered drum.
- If some linings are worn badly at the toe or heel, it might indicate an out of-round drum.

Scored Drum Surface

- The most common cause of this condition is build-up of brake dust and dirt between the brake lining and drum.
- A glazed brake lining, hardened by high heat or in some cases by very hard inferior grade brake lining, can also groove the drum surface.
- Excessive lining wear that exposes the rivet head or shoe steel will score the drum surface.
- If the grooves are not too deep, the drum can be turned.

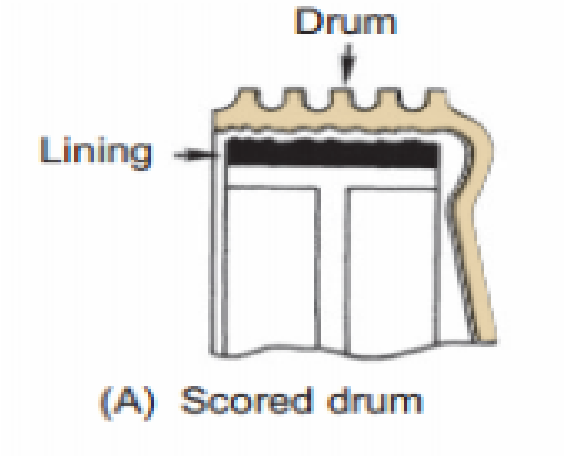


Figure 63 scored drum

Bell-Mouthed Drum

- This distortion is due to extreme heat and braking pressure.
- It occurs mostly on wide drums and is caused by poor support at the outside of the drum.
- Full drum-to-lining contact cannot be achieved and fading can be expected. Drums must be turned

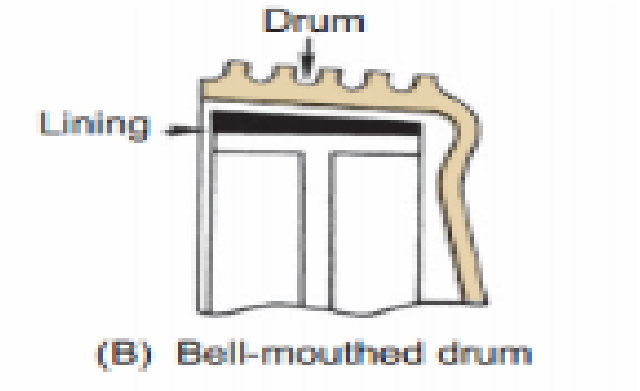


Figure 64 bell mounted drum

Concave Drum

- This is an excessive wear pattern in the centre area of the drum brake surface.
- Extreme braking pressure can distort the shoe platform so braking pressure is concentrated at the centre of the drum.

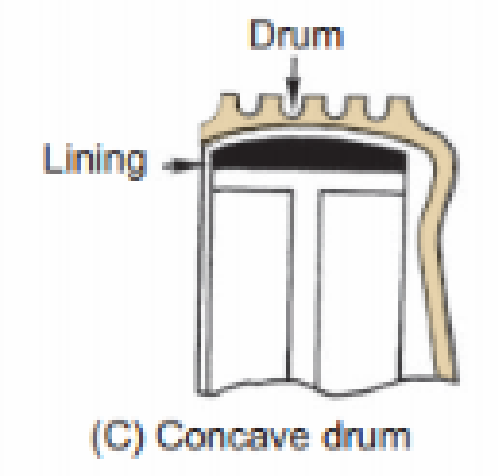


Figure 65 concave drum

Convex Drum

- This wear pattern is greater at the closed end of the drum. It is the result of excessive heat or an oversized drum, which allows the open end of the drum to distort.

