Automotive Technology

Module 6: Brakes

Student Reference

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The *Introduction to Automotive Technology* module is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. All major components of the module have been keyed to the IML's Automotive Technology Competency Profile.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both the teacher and the student. Automotive technology, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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ACKNOWLEDGMENTS

The 1996 revision of *Introduction to Automotive Technology* is the first of nine modules to make up the Automotive Technology Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents IML's commitment to continual improvement of the Missouri Automotive Technology Curriculum. All modules in the guide are based on the Auto Mechanics Technology Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technological advanced field of automotive technology.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

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HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Cross-Reference Table

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items.

Objectives

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent.

Information sheets

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. The corresponding student reference page number appears in the upper right hand corner of the Instructor Guide.

Tests

Tests evaluate students knowledge of the material.

Assignment Sheets

Assignment sheets allow students to respond to cognitive questions in writing.

Job Sheets

Job sheets are designed to guide students through various key tasks. Job sheets also provide a means for instructors to evaluate a student's performance of the task.

Suggested Activities

Students should perform the following activities:

1. Read objective sheet.
2. Study information sheets.
3. Take unit test.
4. Do job sheet(s).

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MODULE 6: BRAKES

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MODULE: BRAKES

UNIT I: INTRODUCTION TO AUTOMOTIVE BRAKE SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the basic principles by which an automotive braking system functions. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with basic principles of automotive braking (all competencies in the Brakes Module, Unit I Test).

II. Identify the braking requirements of an automobile (all competencies in the Brakes Module, Unit I Test).

III. Identify the principles of friction in brake action (all competencies in the Brakes Module, Unit I Test).

IV. Identify how a vehicle's brakes are applied and how the hydraulic system functions (all competencies in the Brakes Module, Unit I Test).

V. Identify the factors associated with controlled stopping of the automobile (all competencies in the Brakes Module, Unit I Test).

MODULE: BRAKES

UNIT I: INTRODUCTION TO AUTOMOTIVE BRAKE SYSTEMS

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT I: INTRODUCTION TO AUTOMOTIVE BRAKE SYSTEMS

LESSON 1: FUNDAMENTAL PRINCIPLES OF BRAKE SYSTEMS

I. Terms and definitions

A. **Coefficient of friction**—The amount of friction produced by two objects rubbing against each other.

B. **Brake fading**—Loss of brakes, usually due to heat.

C. **Brake lining**—Material mounted on the surface of a brake shoe or pad. Brake lining produces a great deal of friction when brought together with another friction surface.

D. **Brake pad**—Disc brake component that is forced against a rotating disc in order to create friction.

E. **Brake shoe**—Drum brake component that is forced against a brake drum in order to create friction.

F. **Calipers**—Disc brake component that forces brake pads against a rotating disc.

G. **Disc brakes**—Brake system that creates friction by forcing brake pads against a rotating disc.

H. **Drum brakes**—Brake system that creates friction by forcing brake shoes against brake drums.

I. **Kinetic energy**—A type of energy that moves objects.

J. **Kinetic friction**—A type of friction occurring between two objects, one of which is moving.

K. **Static friction**—A type of friction occurring between two objects, both of which are stationary.

II. Kinetic energy

A. The energy that moves a vehicle is called kinetic energy. A moving vehicle encounters resistance that depletes (takes away) its kinetic energy. Such resistance includes friction created by the vehicle's tires rolling against the pavement and by the vehicle's body moving through the atmosphere (wind resistance).

B. Wind resistance and tire friction, however, will only slow a vehicle gradually. A modern brake system can bring a vehicle to an abrupt stop by rapidly converting a vehicle's kinetic energy into heat (through the use of friction) and then dissipating it.

III. The principles of friction involved in brake action

A. Friction is the resistance to movement that results from two objects moving or rubbing against each other. There are two types of friction—kinetic and static.

1. Kinetic friction occurs between two objects, one of which is moving. Kinetic friction always produces heat (the more kinetic friction produced, the greater the heat produced). Automotive brakes use kinetic friction to convert the energy of a moving vehicle into heat.

2. Static friction occurs between two objects, both of which are stationary. Automotive brakes use static friction to hold a vehicle while parked. Static friction produces no heat.

B. Various factors that affect the amount of friction produced between two objects

1. The rougher the surfaces of two objects, the more friction they will produce.

a. Extremely rough surfaces create the most friction, but rough surfaces also wear down quickly. Automotive brakes, therefore, use relatively smooth surfaces to avoid rapid wear.

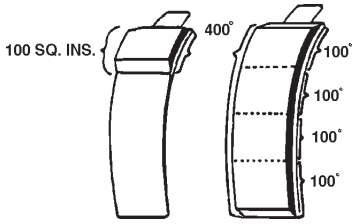
b. In order to compensate for their smooth surfaces, automotive brakes are applied with a great amount of pressure over a relatively large contact area.

2. The greater the pressure bringing the objects together, the more friction they will produce. Therefore, the greater the pressure applied to the brakes (with all other factors equal), the greater their stopping power.

3. The greater the amount of shared contact area between two objects, the greater the amount of friction the objects will produce.

a. Automotive braking systems use the largest contact area possible.

b. The greater the contact area of a brake shoe or pad, the less heat the shoe or pad will generate. Less heat allows for more friction, which makes the brakes more efficient.



(**NOTE**: On drum brake systems, a brake shoe is applied to a brake drum to create friction. On disc brake systems, a brake pad is applied to a disc to create friction. Both of these systems will be discussed later in this module.)

4. The hotter the friction surface of two objects, the less friction they will produce. (Rub your hands together and feel the heat!)

   a. All heat created by the brake system must be dissipated as rapidly as it is created. The brake system can store little or no heat.

   b. Brake friction surfaces are made of material that can conduct heat easily.

   c. Braking system components that produce friction (brake shoes or pads) are positioned so that air cools them. In some braking systems, forced air is used to cool components.

C. The amount of friction produced by two objects rubbing against each other is called the coefficient of friction.

D. An important brake friction surface is the brake lining, which is mounted on either a brake shoe or pad. The brake lining produces friction by directly contacting another friction surface (either a brake drum or disc). The brake lining and the material with which it comes into contact must have special characteristics.

1. The brake drum or disc must do the following: conduct heat easily; hold its shape under extremely high heat; withstand rapid temperature changes; resist warping and distortion; and wear well in general. Therefore, brake drums and discs are typically constructed of iron or steel combined with aluminum.

2. The brake lining must be somewhat softer than the brake drum or disc. At present, most brake linings are made of organic material, metallic particles, and other minerals held together by a bonding agent.

   (**NOTE**: For years asbestos was commonly used in brake linings. Because asbestos is a cancer-causing substance, federal law prohibits its use in brake systems.)

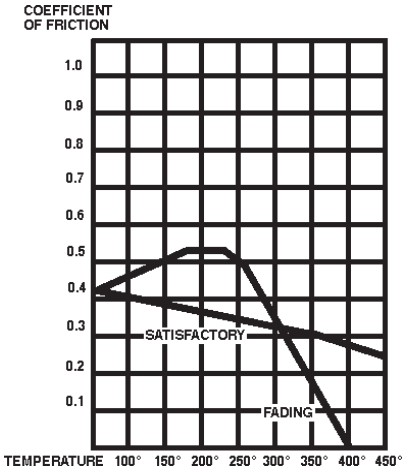
3. When the brake lining is applied to a drum or disc, the proper coefficient of friction must be produced if the brakes are to be effective.

   a. If the friction coefficient is too great, the brakes may be "grabby" or overly sensitive. Overly sensitive brakes may cause the vehicle to skid too easily.

   b. If the friction coefficient is too low, brake application will require excessive pressure. Applying brakes with excessive pressure creates excessive heat, which could result in brake failure.

      (**NOTE**: The coefficient of friction between two objects is always reduced by heat. High temperatures, therefore, may cause brakes to fail.)

c. If brakes create more heat than can be dissipated, the friction coefficient will be reduced, causing the brakes to fade. Excessive heat also causes bonding agents in the lining to melt and flow to the surface, thus producing a glaze on the shoe lining. This glaze will reduce the brake's friction coefficient and cause more brake fading. Brake application will then require more pressure, thus creating more heat and more glazing.



IV. How brakes are applied and how the hydraulic system functions

A. Automotive brake systems fall into two major categories—service brakes (hydraulic brakes) and parking brakes.

1. Service brakes stop the vehicle when it is in motion.

2. A parking brake holds the vehicle while it is parked. A parking brake is not designed to stop a moving vehicle.

(**NOTE**: Parking brakes often use the same friction surfaces as service brakes.)

B. Hydraulic brake systems

1. In modern vehicles, hydraulic systems transfer pressure applied to the brake pedal (by the driver) to brake shoes or pads. In some brake systems, pressure from the driver's pedal is enhanced by servo action and/or power boosters.

2. Most vehicles use two separate hydraulic systems to activate the brakes; therefore, failure of one hydraulic system will not result in complete brake loss.

a. On some vehicles, one hydraulic system activates the front-wheel brakes while the other hydraulic system activates the rear-wheel brakes.

b. On other vehicles, one hydraulic system activates the brakes on one front and one rear wheel while another hydraulic system activates the brakes on the other front wheel and rear wheel. In this design, the brakes on one hydraulic system are always at opposite corners of the vehicle.

3. How the hydraulic braking system functions

a. When the driver presses the brake pedal, hydraulic pressure builds in the master cylinder.

b. Hydraulic pressure travels through brake lines and valves to various brake activators—either wheel cylinders or calipers.

c. The wheel cylinders or calipers convert the hydraulic pressure into mechanical force.

d. In drum brake systems (as was mentioned above), hydraulic pressure causes a wheel cylinder to press the brake shoe against the brake drum. In disc brake systems, hydraulic pressure causes a caliper to press a brake pad against a rotating disc. In both systems, therefore, the action of one component pressing against another creates friction and slows the vehicle.

(**NOTE**: Wheel cylinders and calipers will be discussed in more detail later in this module.)

e. When the brake is released, various devices move the brake shoes or pads away from the drums or discs.

(**NOTE**: The parking brake is not activated by the hydraulic system but rather by a cable or some other mechanical linkage.)

V. Factors associated with controlled stopping of the vehicle

A. Vehicle weight

1. The more weight a moving vehicle has, the more kinetic energy it will possess. Brake systems must convert kinetic energy into heat; therefore, any increase in vehicle weight will put more demand on the brakes.

2. If a vehicle's weight is doubled, the amount of kinetic energy that the brakes must convert into heat is doubled. The amount of heat energy resulting from the conversion will also be doubled. Brakes on an overloaded vehicle may, therefore, become ineffective due to overheating.

B. Vehicle speed

1. When the speed of a vehicle doubles, the brakes must convert four times the amount of kinetic energy into heat. Speed greatly increases the demand on a vehicle's brakes.

2. A combination of high speed and excessive weight may push a vehicle's brakes beyond their performance limit, resulting in a serious loss of stopping power.

C. Friction between tire and road

1. The point at which a vehicle's tire contacts the road is called the tire footprint. Changes in tire footprint affect a vehicle's ability to stop. Below is a discussion of the factors affecting tire footprint.

a. The larger a tire's diameter (sometimes called the tire's rolling radius), the larger its footprint. The larger the tire footprint, the more stopping power that can be applied at the tire's contact point with the road. It is important to realize, however, that the greater a tire's diameter, the more braking power that is needed to stop the vehicle.