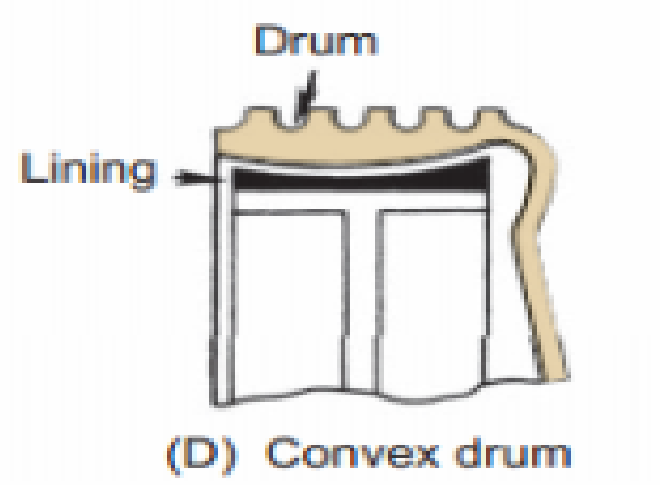


Figure 66 convex drum

Hard Spots on the Drum

- This condition in the cast iron surface, sometimes called chisel spots or islands of steel, results from a change in metallurgy caused by braking heat. Chatter, pulling, rapid wear, hard pedal, and noise can occur.
- These spots can be removed by grinding. However, only the raised surfaces are removed, and they can reappear when heat is applied. If this condition reappears, the drum must be replaced.

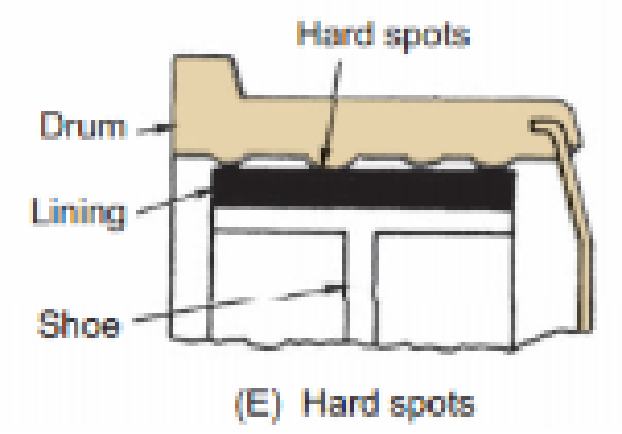


Figure 67 hard spot on drum

Threaded Drum Surface

- An extremely sharp or chipped tool bit or a lathe that turns too fast can result in a threaded drum surface.
- This condition can cause a snapping sound during brake application as the shoes ride outward on the thread, then snap back.
- To avoid this, recondition drums using a rounded tool and proper lathe speed.
- Check the edge of the drum surface around the mounting flange side for tool marks indicating a previous machining.
- If the drum has been machined, it might have worn too thin for use then Check the diameter.

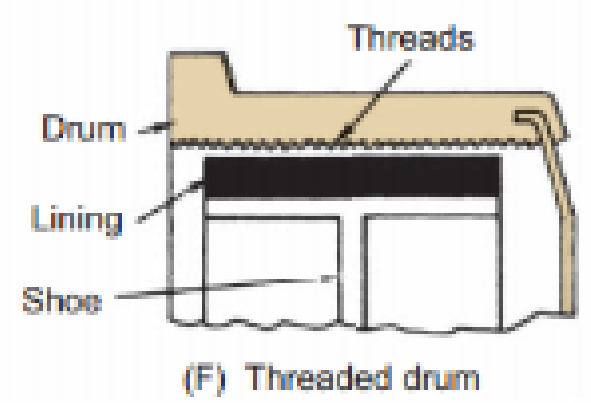


Figure 68 Threaded drum

Heat Checks

- Heat checks are visible, unlike hard spots that do not appear until the machining of the drum. Extreme operating temperatures are the major cause.
- The drum might also show a bluish/gold tint, which is a sign of high temperatures. Hardened carbide lathe bits or special grinding attachments are available through lathe manufacturers to service these conditions.
- Excessive damage by heat checks or hard spots requires drum replacement.