(**NOTE**: A general rule is that the larger a tire's diameter, the more braking power required.)

b. The greater the width of a tire, the larger the tire footprint. The larger the tire footprint, the more stopping power that can be applied at the tire's contact point with the road. It is important to realize, however, that the greater a tire's width, the more braking power that is needed to stop the vehicle.

(**NOTE:** A general rule is that wide tires require large brakes.)

c. Excessive vehicle weight can distort tire tread and thus reduce the tire's hold on the road. Tires that cannot hold the road will reduce the vehicle's ability to stop.

d. High vehicle speed can aerodynamically lift a vehicle as it moves. This lifting reduces the tire's hold on the road, thus reducing the vehicle's ability to stop.

(**NOTE**: Aerodynamic lift merely adds to the stopping problems created by high speed. Remember that, every time a vehicle's speed is doubled, the vehicle's stopping power must be quadrupled, even if there is no aerodynamic lift.)

(**NOTE**: Friction occurring at the tire footprint is needed to control the vehicle. Should this friction be lost, the vehicle would be out of control.)

e. Tires grip the road more securely (and thus can stop better) if the wheels are moving. Therefore, stopping power is decreased if the brakes lock up the wheels. Automotive engineers are careful not to design brake systems that are too powerful for the cars in which they are installed. If a brake system locks up the wheels too easily, stopping power and vehicle control are significantly reduced.

MODULE: BRAKES

UNIT II: DISC AND DRUM BRAKE SYSTEM COMPONENTS AND HOW THEY OPERATE

UNIT OBJECTIVE

After completing this unit, the student should be able to identify disc and drum brake system components and how they operate. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions related to hydraulic systems (Competencies V1-V3, Part I of the Unit II Test).

II. Identify hydraulic principles related to automotive brakes (Competencies V1-V3, Part I of the Unit II Test).

III. Identify principles of split brake systems (Competencies V1-V3, Part I of the Unit II Test).

IV. Identify the principles of master cylinder operation (Competencies V1-V3, Part I of the Unit II Test).

V. Identify various types of master cylinders (Competency V1-V3, Part I of the Unit II Test).

VI. Identify the operating principles of power brake boosters (Competencies Y1-Y4, Part IV of the Unit II Test).

VII. Identify the hydraulic plumbing components of the brake system (all competencies in the Brakes Module, Part I of the Unit II Test).

VIII. Identify basic operation principles of the parking brake (Competencies W3 and X3, Part V of the Unit II Test).

IX. Identify parking brake systems and their operation (Competencies W3 and X3, Part V of the Unit II Test).

X. Identify mechanical brake system components (all competencies in the Brakes Module, Unit II Test).

Lesson 2.

I. Identify terms and definitions related to operation of disc and drum brake systems (Competencies W1-W3 and X1-X3, Parts II and III of the Unit II Test).

II. Identify the various components of drum brakes and how they function (Competencies W1-W3, Part II of the Unit II Test).

III. Identify the principles of operation of servo drum brakes (Competencies W1-W3, Part II of the Unit II Test).

IV. Identify the principles of operation of non-servo drum brakes (Competencies W1-W3, Part II of the Unit II Test).

V. Identify the components of disc brakes (Competencies X1-X3, Part III of the Unit II Test).

VI. Identify the principles of operation of fixed caliper disc brakes (Competencies X1-X3, Part III of the Unit II Test).

VII. Identify the principles of operation of the floating caliper disc brake system (Competencies X1-X3, Part III of the Unit II Test).

MODULE: BRAKES

UNIT II: DISC AND DRUM BRAKE SYSTEM COMPONENTS AND HOW THEY OPERATE

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT II: DISC AND DRUM BRAKE SYSTEM COMPONENTS AND HOW THEY OPERATE

LESSON 1: HYDRAULIC SYSTEM COMPONENTS

I. Terms and definitions

A. **Combination valve** — An assembly that includes either 2 or 3 of the valves used in dual braking systems.

B. **Differential pressure valve** — A valve (usually part of the combination valve) that illuminates a brake warning light when the brake system malfunctions.

C. **Hydraulic pressure** — Pressure applied to fluid to perform work.

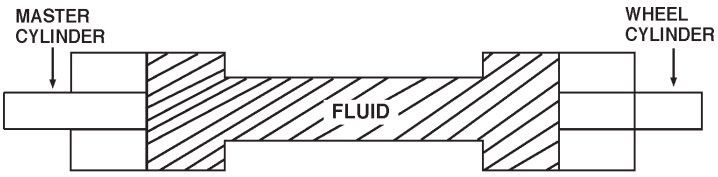
D. **Master cylinder** — A hydraulic cylinder connected to the brake pedal. This cylinder converts brake pedal movement into hydraulic pressure to operate the brakes.

II. Hydraulic principles relating to automotive brakes

A. An important principle of hydraulics states that, when pressure is applied to a fluid, the fluid exerts the same pressure equally in all directions.

PRESSURE IS EXERTED EQUALLY IN ALL DIRECTIONS

B. If two cylinders are filled with liquid and connected by a tube, pressure from one cylinder will be transferred to the other.



PRESSURE EXERTED ON ONE PISTON IS TRANSMITTED TO THE OTHER

(**NOTE**: When put under pressure, fluid will not be compressed, nor will fluid produce any measurable friction. Pressure is not diminished when transferred through fluid.)

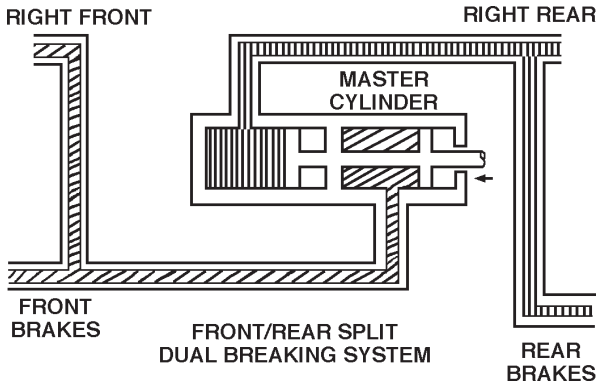
C. Another important principle of hydraulics states that fluids are virtually incompressible. In automotive brake systems, the master cylinder is connected to various brake components by steel tubing and rubber hoses, all containing brake fluid. When the driver presses the brake pedal, the master cylinder exerts hydraulic pressure on the brake components (by way of the tubes and hoses) and thus applies the brakes. Because brake fluid is incompressible, the force applied to the brake pedal is efficiently transferred to the brake actuators.

III. Split brake systems

A. A loss of brake fluid would obviously make it difficult or even impossible to apply the brakes. Federal law, therefore, requires vehicles to have two separate hydraulic systems, with each system operating a different set of brakes. (Such a design is called a "split" brake system.) If one system were to lose hydraulic pressure, the other system could still stop the car.

B. There are essentially two different types of split brake systems: front/rear split systems and diagonally split systems.

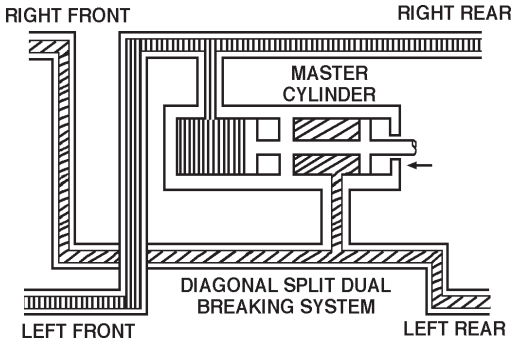
1. In front/rear split systems, the front brakes are activated by one hydraulic system and the rear brakes are activated by the other. Both systems receive pressure from a single master cylinder.



(**NOTE:** Front/rear split systems are often used on larger vehicles with conventional rear-wheel drive.)

(**NOTE**: A pressure drop in either system activates a pressure differential valve, which illuminates a warning or brake light on the vehicle's instrument panel.)

2. In diagonally split systems, one front and one rear brake located on opposite sides of the vehicle are activated by one of the master cylinder pistons.



(**NOTE**: The weight balance in many late-model, front-wheel-drive vehicles makes rear-wheel brakes alone unable to provide adequate stopping power. The diagonally split braking arrangement, on the other hand, provides sufficient stopping power should one hydraulic system fail.)

(**NOTE:** In both front/rear and diagonally split systems, a differential pressure valve activates a warning light if one of the vehicle's two hydraulic systems loses pressure.)

IV. Components of the master cylinder and the principles by which they operate

A. The master cylinder is a hydraulic pump, which is operated by a push rod attached to the brake pedal or power booster. The master cylinder converts mechanical force into hydraulic pressure.

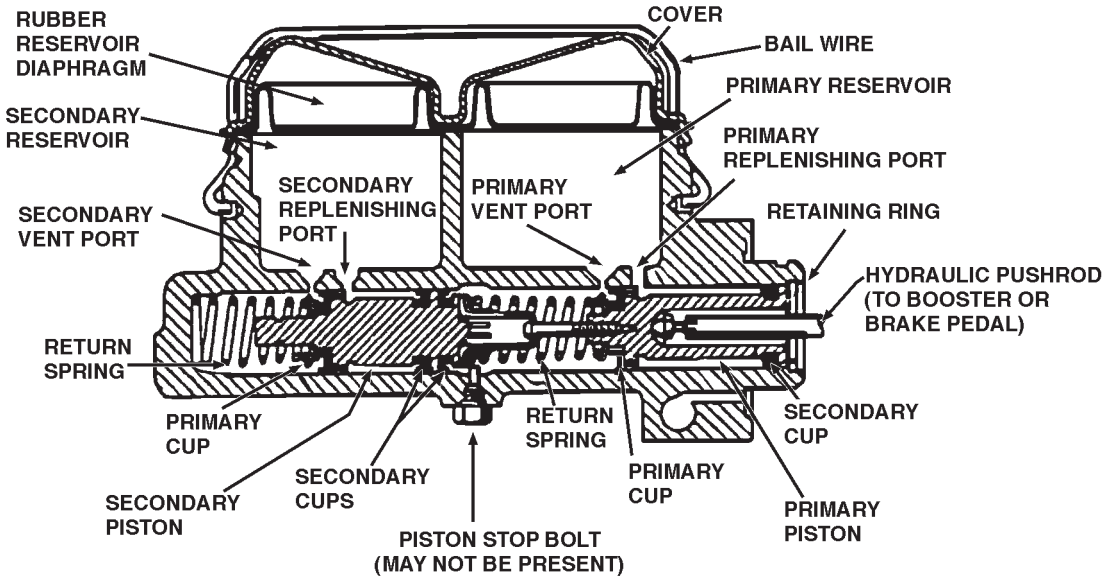
B. As was explained above, modern vehicles use dual hydraulic systems to activate the brakes—either a front/rear or a diagonally split system.

(**NOTE**: Brake systems are split to guard against total brake failure. If one hydraulic system fails, the other will remain operational, thus providing enough braking power to stop the vehicle.)

C. A dual system master cylinder is a single unit that sends hydraulic pressure through the two separate hydraulic systems. In 1967, the federal government mandated that all cars must have dual brake systems.

D. Components of the dual master cylinder

1. The master cylinder housing contains most of the master cylinder components, along with the cylinder bore. The housing is made from either cast iron or anodized aluminum. Reservoirs in iron housings are usually cast as an integral part of the housing. Anodized aluminum housing uses reservoirs made of plastic or fiberglass; these reservoirs are mounted either on the cylinder housing or the vehicle's fire wall.



Courtesy of Wagner Division, Cooper Industries, Inc.