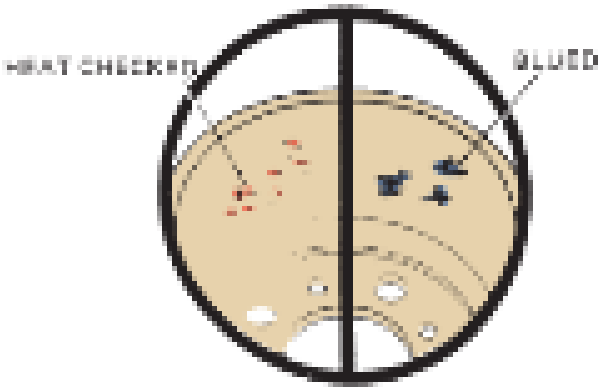


Figure 69 damaged drum by heat

Check Cracked Drum

- Cracks in the cast-iron drum are caused by excessive stress.
- They can be anywhere but usually are in the vicinity of the bolt circle or at the outside of the flange.
- Fine cracks in the drums are often hard to see and, unfortunately, often do not show up until after machining.
- Nevertheless, should any cracks appear no matter how small, the drum must be replaced.

Check Out-of-Round Drums

Drums with eccentric distortion might appear fine to the eye but can cause pulling, grabbing, and pedal vibration or pulsation.

- An out-of-round or egg-shaped condition is often caused by heating and cooling during normal brake operation.
- Out-of-round drums can be detected before the drum is removed by adjusting the brake to a light drag and feeling the rotation of the drum by hand.
- After removing the drum, gauge it to determine the amount of eccentric distortion. Drums with this defect should be machined or replaced.

Disc Rotor inspection

The rotors should be inspected whenever brake pads are replaced and when the wheels are removed for other services. They should be carefully checked to determine if they can be reused or machined or if they should be replaced.

Check Disc Rotor Lateral Run out

Excessive lateral run out 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, vibrate during braking and Chatter can also result.
- Lateral run out also causes excessive pedal travel because the pistons have farther to travel to reach the rotor.
- If run out exceeds specifications, the rotor must be turned or replaced. For the best braking performance, lateral run out should be less than 0.003 inch (0.08 mm) for most vehicles.

- Some manufacturers, however, specify run out limits as small as 0.002 inch (0.05 mm) or as great as 0.008 inch (0.20 mm).

- Run out measurements are taken only on the outboard surface of the rotor, using a dial indicator and suitable mounting adapters.

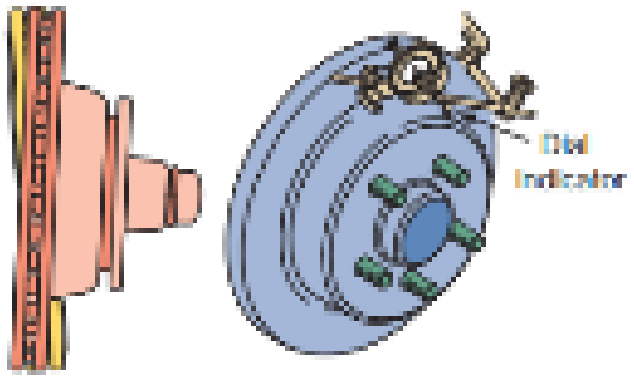


Figure 70 disc run-out measurement

- If the rotor is mounted on adjustable wheel bearings, readjust the bearings to remove bearing end play. Do not over tighten the bearings. On rotors bolted solidly to the axles of FWD vehicles, bearing end play is not a factor in rotor run out measurement.
- If there is excessive bearing end play, the bearing assembly must be replaced. Bearing end play is best checked with a dial indicator.

Additional Checks

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

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.

Disc rotor 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.

Disc 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. Therefore, a rotor with heat checks should be replaced.
- Hard spots appear as round, shiny, bluish areas on the friction surface. Hard spots on the surface of a rotor usually results from a change in the metallurgy caused by brake heat. Pulling, rapid wear, hard pedal, and noise occur.
- These spots can be removed by machining. However, only the raised surfaces are removed, and they could reappear when heat is again encountered. The rotor should be replaced.