2. Reservoir covers and diaphragms

   a. Reservoir covers protect brake fluid from contamination. A vent in the cover allows atmospheric pressure to be exerted on the diaphragm. If these vents were to become blocked, the master cylinder could not transfer pressure through the brake system.

   b. The diaphragm is a thin, flexible piece of material in the master cylinder reservoir. The diaphragm allows atmospheric pressure to be exerted on the brake fluid while keeping the fluid free of contaminants.

   c. In some vehicles, each reservoir may have its own diaphragm and cover. In other vehicles, a single diaphragm and cover may extend over both reservoirs.

3. Pistons, cups, and reservoir ports

   a. A dual master cylinder contains two pistons in the same bore. The piston located toward the rear of the vehicle is called the primary piston. The primary piston creates hydraulic pressure in the primary brake system, which, in most front/rear brake systems, operates the front brakes. The piston located toward the front of the vehicle is called the secondary piston. The secondary piston provides hydraulic pressure to the secondary brake system, which, in most front/rear brake systems, operates the rear brakes. On some vehicles, the master cylinder pistons are of different diameters.

   b. Both master cylinder pistons are connected to the brake pedal via a push rod. When the driver applies pressure to the brake pedal, the push rod moves the pistons forward, thus creating hydraulic pressure throughout the brake system. After the driver releases the brake pedal, return springs push the pistons back to their original position.

(**NOTE**: A rubber, accordion-shaped boot, located at the point where the push rod enters the master cylinder, prevents brake fluid contamination.)

(**NOTE**: Additional springs are sometimes used to return the brake pedal to its "off" position.)

c. Each of the pistons is fitted with a cup (a rubber seal shaped like a cup), which moves fluid forward when the piston is moved forward.

(**NOTE**: Washers, spring seats, and cup protectors are often used to prevent the cylinder return springs from damaging the cup.)

d. Each reservoir has a vent and a replenishing port which allow brake fluid to move from the reservoir to the hydraulic cylinder and back again.

(**NOTE**: In vehicles with disc brakes in front and drum brakes in back, the reservoir for the disc brakes will be bigger than the reservoir for the drum brakes.)

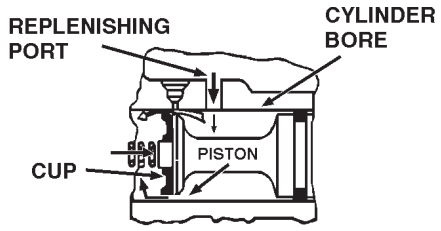
4. In front/rear brake systems, residual pressure check valves are found in the secondary outlet port, which controls the rear drum brakes. Residual pressure check valves are not used in hydraulic systems that control disc brakes; nor are the valves used in diagonally split brake systems.

(**NOTE**: Diagonally split systems use a residual pressure check valve in the lines that lead to drum brakes.)

E. Operation of the dual master cylinder

1. When the brake pedal is depressed, the primary piston moves forward in the cylinder and the primary vent is sealed off from the fluid, thus creating a solid column of fluid that moves the secondary piston. As the two pistons move forward, they put pressure on the brake fluid in the master cylinder bore. As a result, pressure builds throughout the brake lines and activates the brakes. This process will be described in more detail in Lesson 2 of this unit.

2. When the brake pedal is released, primary and secondary return springs force the pistons back to their resting position. The pistons usually move to their resting positions faster than the fluid can return to the master cylinder. As a result, a low pressure area is created in front of the returned pistons, thus slowing the release of the brakes. To prevent low pressure from forming in front of the pistons, fluid from the replenishing ports pushes the cylinder cups into the low pressure area, thus keeping the area in front of the pistons full of fluid.



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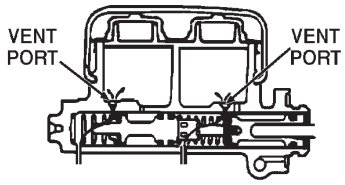
(**NOTE**: Any excessive fluid that may build up as line pressure decreases is returned to the reservoir via the vent ports.)



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F. Operation of the master cylinder during a failure of the hydraulic system

1. If a problem occurs in primary hydraulic system, the primary piston will move forward without creating any hydraulic pressure in the primary system. Even though no hydraulic pressure is created, the primary piston will contact the secondary piston, thus creating hydraulic pressure in the secondary system and applying two of the vehicle's brakes.
2. If a problem occurs in the secondary brake system, the secondary piston will bottom out at the end of the cylinder bore; therefore, no hydraulic pressure will be created in the secondary system. When the secondary system bottoms out, the primary piston will then develop pressure in the primary system. The primary hydraulic system will still activate at least two of the vehicle's brakes.

   (**NOTE**: When a hydraulic system problem occurs, the brake pedal will move noticeably farther before braking begins to occur.)

V. Single system master cylinders and variations on the dual master cylinder

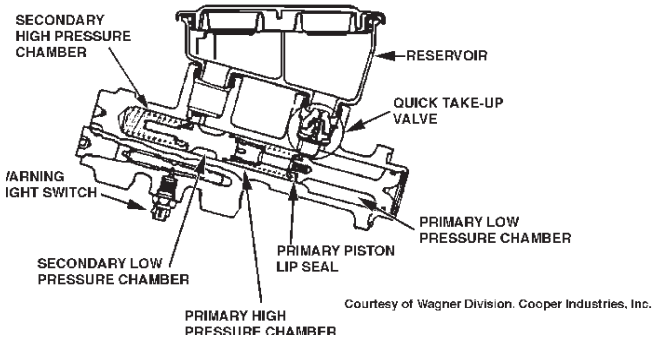
A. Single system master cylinders are found on vehicles built before 1967. These cylinders have only one primary piston, which activates all four brakes. A single reservoir provides fluid to the piston.

B. Dual bore master cylinders incorporate a hydraulic clutch master cylinder in the same unit that houses the brake master cylinder. The bore containing the clutch cylinder is serviced in much the same way as the bore containing the brake cylinder.

C. The vertical master cylinder is used on many trucks which have limited space. The vertical master cylinder operates in much the same way as a horizontal cylinder. The reservoirs for vertical master cylinders must be mounted **away from** the master cylinder.

D. In the step bore dual master cylinder, the secondary piston is smaller than the primary piston. This cylinder balances the combination brake system without the use of exterior valves.

E. The quick take-up master cylinder is usually found on front-wheel-drive vehicles with diagonally split brakes. In order to improve fuel economy, these vehicles have calipers that retract the brake pads material slightly when the brakes are not applied. Upon brake application, the quick take-up cylinder must provide large amounts of low hydraulic pressure to move the pads into contact with the disc before greater hydraulic pressure is applied. Most of these cylinders are made of aluminum and use plastic reservoirs.

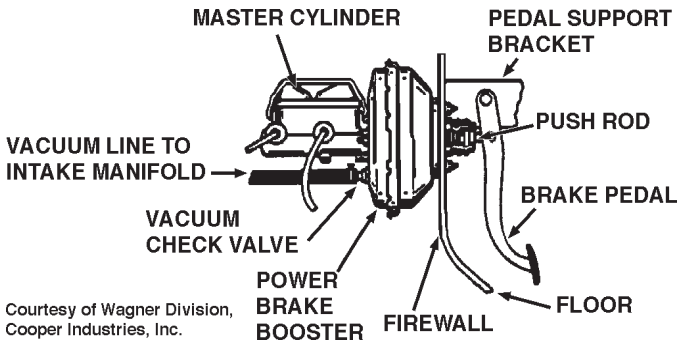


VI. Power brake boosters

(**NOTE**: Almost all late-model automobiles are equipped with power brakes. Power brakes reduce the amount of effort required to apply the brake pedal, which in turn activates the master cylinder. Most power brakes are either vacuum or hydraulically operated.)

A. Vacuum-operated power brakes

1. Vacuum-operated power brakes take power from the engine intake manifold vacuum. A vacuum booster is mounted between the master cylinder and the fire wall. The brake pedal pushes against the booster push rod, which in turn operates a valve assembly.

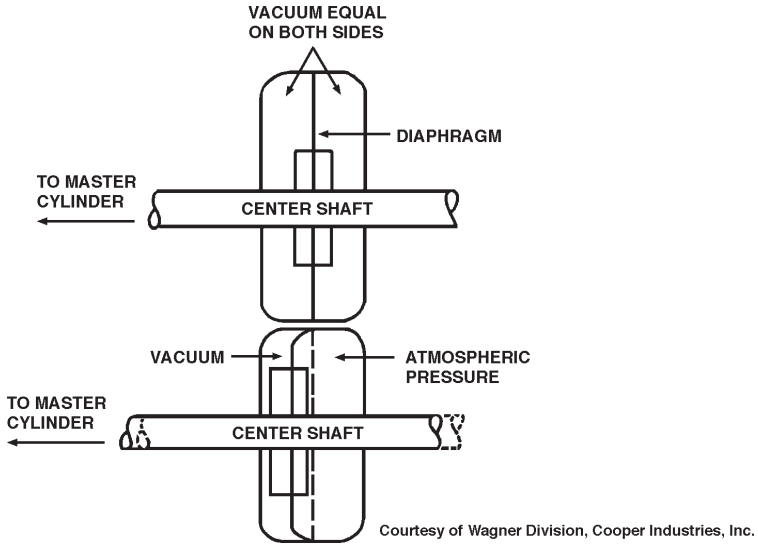


2. The valve assembly closes off the vacuum to the rear chamber of the booster and admits atmospheric pressure to that side. This action causes the piston to move toward the master cylinder. The piston pushes against the master cylinder push rod, thus activating the brakes.

3. The booster, therefore, applies most of the brake application force; however, a reaction assembly allows part of the application pressure to be felt by the driver.

4. Positions of the vacuum booster during brake application

   a. When the brakes are released, the atmospheric valve is closed and the intake manifold vacuum is present on both sides of the piston, allowing the piston return spring to hold the piston in the release position.



   b. When the brake pedal is depressed, the booster is in the apply position. The vacuum port to the rear booster chamber is closed, and the atmospheric port is opened, thus allowing atmospheric pressure to push the piston forward, applying the brakes.

   c. The booster moves into the hold position when the driver holds the brake pedal stationary. In the hold position, the piston has caught up with pedal and push rod movement, causing the atmospheric port to close. Since the vacuum port is already closed, the booster holds the brake application position desired by the driver. As soon as the pedal is released, the atmospheric port closes and the vacuum port opens, allowing the spring to return the booster piston to the release position.

      (**NOTE**: If the vehicle's engine stalls, the vacuum booster will not operate. The brakes will operate normally but without power assistance, thus requiring the driver to exert more pressure on the pedal.)

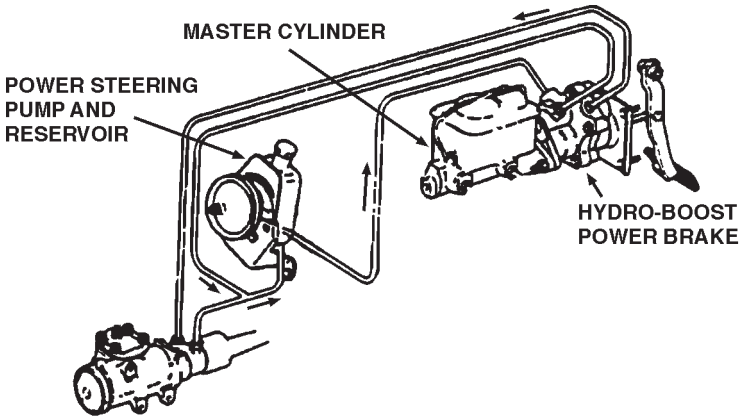
1. Emission control devices can reduce the available intake manifold vacuum, sometimes leaving insufficient vacuum to operate vacuum assisted brakes. Vehicles with significantly reduced vacuum use a hydraulic brake booster called hydro-boost. The hydro-boost uses power-steering pump hydraulic pressure to assist the driver in applying the brakes.