Disc Rust

- If the vehicle has not been driven for a period of time, the discs will rust in the area not covered by the lining and cause noise and chatter.
- This also can result in excessive wear and scoring of the discs and pads. Wear ridges on the discs can cause temporary improper pad contact if the ridges are not removed before the installation of new pads.
- Rusted rotors should be cleaned before any measurements are taken. Inspect the fins of vented rotors for cracks and rust.
- Rust near the fins can cause the rotor to expand and lead to rotor thickness variations and excessive run out problems.
- Machining the rotor may remove run out and thickness variations, but rotor expansion due to rust may cause these problems to reappear soon.
- Rusted rotors should be replaced.

Checking the spring

- Check springs for spread or collapsed coils, twisted or nicked shanks, and severe discoloration

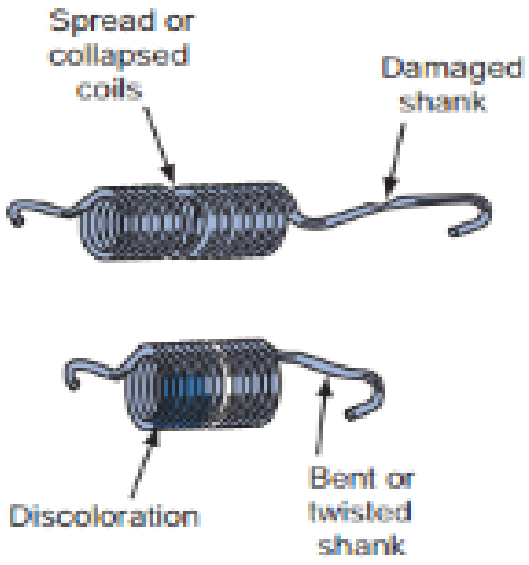


Figure 71 damaged return spring

The Drop Test

- Brake return (retracting) springs can be tested by dropping them to the floor. A good spring should “thud” when the spring hits the ground. This noise indicates that the spring has not stretched and that all coils of the springs are touching each other.
- If the spring “rings” when dropped, the spring should be replaced because the coils are not touching each other.

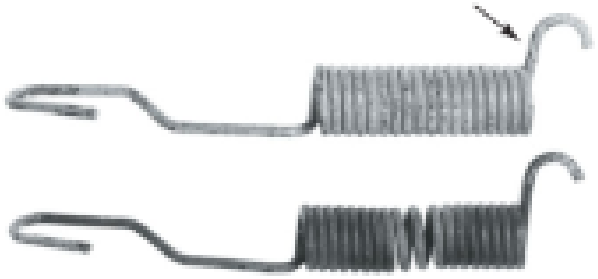


Figure 72 return spring dropped

- Although this drop test is often used, many experts recommend replacing all brake springs every time the brake linings are replaced. Heat generated by the brake system often weakens springs enough to affect their ability to retract brake shoes, especially when hot, yet not “ring” when dropped.
- These springs should be tested prior to a brake overhaul, especially when uneven lining wear is discovered.

Checking Cables

- Parking brake linkages transmit force from the pedal, lever, or handle inside the vehicle to the brake friction assemblies.

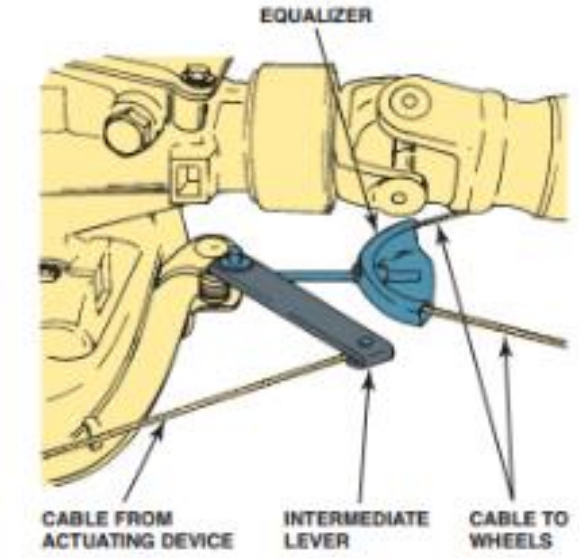


Figure 73 parking brake cable checks (wear and corrosion)

- Parking brake cables are subject to damage from water, dirt, and other debris thrown up under the vehicle by the tires. Most parking brake cables do not require lubrication because they are lined with nylon or Teflon, and any cable housing ends located under the vehicle are protected by rubber or nylon seals.
- Always inspect parking brake cables for proper operation. A cable that is larger in diameter in one section indicates that it is rusting inside and has swollen.