2. Operation of hydro-boost brakes

   a. When the brake pedal is depressed, a control valve in the hydro-boost unit allows power-steering pump pressure to act on a piston, which in turn pushes on the master cylinder push rod. The amount of brake application pressure provided depends on pedal pressure and the position of the control valve.

   b. In the hold position, the valve shuts off any additional hydraulic pressure from the power-steering pump to the booster. On release, the valve releases pressure as the piston is returned to the release position.

   c. An accumulator stores sufficient hydraulic pressure for several brake applications should the power-steering pump fail. Once the accumulator pressure is depleted, the brakes will operate normally but without power assistance, thus requiring the driver to exert more pressure on the pedal.



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(**NOTE**: If the vehicle's engine stalls, the hydro-boost will not operate. The brakes will operate normally but without power assistance, thus requiring the driver to exert more pressure on the pedal.)

VII. Hydraulic plumbing components

A. Brake lines transfer hydraulic pressure within brake systems.

1. All brake lines in modern automobiles are made of double-walled steel tubing. These lines are usually coated with a corrosion-retarding substance.

2. Brake lines are preformed to fit the location in which they are used. Replacement lines can, however, be purchased in straight lengths and bent to fit.

B. Brake hoses transfer hydraulic pressure from brake lines to either wheel cylinders or calipers. Brake hoses are used on areas of the car where vibration or movement may occur—such as on the front wheels or between the body and the rear suspension.

1. Brake hoses are made of laminated rubber and can withstand at least 1500 psi of hydraulic pressure. On some anti-lock brake systems, the brake hoses must withstand 2,700 psi of hydraulic pressure.

2. The length of the replacement brake hose must be compatible with the vehicle on which the hose will be installed. The connecting fittings must also be compatible. Replacement hoses must fit perfectly.

C. Fittings are used to connect brake hoses and brake lines to each other or to various brake components.

1. Some fittings use a hollow bolt to carry brake fluid. These fittings are called banjo fittings and banjo bolts.

2. Only use replacement fittings that are designed for the brake system.

3. On most vehicles, the brake lines are coupled with double-lap flares.

4. GM vehicles use a brake line flare called an ISO. The ISO design is not subject to overtightening as is the double-lap flare.

(CAUTION: Never cut a brake line in order to repair it. Brake lines must always be replaced instead of repaired.)

(**NOTE**: If brake lines are to be replaced, purchase a line as close to the proper length as possible and adjust the routing of the line to achieve the correct fit.)

D. Residual check valves

1. On a drum brake system, the residual check valve holds a small amount of pressure in the brake lines and wheel cylinders.

2. The pressure held is not enough to overcome the tension of the brake shoe return spring. However, this pressure does hold the wheel cylinder cups tight against the cylinder when the brake pedal is suddenly released.

3. If the cups are tight against the cylinder, air will not be pulled through the cups when the pressure behind them suddenly drops below zero.

4. Residual pressure valves are not used in disc brake systems. Residual pressure valves would tend to cause disc brakes to drag because the residual hydraulic pressure would be sufficient to hold the pads against the rotor.

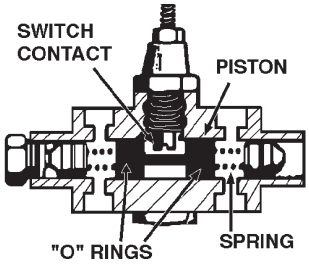
5. In systems that use disc and drum brake combinations, a residual check valve will be found in the line that feeds hydraulic pressure to the drum brakes.

E. Differential pressure valve

1. In dual brake systems, the differential pressure valve indicates a loss of pressure in one of the vehicle's two brake systems.

2. If one brake system loses pressure upon brake application, the system that remains under pressure moves the piston in the differential pressure valve. As the piston moves, it grounds the warning light circuit, illuminating a brake warning light in the dash.

3. In some differential pressure valves, two centering springs—one on each side of the piston—return the piston back to its original position after the driver releases the brake pedal. Valves with centering springs, therefore, activate the warning light only when the brake pedal is applied. Because the valve centers itself, the piston does not have to be reset after the brake system is repaired.



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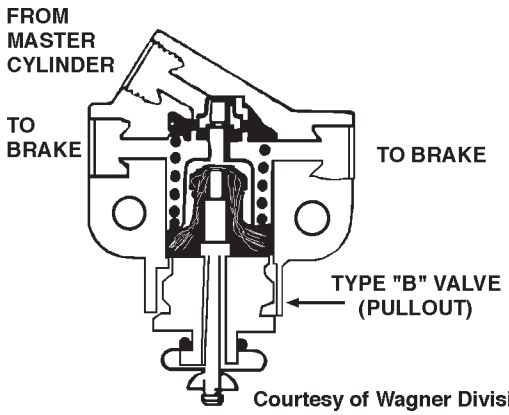
4. Some differential pressure valves use no centering springs. In these valves, once the piston moves, it must be manually returned to its original position. Therefore, when a loss of pressure occurs during brake application, the warning light (activated by the valve's piston) will stay on until the technician resets the piston.

5. Some differential pressure valves have two pistons, both with centering springs. These valves operate in the same manner as a single-piston valve with centering springs. During brake bleeding operations, however, the switch assembly must be removed from the two-piston valve. Removal will prevent the switch terminal from getting wedged between the pistons should they become separated.

F. Metering valve

1. Most vehicles use disc brakes on the front and drum brakes on the rear. The disc brakes can be applied at lower pressures than the drum brakes. The metering valve denies pressure to the disc brakes until the drum brake shoes have contacted the brake drum. The metering valve, therefore, ensures that disc and drum brakes are applied evenly.



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2. When the driver applies the brake pedal, the metering valve prevents fluid from moving to the front disc brakes until 75 to 125 pounds of pressure has built up in the lines. When the correct amount of pressure occurs, the metering valve allows hydraulic pressure to be applied to the disc brakes.

3. 75 to 125 pounds of pressure is enough to allow the brake shoes to contact the rear brake drums; thus the rear drum brakes are applied just before the front disc brakes.

4. The metering valve is most effective during light braking. Without the action of the metering valve, the front disc brakes (which are activated with less pressure) would tend to lock during light braking, causing a loss of vehicle control.

5. Four-wheel drum or four-wheel disc systems do not use a metering valve because all brakes require the same amount of pressure to be activated.

   (**NOTE**: Four-wheel disc brake systems do use differential pressure valves, though they may be located at different points within the system.)

   (**NOTE**: Diagonally split braking systems must use one metering valve for each individual system. Not all diagonally split systems use metering valves, however.)

6. Another name for the metering valve is hold-off valve.

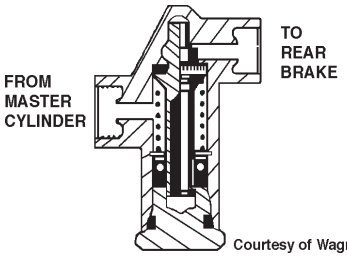
G. Proportioning valve

1. Like the metering valve, the proportioning valve is used on many combination disc and drum brake systems.

2. The proportioning valve is found in the hydraulic line that leads to the rear brake.

3. If, during heavy brake application, the same hydraulic pressure were applied to both the front and rear brakes, the rear brakes would lock up, resulting in a skid and loss of vehicle control.

4. The proportioning valve prevents lockup of rear brakes by reducing hydraulic pressure to the rear brakes during heavy braking.



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5. Weight-sensing proportioning valve

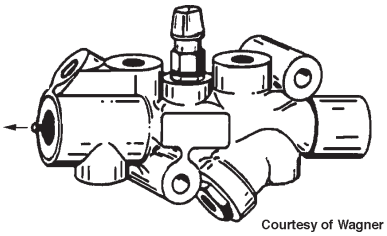
   a. Some proportioning valves are connected to the rear suspension by a mechanical link. By sensing the deflection of the rear suspension, these proportioning valves can determine vehicle weight.

   b. Vehicle weight affects braking requirements (the heavier the vehicle the more hydraulic pressure required by the rear brakes). The weight-sensing proportioning valve varies hydraulic pressure to the rear brakes in accordance with the vehicle weight.

   (**NOTE**: Most diagonally split braking systems use two proportioning valves, one for each hydraulic circuit.)

H. A combination valve is a device that contains either two or three of the valves mentioned above (the differential pressure valve, the metering valve, and the proportioning valve).

(**NOTE**: Some control valves are built into the master cylinder. Others are located in the brake lines.)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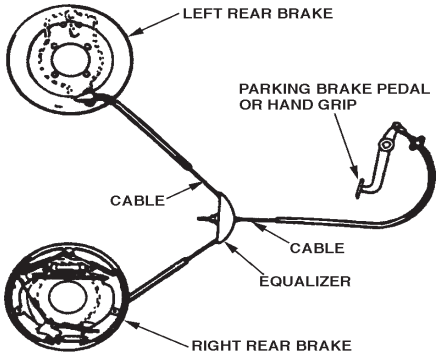
VIII. Basic operation of the parking brake

A. The parking brake is a mechanical braking system that operates independently of the hydraulic service brakes.

B. The parking brake consists of a foot pedal or hand-operated lever which is connected through linkages and cables to both rear brake assemblies.



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C. When the pedal or lever is activated, the cables to the rear brakes are stretched tight and thus lock the brake against the friction surface.

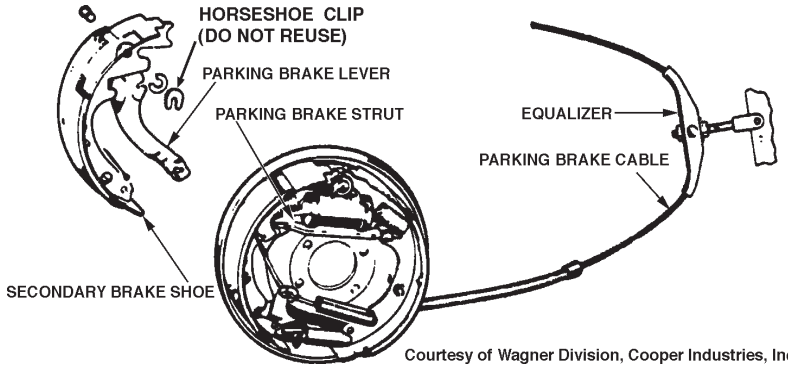
D. In some parking brake systems, a vacuum motor releases the parking brake when the transmission is shifted out of park. In most other systems, the parking brake is manually released.

IX. Parking brake systems and their operation

A. Integral parking brake

1. The integral parking brake system consists of a system of cables, a parking brake strut, and a parking brake lever located on each rear wheel.

2. When the parking brake is applied, the cable pulls the parking brake levers forward, causing the levers to apply pressure to the parking brake strut, which, in turn, forces the primary rear brake shoe into the drum. As more pressure is exerted on the lever, the secondary shoe is also forced into the drum.