Figure 74 swollen parking cable

- A rusting parking brake cable can keep the rear brake applied even though the parking brake lever has been released. This can cause dragging brakes, reduced fuel economy, and possible vehicle damage due to overheated brakes.

Inspecting the Brake Shoes

Carefully inspect before the replacement brake shoes Check all of the following points:

1. Check that the replacements are exactly the same size (width and diameter) as the original. Hold the replacement shoes up against the old shoes to make the comparison.

2. Check for sound rivets (if rivet type). The friction material should also be snug against the metal brake shoe backing.

After checking that the replacement brake lining is correct, place the old shoes into the new linings' box. This helps ensure proper credit for the old shoes (called the core) as well as protection against asbestos contamination exposure.

Checking Pads

Even with operating wear-indicating sensors, a thorough visual inspection is very important.

- A lining thickness check alone should not be the only inspection performed on a disc brake. A thorough visual inspection can only be accomplished by removing the friction pads.
- For an example of a disc brake pad that shows usable lining thickness, but is severely cracked and must be replaced. Minimum thickness for various types of disc brake pads:

Note: Pad wear sensors often make a "chirping" sound when the vehicle is moving if the pads are worn. Do not confuse that noise for a defective wheel bearing or other fault.

- This cracked disc brake pad must be replaced even though it is thicker than the minimum allowed by the vehicle manufacturer and the wear sensor was not close to the rotor.
- Be careful to observe the direction in which replacement linings are facing. Some vehicle manufacturers offset the friction material on the steel backing to help prevent or minimize tapered pad wear.
- Check service information for details as to which direction the pads should be installed.
- Some disc brake pads may show more wear on the end of the pad that first contacts the rotor as compared to the trailing end of the pad.
- This uneven wear is caused by the force between the pad and the abutment (slide area). In designs that place the caliper piston exactly in the center of the leading edge of the pad that first contacts the rotor as it is revolving through the caliper, pressures are often one-third higher than the average pressure exerted on the entire pad. The result of this higher pressure is greater wear.

- Brake engineers design brakes to minimize or eliminate tapered pad wear by offsetting the piston more toward the trailing edge of the shoe or by other caliper/pad mounting designs.
- One method used to help reduce tapered pad wear is the design that offsets the friction material off center. Be certain to position the pads correctly or severe tapered pad wear will occur.
- These pads were found to be cracked and a section was missing from a part of one pad.

Figure 75 pad cracked

- Many callipers are equipped with a brake inspection opening that allows the technician to view the thickness of the brake pads.

Figure 76 ispect thickness of pad

Rubber booster

The following Symptoms of bad or failing rubber booster must be checked:

- Check the performance of brake pedal and rubber booster assembly for wear
- Check if the brake pedal is difficult to engage
- Check the brake if they are spongy
- Check if the pedal release after braking

Adjuster screw assembly

- Disassemble the adjusting screw assembly) and clean the parts in a suitable solvent.

- Make sure the adjusting screw threads into the pivot nut over its complete length without sticking or binding.

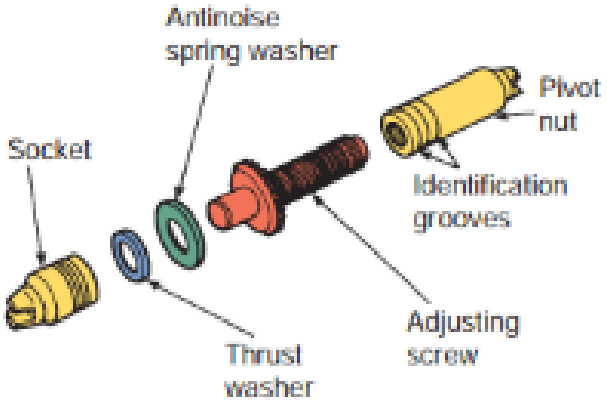


Figure 77 adjuster screw assembly

Check that none of the adjusting screw teeth are damaged. Lubricate the adjusting screw thread.