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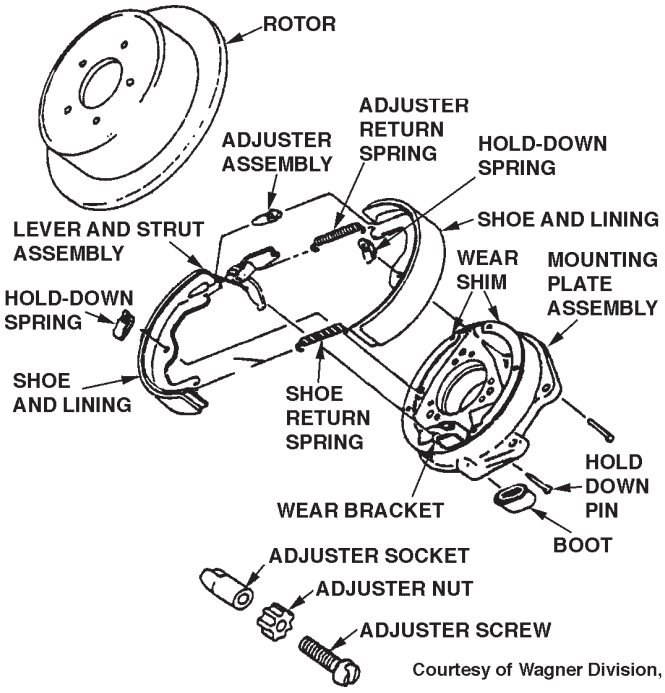
3. When the brake is released, a spring on the parking brake strut recenters the shoes in the drum.

B. Auxiliary drum parking brake

1. The auxiliary drum parking brake system is used on some vehicles equipped with disc brakes on all four wheels.

2. The auxiliary drum parking brake operates in almost the same manner as the integral parking brake systems. The auxiliary drum parking brake, however, uses the inside of each rear wheel hub and rotor assembly as the parking brake drum.



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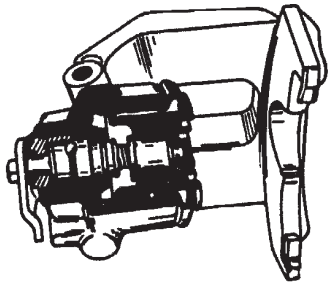
C. Rear disc parking brakes

1. The rear disc parking brake system uses the rear service brake pads for the parking brake.

2. The rear disc parking brake operates much like the auxiliary and integral systems described above. Rear disc parking brakes, however, use rear calipers, which have an adjuster screw that forces the rear-wheel service brake pads against the rotor. The designs for operation of specific calipers are often quite complicated. Consult a proper service manual before attempting caliper repair on these systems.



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X. Mechanical brake system components

A. Pedal mounts or hangers are the fixtures upon which the brake pedal is mounted.

1. The clutch pedal is often mounted in the same hanger as the brake pedal. The hanger includes the bushings and bearings upon which the pedals swing.

2. If the vehicle has a manual transmission, the hanger will usually include a switch that prevents starter engagement unless the clutch pedal is depressed. These hangers will have another switch on the brake pedal to control the brake lamps.

B. Various cables, levers, struts, and linkages serve to connect the parking brake system to its operating lever or handle.

MODULE: BRAKES

UNIT II: DISC AND DRUM BRAKE SYSTEM COMPONENTS AND HOW THEY OPERATE

LESSON 2: OPERATING PRINCIPLES OF DISC AND DRUM BRAKES

I. Terms and definitions

A. **Adjustment mechanism** — A group of parts which adjust the position of the drum brake shoe.

B. **Anchor (anchor pin or anchor block)** — Steel component which prevents the brake shoe from rotating with the wheel during brake application. (The brake shoe contacts the anchor when the brakes are applied.)

C. **Asbestos —** A mineral that is capable of withstanding extreme heat. Until recently, asbestos was widely used in brake linings. Asbestos, however, has been identified as a carcinogen (a cancer-causing substance), and federal law now prohibits its use in brake systems. The technician will, however, still encounter older brake shoes or pads that contain asbestos. **Proper precautions should be taken when servicing brake systems**.

D. **Brake backing plate —** A stationary metal plate fastened to the spindle or axle. Several brake components may be attached to the brake backing plate.

E. **Brake pads —** Flat pieces of metal on which brake lining is mounted. During brake action, the pads are forced against the rotor face.

F. **Caliper —** On disc brake systems, a caliper is a device that clamps the brake pads against the rotor. The caliper is acted upon by hydraulic pressure.

G. **Dissipate —** To scatter or dispel. To be effective, brakes must dissipate the heat created by the brakes.

H. **Fixed caliper disc brake design —** A design in which the caliper is fixed in position and cannot move. The caliper usually has four pistons, two on each side of the disc (rotor).

I. **Floating caliper disc brake design —** A design in which the caliper is mounted on rubber bushings. The bushings permit the caliper to "float" (move) when the brakes are applied. A floating caliper usually has only one large piston.

J. **Friction material —** A material designed to create friction. Friction material is mounted on brake pads or shoes in the form of brake lining.

K. **Friction surface —** Any surface designed to create friction when contacting another surface. Brake shoes and pads and drums and discs all have friction surfaces.

L. **Primary brake shoe —** The first shoe to contact the drum in a servo system. In servo systems, the primary shoe is pulled away from the anchor.

M. **Rotor —** In disc brake systems, a disc-shaped component that revolves with the axle. Pads are applied to the rotor to stop the vehicle.

N. **Secondary brake shoe —** In servo systems, a shoe forced into the anchor by the primary shoe.

O. **Servo action (self energizing) —** Brake shoes acting with a rotating brake drum to increase the force of brake application.

II. Drum brake components

A. The brake drum

1. The drum provides a friction surface (usually iron) to which brake shoes are applied. When the shoes and drum come together, they convert the kinetic energy of the moving vehicle into heat, which is then dissipated.

2. The brake drum rotates with the wheel. In some brake systems, the drum contains the wheel hub and the wheel bearings.

a. If the drum contains the hub, the drum provides the mounting hardware for the wheel and tire assembly.

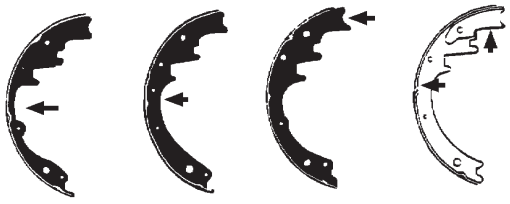
b. If the drum and hub are separate, the hub provides the mounting hardware for both the drum and the wheel/tire assembly.

3. The brake drum must be perfectly round and concentric with the spindle or axle. Brake pedal pulsation will occur if the drum is out of round or nonconcentric with the spindle or axle.
4. Deep grooving in the drum friction surface will prevent new shoes from conforming to the drum. Because grooves in the drum surface key into whatever component that cuts them, grooved drums can be difficult to remove.

B. Brake shoes

1. When the driver depresses the brake pedal, hydraulic pressure from the wheel cylinder forces the shoes against the rotating brake drum, thus producing friction, which transforms kinetic energy into heat.

2. Brake shoes are arc shaped to conform to the brake drum surface.



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3. Brake lining (a layer of special friction materials) is either bonded (glued) or riveted to the brake shoes.

C. Wheel cylinders

1. When the driver applies the brake pedal, hydraulic pressure from the master cylinder moves to the wheel cylinder. In the wheel cylinder, hydraulic pressure causes cylinder cups to push pistons outward. The action of the cylinders forces the brake shoes against the drum.

2. When the driver releases the brake pedal, hydraulic pressure is relieved. Brake shoe return springs then pull the shoes back against their anchor(s) and retract the wheel cylinder pistons.

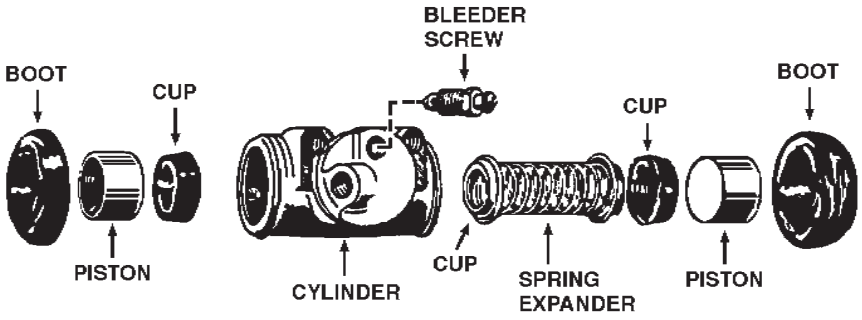
3. Wheel cylinders are connected to the master cylinder through a series of steel tubes and special rubber high-pressure hoses.

4. The wheel cylinders are always fastened firmly to the brake backing plate.

(**NOTE**: The backing plate is a steel disc, which is firmly attached to the spindle or axle housing. The backing plate will be discussed later in this unit.)

5. Each wheel cylinder has a bleeder valve, which allows air to be removed from the cylinder.

6. Wheel cylinders may contain either one or two pistons, depending on the type of brake system in which they are used.



D. Anchors

1. A brake anchor is a round piece of steel that is either attached to the backing plate or threaded into the spindle through a hole in the backing plate.

2. Anchors bear all the force that the brake shoe(s) applies to the drum and, therefore, must be very solid.

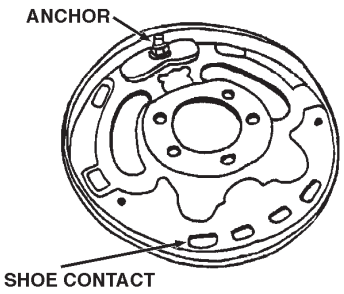
3. Most servo systems use one anchor per wheel. Some non-servo systems use two anchors per wheel (one for each shoe).

   (**NOTE**: Servo and non-servo brake systems will be discussed in more detail later in this unit.)

E. Backing plate

1. The backing plate is a steel disc, which is firmly attached to the spindle or the axle housing. (The backing plate cannot rotate.)

2. The backing plate provides a foundation for the drum brake system. The anchor(s) and wheel cylinders (along with the brake shoe return springs and some of the adjuster linkages) are fastened to the backing plate. The plate has built-in pads, on which the brake shoes can move.



F. Shoe hold-down devices are springs and pins, which hold the brake shoes against the backing plate, allowing them to slide outward to the drum when the brakes are applied.

G. Brake shoe return springs either return shoes to their rest position or pull the brake shoes away from the drum. In some systems, the return springs help control automatic adjusters.

H. Brake adjusters

1. Brake adjusters are used to achieve proper brake clearance between the brake lining and drum (while shoes are in the rest position). Maintaining proper clearance is important. Too much resting clearance results in excessive brake pedal travel. Too little resting clearance may cause the brake shoes to overheat.

2. Brake adjusters fall into two basic categories: automatic and manual.

a. Automatic brake adjusters automatically adjust clearances during normal brake system use.

b. Manual adjusters must have clearances adjusted periodically by the technician.

III. Operating principles of servo drum brakes

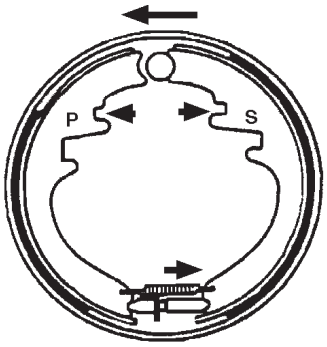
A. How servo drum brakes function

1. The brake pedal is connected to the master brake cylinder located under the hood. When the driver presses the vehicle's brake pedal, the master cylinder applies hydraulic pressure (through a series of lines and hoses) to pistons located in the wheel cylinders.

2. Once hydraulic pressure is applied, the wheel cylinder pistons force two brake shoes outward against the rotating drum. (The drum rotates with the wheel.)

3. When the brake shoes contact the rotating drum, the primary shoe is forced away from the anchor while the secondary shoe is forced into the anchor, causing the secondary shoe to stop. (The adjuster is located between the two brake shoes and moves along with them.)

4. The force of the rotating drum then presses the primary shoe (and adjuster) against the secondary shoe (which is stopped by the anchor) with great force. The primary shoe, therefore, applies a great deal of extra pressure to the secondary shoe, which, in turn, applies the extra pressure to the drum.



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(**NOTE**: The extra pressure created by the rotating drum pressing the primary shoe into the secondary shoe is the result of a servo or self-energizing action for which the brake system is named.)

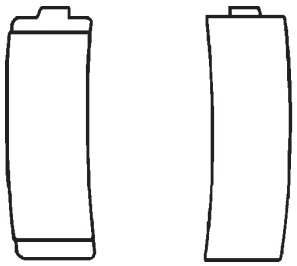
5. When the driver releases the brake pedal, hydraulic pressure is relieved. Brake shoe return springs retract the pistons and return the brake shoes to their rest position.

B. Important characteristics of servo drum brakes

1. In servo drum brake systems, both brake shoes are applied to the drum regardless of the vehicle's direction.

   (**NOTE**: In some non-servo systems, brake shoe application depends on the direction that the vehicle is moving.)

2. The primary and secondary shoes on servo brakes are different and often cannot be interchanged. The primary shoe (located at the front of the wheel) will sometimes have less brake lining than the secondary shoe (located at the back of the wheel).



3. In most servo systems, the anchor is located near the top of the backing plate.

   a. When not in use, the shoes are held against the anchor by the brake return springs.

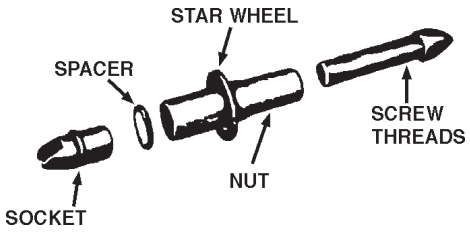
   b. When the brake pedal is depressed, the primary shoe is pulled away from the anchor as it contacts the rotating drum. As is described above, the secondary shoe is abruptly stopped as it attempts to rotate with the drum.

4. In servo brake systems, each wheel cylinder uses two pistons; the cylinder is usually mounted near the top of the backing plate. The wheel cylinder uses pistons to push both of the brake shoes off the anchor and into contact with the drum.

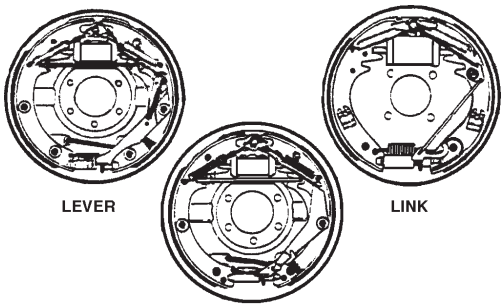
5. Most servo systems use automatic adjuster linkages. These adjuster linkages are activated by movement of the secondary brake shoe when the brakes are applied while the vehicle is in reverse. As the clearance between the shoe and drum increases, the distance that the shoe moves increases. When a predetermined amount of shoe movement occurs, the linkage moves the adjuster's star wheel, thus adjusting the clearance.

   (**NOTE**: In servo brakes, the adjuster is a threaded link that bridges the end of the brake shoe located opposite the anchor.)

   (**NOTE**: Servo brake adjusters can be used only on the side of the vehicle that they were originally installed. They are not interchangeable from one side to the other.)



6. There are three types of automatic adjuster linkages: the lever type, the cable type, and the link type.



Courtesy of Wagner Division, Cooper Industries, Inc.

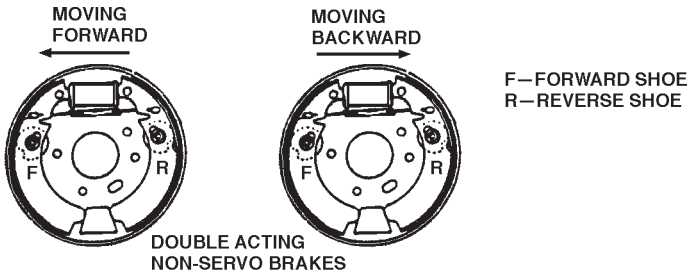
IV. Operating principles of non-servo drum brakes

A. On non-servo systems, an anchor is located at the end of each shoe. Depending on the system design, these anchors can be located either at the opposite ends or the same ends of each shoe. The brakes will function differently according to anchor location.

1. Non-servo systems with anchors located near backing plate bottom

a. In most non-servo systems, the anchors are located together near the bottom of the backing plate. The wheel cylinder bridges the space between the tops of the shoes.

b. When the driver presses the vehicle's brake pedal as the vehicle moves forward, the master cylinder applies hydraulic pressure (through a series of lines and hoses) to pistons located in the wheel cylinder. The cylinders then spread the top of the shoes apart until they both contact the drum. When contact is made, hydraulic pressure and energy produced by the drum's rotation forces the shoe located at the front of the wheel against its anchor. The shoe located at the rear of the wheel is forced away from its anchor and merely maintains light pressure against the brake drum. In this type of system, therefore, the front shoe (the one forced against the anchor) is applied to the drum with the greatest force and therefore provides the greatest stopping power. The rear shoe provides only a small amount of stopping power.



Courtesy of Wagner Division, Cooper Industries, Inc.

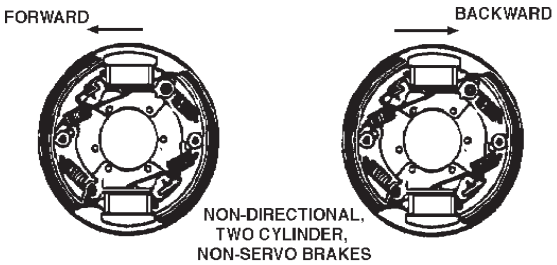
(**NOTE**: Non-servo brake systems are used on most front-wheel-drive vehicles.)

(**NOTE**: The above is a description of non-servo brake action on a vehicle that is moving forward. When the vehicle moves backward, the rear brake shoe is forced against the anchor and provides the greater stopping power.)

c. When the driver releases the brake pedal, hydraulic pressure is relieved. Brake shoe return springs retract the pistons and return the brake shoes to their rest position.

2. Non-servo systems that have one anchor placed opposite the other on the backing plate

a. In the second type of non-servo system, one anchor is placed opposite the other on the backing plate. Each shoe is held against its own anchor. In this system there are two single-piston wheel cylinders for each wheel (i.e. one cylinder for each shoe). The cylinders are hydraulically connected by metal tubing. The cylinders, therefore, act simultaneously, causing both shoes to stop drum rotation regardless of the direction of vehicle travel.



Courtesy of Wagner Division, Cooper Industries, Inc.

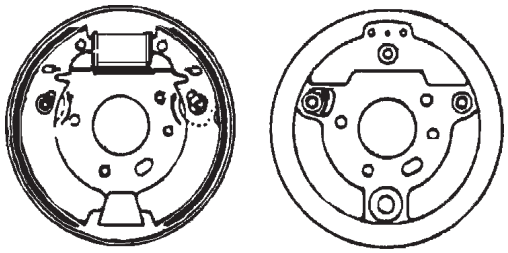
b. When the driver releases the brake pedal, hydraulic pressure is relieved. Brake shoe return springs retract the pistons and return the brake shoes to their rest position.

B. Important characteristics of non-servo drum brakes

1. Non-servo systems use either single- or double-piston wheel cylinders. Single-piston cylinders are mounted near the end of each brake shoe opposite the anchor. Double-piston cylinders are mounted between the shoes.

2. Some non-servo systems use automatic adjuster linkages. The movement of each shoe or use of the parking brake causes automatic adjusters to adjust the rest position of each shoe. There are three styles of automatic adjusters: lever latch, contact plug, and link crank.

3. In some non-servo systems, the adjusters are located at each shoe and are adjusted individually. The adjusters are manually adjusted by the technician from time to time.

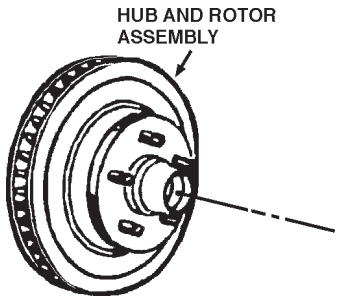


Courtesy of Wagner Division, Cooper Industries, Inc.

V. Disc brake components

A. The rotor

1. In disc brake systems, the rotor is an iron or steel disc, which revolves with the wheel. In most vehicles, the wheel is bolted to the rotor. Brake pads are applied to both sides of the rotor to create friction, which, in turn, converts kinetic energy into heat and dissipates it.



a. In front-wheel-drive vehicles, rotors on the front wheels are driven by the drive train. In such cases, the rotor is either splined to the drive axle or attached to it in some other way.

b. In rear-wheel-drive vehicles, the rotor often includes the hub and bearings, which support the wheel itself.

c. In some cases, the rotor on either a front- or rear-wheel-drive vehicle may be a separate unit. If so, the rotor is fastened to the hub by the same bolts that hold the wheel.

2. Because disc brakes have the ability to clean and cool themselves, they are generally considered to be more effective than drum brakes.

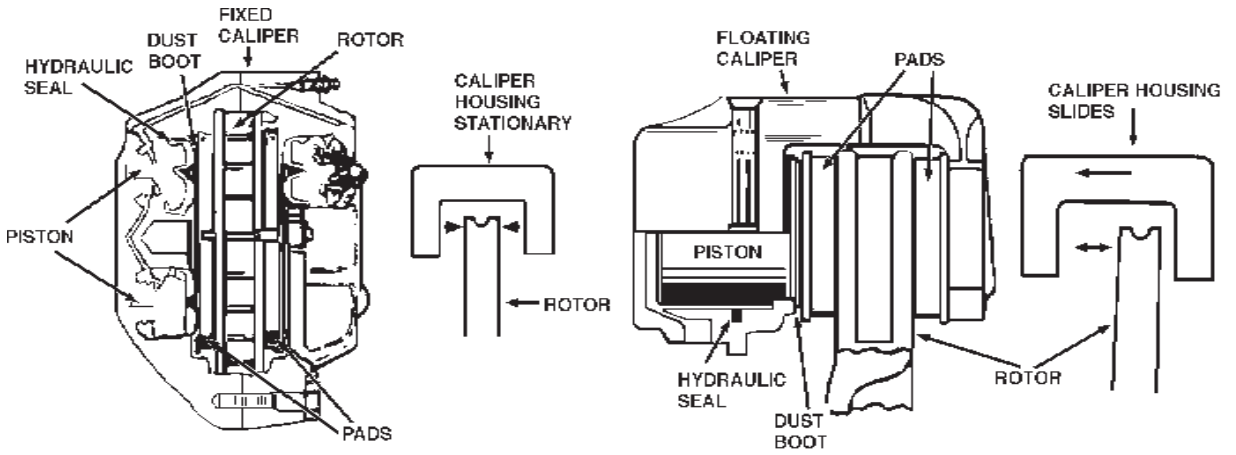
3. Bearing assemblies support the rotor while allowing it to rotate. Each bearing must be serviced at the same time as the rotor. These bearings will differ, depending on the make of the vehicle and the type of drive line it uses (front- or rear-wheel).

   (**NOTE**: In order to remove any rotor, the wheel and caliper must first be removed.)

B. The caliper

1. During brake applications, the caliper applies brake pads to both sides of the rotor (in effect, squeezing the rotor).

2. Disc brake systems use either a fixed or a floating caliper design.



Courtesy of Wagner Division, Cooper Industries, Inc.