LO 3.2 – Clean mechanical brake components

- Content/Topic 1 Cleaning methods and cleaning mediums

Methods of cleaning

There are three types of cleaning methods that can be used when cleaning mechanical brake component, there are dry cleaning method, air blowing method, solvents or wet cleaning method.

a) Dry cleaning method

It is done by using clean cloth rags and sand paper, clean the break pad friction surface. In this method ensure that the dust is not inhaled.

b) Air blowing method

In this method the compressed air is used with the air gun to blow the dirt ou of the mechanical brake component.

C) Solvents or wet method

- This includes methods such as vapour degreasing, spraying, immersion.
- Brake cleaner, often also called parts cleaner, is a mostly colour less cleaning agent, mainly used for cleaning the brake disks, the engine compartment and under floor of motor vehicles.
- An important feature is that the brake cleaner leaves no residue after the solvents evaporates.

Figure 78 brake shoes cleaning

- The main application of brake cleaners is the degreasing and cleaning metal parts or metallic surfaces. They are used for removing oils, fats, resins, tar and dust

Cleaning mediums

- **Cloth rags:** Cloth rags are rags made from unwanted clothing, household fabric items and similar sources. They are useful for cleaning, mopping up messes

Figure 79 cloth rags

- **Sand paper**

Sandpaper and glass paper are names used for a type of coated abrasive that consists of sheets of paper or cloth with abrasive material glued to one face.

Figure 80 sand paper

LO 3.3 – Replace damaged parts of mechanical brake system

- Content/Topic 1 Replacing damaged parts of mechanical brake system

Steps Removing and Replacing Brake Pads

Step 1: Front brake pad replacement begins with removing brake fluid from the master cylinder reservoir

Step 2: Raise the car. Make sure it is safely positioned on the lift. Remove its wheel assemblies.

Step 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.

Step 4: Loosen the bolts and remove the pad locator pins.

Step 5: Lift and rotate the caliper assembly from the rotor.

Step 6: Remove the brake pads from the caliper assembly.

Step 7: Fasten a piece of wire to the car's frame and support the caliper with the wire.

Step 8: Check the condition of the locating pin insulators and sleeves.

Step 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.

Step 10: Remove the clamp and install new locating pin insulators and sleeves, if necessary.

Step 11: Install the new pads into the caliper.

Step 12: Set caliper with pads over the rotor and install the locating pins. After the assembly is in the proper position, torque the pins according to specifications.

Learning Unit 4 – Re-assemble and test mechanical brake system

LO 4.1 – Reassemble mechanical brake components

- **Content/Topic 1 Rea-assembling mechanical brake components**

Steps of Reassembling Drum Brake

Step 1: Gather Tools needed to service a drum brake assembly include brake tools, silicone grease, wheel lug nut sockets, and torque limiting adapters or a torque wrench.

Step 2: Reassemble the primary (forward facing) shoe return spring, using a brake tool. then remove return spring.

Step 3: Reassemble the parking brake strut along with anti-rattle spring.

Step 4: Use brake tool to depress the hold-down spring, and then rotate it until the slot in the retainer lines up with the flattened part of the hold down pin.

Step 5: Reassemble primary brake shoe plus star wheel adjuster and connecting spring.

Step 6: when the secondary lining hold down spring is reassembled, the adjusting lever and the pawl return spring can be reassembled.

Step 7: The parking brake lever can now be connected from the secondary brake shoe.

Step 8: Check wheel cylinders for leakage. Check the pistons to see that they can move too during inspection this wheel cylinder is relatively new and not leaking.

Step 9: Clean all brake shoes ledges. Lubricate the ledges with the silicone brake grease.

Step 10: Many technician prefer to assemble the connecting spring and star-wheel adjuster to both shoes in the reinstallation

Step 11: attaching the parking brake lines to the secondary shoe. the reassembled parts at the bottom help to keep everything together.