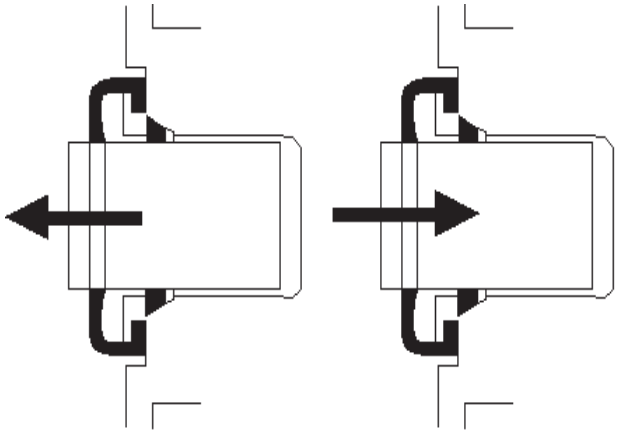
(**NOTE**: Brake systems must dissipate tremendous amounts of heat or the brakes will fail. Because of their exposure to the surrounding air, disc brakes dissipate heat more quickly than drum brakes. Some rotors are ventilated, allowing air to circulate between the friction surfaces and dissipate heat even more efficiently.)

(**NOTE**: Calipers use no brake return springs. Seal deflection releases the brake pads.)

3. When the driver releases the brake pedal, the piston seal pulls the piston back, allowing for brake release.

VI. Operation of fixed caliper disc brakes

A. When the driver depresses the brake pedal, hydraulic pressure from the master cylinder enters the caliper and then travels through transfer passages to the pistons. (Transfer passages are either internally drilled passages or externally mounted tubing) . There is an equal number of pistons on each side of the rotor. All pistons receive fluid pressure simultaneously. In turn, the pistons apply pressure to the brake pads.



Courtesy of Wagner Division, Cooper Industries, Inc.

B. Fixed calipers usually have four pistons (two on each side of the rotor).

C. The fixed caliper does not move when the brake is applied. The fixed caliper (and sometimes a dust shield) is mounted directly on the anchor plate or adapter.

D. In some vehicles, there are shims and spacers between the caliper and anchor plate or adapter to allow for adjustment. In these vehicles, the caliper must be precisely centered on the rotor. Centering can be accomplished by placing shims between the caliper and the anchoring device.

E. Fixed caliper systems have one significant disadvantage over floating caliper systems: if one of the pistons becomes stuck in its bore, the other three will still apply pressure to the rotor. Pressure from only three pistons can cause the pads to wear unevenly, resulting in damage to both the rotor and the caliper.

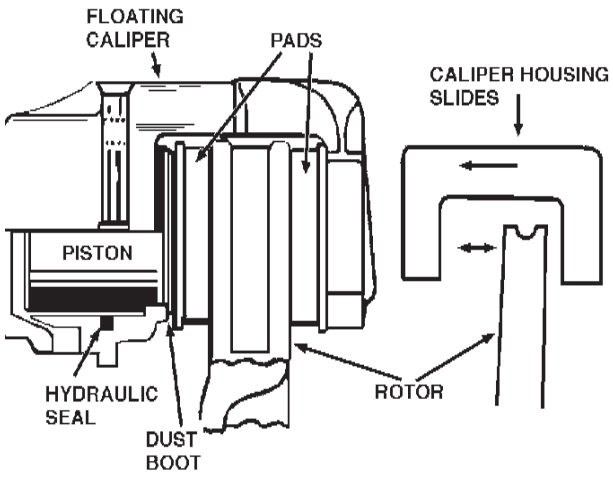
VII. Operation of the floating caliper disc brake system

A. In the floating caliper design, the caliper moves laterally when the brakes are applied. (The caliper does not rotate with the wheel, however.) The floating caliper uses only one piston, which is located on the caliper's inward side.

1. In some vehicles, bolts hold the floating caliper to the brake assembly. The bolts are, in fact, threaded pins upon which the caliper can slide.

2. In other vehicles, spring plates retain the caliper by matching grooves in the adapter/attaching plate and the caliper. These plates can be held by bolts or retaining pins.

(CAUTION: Before attempting repairs, the technician must determine whether the system to be serviced uses a floating or a fixed caliper. If the caliper has only one piston, it is floating; if it has two or more, it is fixed.)



B. When the driver depresses the brake pedal, hydraulic pressure from the master cylinder is applied to a single piston on the inboard side of the caliper. This piston forces the inboard pad against the rotor.

C. As the inboard pad contacts the rotor, the caliper is forced inward, thus bringing the outboard pad in contact with the rotor.

(**NOTE**: The floating caliper will center itself on the disc.)

D. When the driver releases the brake pedal, the piston seal pulls the piston back, allowing for brake release.

(**NOTE:** Disc brake systems do not use return springs to release the pads.)

MODULE: BRAKES

UNIT III: PROPERTIES OF BRAKE FLUID AND PROCEDURES FOR BLEEDING THE BRAKE SYSTEM

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the properties of brake fluid, the principles of brake fluid selection and handling, and the procedures for bleeding the brakes. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with brake fluid (Competencies V1-V3, W3, and X3, Part I of the Unit III Test).

II. Identify the properties of brake fluid (Competencies V1-V3, W3, and X3, Part I of the Unit III Test).

III. Identify three classifications of brake fluid and how they should be handled (Competencies V1-V3, W3, and X3, Part I of the Unit III Test).

IV. Identify procedures for selecting brake fluid and adding it to a vehicle (Competencies V1-V3, W3, and X3, Part I of the Unit III Test).

V. Demonstrate the ability to:

   a. Check and adjust master cylinder fluid level (Competencies V1, W3, and X3, JS1-L1-UIII).

Lesson 2.

I. Identify terms and definitions associated with bleeding brake systems (Competencies V2, W3, and X3, Part II of the Unit III Test).

II. Identify brake bleeding procedures (Competencies V2, W3, and X3, Part II of the Unit III Test).

III. Demonstrate the ability to:

   a. Bleed the brake system (Competencies V2, W3, and X3, JS1-L2-UIII).

MODULE: BRAKES

UNIT III: PROPERTIES OF BRAKE FLUID AND PROCEDURES FOR BLEEDING THE BRAKE SYSTEM

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT III: PROPERTIES OF BRAKE FLUID AND PROCEDURES FOR BLEEDING THE BRAKE SYSTEM

LESSON 1: THE SELECTION AND HANDLING OF BRAKE FLUID

I. Terms and definitions

A. **Boiling point** — The temperature and pressure at which a fluid boils.

B. **Chemical drying** — A chemical process by which moisture is removed from a fluid.

C. **Contamination** — The process of damaging a substance by introducing a foreign substance.

D. **The Department of Transportation (D.O.T.)** — A federal agency that establishes and enforces standards for the transportation industry.

E. **Denatured alcohol** — Alcohol that is used as a cleaning solvent for brake systems. Denatured alcohol is poisonous and not fit for human consumption.

F. **Hygroscopic** — A term used to describe the ability of a substance to absorb and hold moisture.

G. **Inert** — A term used to describe a substance that does not react with another substance.

H. **Soft parts** — Brake system components made of rubber or other soft material.

I. **Toxic** — Poisonous.

J. **Vapor point** — The temperature and pressure at which a fluid vaporizes.

II. Properties of brake fluid

A. Brake fluid must be compatible to all brake system components.

(**NOTE**: Contamination may reduce the quality of brake fluid.)

B. Brake fluid must maintain an even viscosity (thickness) through a very wide range of temperatures.

(**NOTE**: Contamination may change the viscosity of brake fluid.)

C. The boiling point of brake fluid must exceed its highest operating temperature.

(**NOTE**: Contamination may lower a brake fluid's boiling point.)

D. Brake fluid must have a very low freezing point.

(**NOTE**: Contamination may raise a brake fluid's freezing point.)

E. In order to prevent evaporation, brake fluid must have a high vapor point.

(**NOTE**: Contamination may lower a brake fluid's vapor point.)

F. Brake fluid must be very hygroscopic (able to absorb and hold moisture) to prevent it from freezing.

G. Brake fluid must act as a lubricant for internal hydraulic components of the brake system.

III. Methods of storing and handling three classifications of brake fluid

A. The Department of Transportation (D.O.T.) has established the following three classifications of brake fluid: D.O.T. 3; D.O.T. 4; and D.O.T. 5.

1. D.O.T. 3 fluid ranges from amber to clear in color. D.O.T. 3 meets the minimum brake fluid standards for today's vehicles.

2. D.O.T. 4 fluid also ranges from amber to clear in color. D.O.T. 4 has a higher boiling point than D.O.T. 3 and does not absorb moisture as quickly.

3. D.O.T. 5 fluid is made from a silicone base and is purple. D.O.T. 5 has the highest boiling point of any brake fluid.

(**NOTE**: D.O.T. 3 and 4 brake fluids can be intermixed.)

(CAUTION: D.O.T. 5 brake fluid cannot be mixed with D.O.T. 3 or 4. Mixing 5 with 3 or 4 may cause system failure.)

B. Storing brake fluid

1. In order to prevent contamination, brake fluid must not be exposed to the open air. Brake fluid containers must be tightly capped and clearly marked.

(**NOTE**: Moisture is very harmful to brake fluid.)

(**NOTE**: Brake fluid is toxic to both humans and animals. Never store brake fluid in a manner that could allow it to be mistaken for food or drink.)

2. Do not punch air holes in brake fluid containers.

3. Do not store brake fluid in extreme heat or cold.

4. Do not store more fluid than can be used in a month. Brake fluid can easily be contaminated with moisture if stored for long periods.

(**NOTE**: Brake fluid must always be handled carefully to prevent contamination.)

C. Handling brake fluid

1. Brake fluid is toxic to humans and animals. Ingestion of brake fluid will cause sickness or death. If brake fluid contacts the eyes, blindness may result. Avoid contact between brake fluid and skin.

2. Brake fluid will damage automotive paint and other finishes.

3. Never re-use brake fluid.

4. Do not allow used brake fluid to collect in large amounts.

5. Immediately and safely dispose of brake fluid that is contaminated or even suspected of being contaminated.

(**NOTE**: Do not pour used brake fluid on the ground.)

IV. Selecting brake fluid and adding it to a vehicle

A. Selecting brake fluid

1. Always choose high-quality brake fluid that has been approved by the D.O.T.

(**NOTE**: Never use anything but D.O.T. approved brake fluid.)

2. Avoid "bargain brand" brake fluids. A technician must never skimp or cut corners when servicing a vehicle's brake system. Always choose a fluid that meets or exceeds manufacturer's specifications for the brake system to be serviced.

3. Do not mix petroleum- and silicon-based brake fluids.

B. Procedure for adding brake fluid to vehicle

1. Park the vehicle on a level surface.

2. Carefully clean all dirt from the master cylinder cover.

3. Remove the master cylinder cover.

4. Make sure the fluid in the reservoir is clear and clean. If the fluid has a rusty or milky appearance, the brake system should be drained, flushed, and bled.

5. Add fluid to the system until the level is within 1/4 inch of the top of reservoir.

6. Restore the shape of the cover diaphragm. Make sure the diaphragm has no holes and is in good condition. The diaphragm may have become soft as a result of contaminated fluid.

7. Reinstall the cover.

   (CAUTION: Special procedures must be followed when brake fluid is added to anti-lock brake systems; failure to do so could result in injury to the technician and damage to the brake system.)

8. Check vehicle to ensure that no brake fluid has been spilled or slung on painted surfaces. Use soap and water to clean brake fluid off any painted surfaces.