Step 12: Installing the secondary shoe hold-down spring.

Step 13: Installing the secondary shoe return spring. Note that the primary return spring has already been installed.

Step 14: After installing the brake shoes and springs, use a drum/shoe clearance gauge and set it to the inside diameter of the drum and fix the drum.

Step 15: Adjust the star-wheel adjust until the linings contact the drum brake shoes clearance gauge.

Step 18: After installing the drum, it may be necessary to make the final adjustment using a brake adjusting tool

Step 17: After completing the brake service, be sure to cover the brake adjustment opening to prevent water from getting into the brake

Wheels and tires remounting

Step 18: Reinstall the wheel/tire assembly

Step 19: Torque the lug nut to the factory specification or use a torque limiting adapter.

LO 4.2 – Adjust mechanical brake components

- Content/Topic 1 Adjusting of mechanical brake components

Parking brake adjustment

If you have tightened the brake shoes so that there is no excess travel before they come on, yet the handbrake lever still pulls up a long way, the cable has probably stretched and must be adjusted.

Adjusting Nut and screw

- A single adjustment compensates for wear on separate pads and for cable stretch.
- Some are inside the car, at the base of the handbrake lever. Most, however, are underneath the car - and are probably dirty and rusty.
- About two hours before you plan to do the job, squirt penetrating oil on to all the nuts and screw threads you will unscrew. This gives the oil time to free any seized parts. The adjustment for the enclosed Bowden cable is located on a bracket.

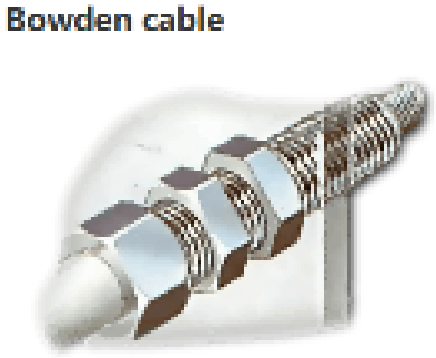


Figure 81 bowden cable

- Whenever you work under the car, always put it on firm supports such as axle stands. Chock the wheels remaining on the ground.

- Raise the rear wheels clear of the ground and support them on axle stands. Chock the front wheels and fully release the handbrake.
- The adjusters are inside the car, at the lower end of the handbrake lever. Pull away the covering or carpeting.
- Remove the rubber cover on the handbrake to reach the adjusters.

Figure 82 adjust the parking brake

- Hold the adjuster nut with a spanner and slacken off the locknut a few turns.
- The threaded end of each cable has one or two nuts. If there are two, grip each with a spanner and screw them apart, freeing the locknut.
- Hold the lower end of one rod with a pair of pliers to stop it turning, or fit a screwdriver into the front end of the rod if that is slotted.
- Turn the lower nut clockwise down the thread, drawing the rod forward. Stop turning when the handbrake lever can be pulled up only three to five 'clicks'. Adjust the other rod by the same amount.

Figure 83 adjustment the parking brake

Screwed sleeve adjuster

- Exact details of the adjuster vary considerably from car to car, but there is probably a pair of nuts on the adjuster rod - one an adjuster nut on a screwed sleeve, the other a locknut to hold it firmly.
- Loosen the locknut and screw it back three or four threads.
- Turn the adjuster nut clockwise until the raised wheel can be turned only with firm hand force.
- Apply the handbrake and check that the wheels do not bind when it is released. If they do, readjust. Tighten the locknut.
- Slacken the locknut and tighten the nut on the sleeve adjuster.

Bowden cable adjustment

- Raise the wheels on which the handbrake operates clear of the ground, and support that end of the car on axle stands. Chock the other wheels. Pull the handbrake lever on three clicks.
- Loosen the locknut and screw it back along the threaded part of the outer casing a few turns. Screw the adjuster nut in the same direction until some resistance is felt on the cable.
- Turn a wheel - it should turn only with firm hand force. Move the adjuster again if necessary, until it does.
- When the wheel movement is correct, hold the adjuster nut with one spanner and tighten the locknut on to it with another.
- Screw the adjuster nut along the cable casing until there is resistance.

Adjusting primary and secondary cables

Some cars have a pair of handbrake cables separated by a relay lever located under the car**.**

- A primary cable runs from the handbrake lever to the relay lever; a secondary cable goes from the relay lever to the brakes.
- Set the handbrake lever one or two clicks 'on'. Jack up the car and support it securely on axle stands. Chock the un-braked wheels.
- Free any lock nuts, then tighten the cable that has the most slack until it is taut. Repeat the procedure with the second cable, and then tighten the locknuts.

Equalising cable adjustment

Sometimes the adjustment is on an equalising unit mounted on the rear axle, or on a fork at the end of a rod or cable just before it reaches the brake back plate.

Figure 84 equalizing cable adjustment

- A clevis pin holds the fork to a lever on the back plate. Take out the split pin which holds the clevis pin: remove the clevis pin.

LO 4.3 – Perform road testing of mechanical brake system

- Content/Topic 1 Performing road testing of mechanical brake system

A) Test for brake pads and brake shoes slipping when braking

- Slip brake testing is a long standing method of measuring the braking performance of a vehicle.
- The brake tests are mainly carried out on brake dynamometers. This has two identical sets of rollers so that the brakes for both wheels on an axle can be tested at the same time.
- These rollers each drive one braked wheel during the test. The drive rollers on one side are driven together. The third roller is a sensor roller. It automatically activates the dynamometer and the locking protection. The braking force (peripheral force) of every wheel is measured.

Figure 85 dynamic brake testing

The following are measured for each wheel:

•Braking force

Rolling resistance

•Fluctuation of the braking force, e.g. in the case of an out-of-round drum

•Occurrence of incipient lock

- **Test for brake performance**

Performance testing of automotive brakes involves determination of stopping time, distance and deceleration level. Braking performance of an automobile is required to be ensured for

various surfaces like dry, wet, concrete, bitumen etc. as well as for prolonged applications. Various brake testing standards are used worldwide to assure vehicle and pedestrian safety.

figure 86 wheel on performance brake testing

Brake Performance Testing Parameters

1. Following are the main parameters used to characterize the brake performance.

(a) Stopping Time: The time elapsed between the moment the brake force is applied to the pedal and the vehicle stops (considering full stop) [1].

(b) Stopping Distance: The distance covered by vehicle from the moment when driver begins to actuate the brake control(s) until the moment the vehicle stops [2].

The mathematical expressions for these parameters are as shown in Eqs. (1) and (2):

Stopping time=Vo/Dx (1)

Stopping distance=V2o/2Dx (2)

- Where, Vo is the initial velocity and Dx is deceleration due to brake application. It has been assumed that the final velocity of the vehicle is zero (full stop) and other forces on the vehicle remain constant during brake application.
- The influencing parameters on the brake performance are initial velocity and deceleration of the vehicle
- Following are the tests conducted to assess braking performance of a vehicle.

  (i) Type P Test (Dynamic Performance)

  (ii)Type F Test (Heat Fade)

  (iii)Type W Test (Water Fade

- **Test for noise**
  Brake dynamometer squeal noise test is well defined and proved to make sure that the brakes will be in the best possible state when it comes to brake squeal before starting the vehicle testing. It is performed in a noise, vibration and harshness.

Figure87 wheel brake noise test

- Brake dynamometer squeal noise test is well defined and proved to make sure that the brakes will be in the best possible state when it comes to brake squeal before starting the vehicle testing.
- It is performed in a noise, vibration and harshness (NVH) brake dynamometer according to SAE J2521. Brake squeal is defined to be between 1 - 17 kHz.

Test for brake pedal vibrations

- A road test is the best way to check your brake rotors. When performing a road test, make sure the vehicle speed reaches 30mph and then safely apply the brakes firmly while coming to a complete stop. Be on the lookout for a pulsation or vibration in the vehicle or on the brake pedal.
- A warped rotor is usually the cause for Pedal Pulsation when braking and can cause vibration.

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