JS1-L1-UIII

MODULE: BRAKES

CHECKING AND ADJUSTING MASTER CYLINDER FLUID LEVEL

Equipment:

Common hand tools
Vehicle repair manual
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for identifying the proper brake fluid for the vehicle to be serviced. The procedure should also tell how to determine if a brake system has adequate brake fluid. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, check and adjust the fluid level in the master cylinder. Answer the questions below.

   a. Is the brake fluid free of contamination and in good general condition? Describe any problems with the fluid.

   b. Is the brake fluid at its proper level in each reservoir? How much fluid, if any, must be added?

MODULE: BRAKES

UNIT III: PROPERTIES OF BRAKE FLUID AND PROCEDURES FOR BLEEDING BRAKE SYSTEMS

LESSON 2: BLEEDING BRAKE SYSTEMS

I. Terms and definitions

A. **Pressure bleeder —** Brake bleeding equipment that forces replacement brake fluid through the brake system. As the new fluid is forced through the system, the old fluid is forced out, thus removing moisture and other contaminants.

B. **Bleeder hose** — A piece of hose used to conduct fluid forced out of the brake system. The technician can either purchase a ready-made bleeder hose or fashion one out of transparent plastic or rubber tubing.

C. **Bleeder valve (bleeder screw)** — A valve located in the disc brake caliper, wheel cylinder, or master cylinder. The bleeder valve allows the technician to bleed off air or contaminated fluid. The bleeder valve is usually located at a point in the system where air will likely build up.

D. **Bleeder wrench —** A wrench designed to turn the bleeder valve.

E. **Brake bleeding** — A process by which old brake fluid and air and other contaminants are removed from the brake system.

F. **Mineral oil —** A petroleum-based fluid used in some power brake systems as a hydro-boost. Mineral oil will severely damage brake systems that are not especially designed for its use.

G. **Spongy pedal (soft pedal) —** A brake pedal that does not feel solid when pushed all the way down. A spongy pedal is usually caused by air trapped in the hydraulic system.

H. **Undercoating —** A rubbery substance that protects the underside of a vehicle from rust and corrosion. Undercoating is usually found on newer vehicles.

I. **Vacuum —** A condition in which pressure of a specific area is much less than the pressure of the surrounding atmosphere.

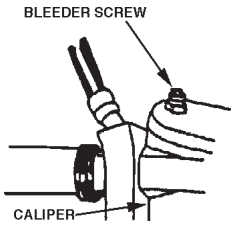
J. **Vacuum bleeder** — Brake bleeding equipment that uses vacuum to bleed the brake system.

II. Brake bleeding

A. There are generally three methods for bleeding brake systems: the manual method, the pressure method, and the vacuum method. A good technician will always do the following tasks and take the following precautions, no matter what bleeding procedure is used.

1. Consider what type of vehicle is to be serviced and what equipment is available when choosing which bleeding procedure to use.

2. Make sure all bleeder screws are free and are not plugged with dirt or undercoating. If necessary, the screws may be removed and cleaned or replaced prior to the bleeding process.



3. Make sure that the master cylinder remains full throughout the bleeding procedure. If at any point the cylinder runs dry, the procedure must be started again.

4. In front/rear split system, bleed the brakes in the following sequence.

a. Master cylinder (if bleeders are present)

b. Right rear

c. Left rear

d. Right front

e. Left front

(**NOTE**: The above sequence applies to most vehicles. Always consult a manual for the bleeding sequence for the vehicle to be serviced.)

5. Take the following precautions when bleeding the brakes.

a. Always add new brake fluid to the system. Never re-use brake fluid after it has been used for any purpose.
b. Take extreme care not to allow dirt or moisture to get into the brake system or in the fluid supply.

c. Safely dispose of used brake fluid.

d. Do not use engine solvent to clean brake parts.

e. Do not use mineral oil or mineral-based fluids in brake systems.

(**NOTE:** Use only D.O.T. approved brake fluid and solvents made especially for brake systems.)

f. All bleeding procedures require at least one technician to work under the vehicle. Follow all safety procedures related to lifting a vehicle.

(CAUTION: Do not work under a vehicle that is supported by a jack. Only work under a vehicle that is supported either by jack stands or a lift that supports the vehicle by its frame.)

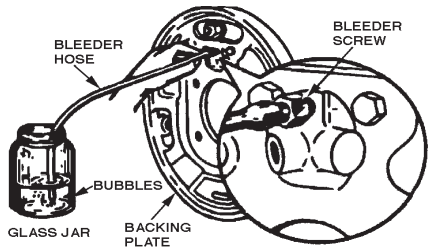
B. Procedure for manually bleeding the brakes

1. Position the vehicle so that one technician can work underneath the vehicle while another works inside.

2. Add clean, new brake fluid to a clear glass jar until it is half full.

3. Install a six-point boxed end bleeder wrench on the bleeder screw.

4. Attach one end of a transparent bleeder hose to the bleeder screw. Make sure the other end of the hose hangs in the brake fluid jar.



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5. Override the metering valve (if included in system) by applying a special tool to activate the valve's plunger.

6. Open the bleeder valve (screw) about one-half turn.

7. Have another technician depress the brake pedal slowly to the floor and hold it there. While the pedal is being depressed, observe the fluid flowing into the jar.

8. Close the bleeder valve.

(**NOTE**: To prevent additional air from being sucked into the brake system, the valve must be completely closed before the brake pedal is released .)

9. Release the brake pedal.

10. The pedal should be repeatedly pressed to the floor until the fluid released into the jar is clear and free of air bubbles. (Remember that the valve must be completely closed each time the brake pedal is released.) Once the released fluid is clean, go to the next wheel. Repeat the procedure until the brake system is completely bled.

    (**NOTE**: Make sure that the master cylinder remains full throughout the bleeding procedure. If at any point the cylinder runs dry, the procedure must be started again.)

11. Remove metering valve tool, if used.

12. Top the fluid level in the master cylinder; check all bleeder valves for leaks.

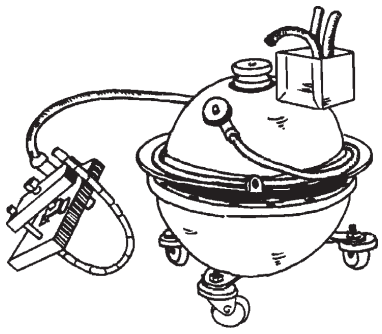
13. Press the brake pedal to the floor. If pedal feels spongy or soft, repeat the entire process.

    (CAUTION: The above procedure does not apply to anti-lock brakes. Consult the appropriate service manual before bleeding anti-lock brakes.)

    (CAUTION: The above procedure may vary from vehicle to vehicle. Always consult the appropriate manual for procedures for the vehicle to be serviced.)

C. Procedure for pressure bleeding brakes

1. A piece of equipment called a pressure bleeder must be used to pressure bleed brakes. There are several types of pressure bleeders available. The technician should read the manual accompanying the pressure bleeder to be used.



2. Following the directions in the pressure bleeder manual, charge the pressure bleeder with clean brake fluid and compressed air.

   (CAUTION: No pressure bleeder should be charged beyond 45 psi.)

3. Make sure that all bleeder screws are free and clean. Remove and clean screws as necessary.

4. Add clean, new brake fluid to a clear glass jar until it is half full.

5. Connect the pressure bleeder to the master cylinder, using the proper adapter fitting.

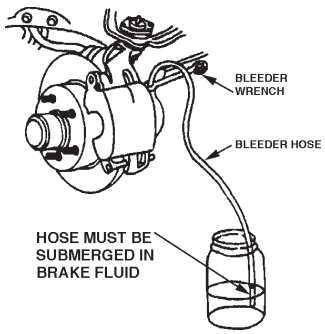
6. Override the metering valve (if included in system) by applying a special tool to activate the valve's plunger.

7. Open the valve in the pressure bleeder hose and lift the vehicle.

8. Install a six-point bleeder wrench on the first bleeder valve in sequence. Next, attach a transparent bleeder hose to the valve and allow the open end of the hose to hang immersed in the brake fluid jar.

9. Open the bleeder valve one-half turn or more and observe the fluid as it runs into the jar. Watch for air bubbles and other signs of contamination in the fluid. When clear fluid exits the hose, close the valve.

   (**NOTE**: Make sure that the master cylinder remains full throughout the bleeding procedure. If at any point the cylinder runs dry, the procedure must be started again.)



10. Repeat the above procedure until the brake system is completely bled. Make sure brakes are bled in the proper sequence.

11. Check for leaks.

12. Lower vehicle and close valve in pressure bleeder hose.

13. Remove metering valve tool, if used.

14. Check the entire brake system for leaks.

15. Press the brake pedal to the floor. If pedal feels spongy or soft, repeat the entire process.

    (CAUTION: The above procedure does not apply to anti-lock brakes. Consult the appropriate service manual before bleeding anti-lock brakes.)

(CAUTION: The above procedure may vary from vehicle to vehicle. Always consult the appropriate manual for procedures for the vehicle to be serviced.)

D. Procedure for vacuum bleeding

(**NOTE**: Vacuum bleeding is a relatively new process that includes steps from both the manual and pressure bleeding procedures.)

1. Vacuum bleeding requires a piece of equipment called a brake vacuum bleeder, which is essentially a pump. The brake vacuum bleeder uses compressed air as a power source.

   (CAUTION: When doing brake work, observe all safety rules regarding lifting a vehicle. Never work under a vehicle that is supported by any type of jack. Always use solid-metal jack stands or a lift that can support the entire vehicle by its frame.)

   (CAUTION: Never work under or around a vehicle supported by a bumper jack. Bumper jacks are especially dangerous.)

2. Lift vehicle.

3. Make sure all brake bleeder valves are free and clean. Remove and clean valves as necessary.

4. Connect the compressed air supply to the vacuum bleeder. Turn on compressed air.

5. Attach a transparent bleeder hose from the vacuum bleeder to the first bleeder screw in the bleeding sequence.

6. Override the metering valve (if included in system) by applying a special tool to activate the valve's plunger.

7. Open the bleeder valve and observe the fluid as it runs down the clear plastic hose. As soon as the fluid runs clear, close the bleeder valve.

   (**NOTE**: Make sure that the master cylinder remains full throughout the bleeding procedure. If at any point the cylinder runs dry, the procedure must be started again.)

8. Repeat the bleeding procedure on all the other brakes. Make sure to bleed brakes in the proper sequence.

9. Remove the bleeding equipment and check brake system for leaks.

10. Remove metering valve tool, if used.

11. Lower vehicle and press the pedal to the floor. If the pedal feels soft or spongy, repeat the entire bleeding procedure.

(CAUTION: The above procedure does not apply to anti-lock brakes. Consult the appropriate service manual before bleeding anti-lock brakes.)

(CAUTION: The above procedure may vary from vehicle to vehicle. Always consult the appropriate manual for specific procedures for the vehicle to be serviced.)

JS1-L2-UIII

MODULE: BRAKES

BLEEDING THE BRAKE SYSTEM

Equipment:

Common hand tools
Bleeder wrench
Bleeder hose
Pressure bleeder (if needed)
Vacuum bleeder (if needed)
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Using a service manual of other information source, locate a procedure for either a manual, pressure, or vacuum precedure for bleeding the vehicle's brakes. Make sure the procedrue is appropriate for the make and model of the vehicle to be serviced and that the proper equipment is available. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, bleed the brake system on the vehicle. Record observations.

MODULE: BRAKES

UNIT IV: DIAGNOSING AND DETERMINING NEEDED REPAIRS ON AUTOMOTIVE BRAKE SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose a vehicle's brake system. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the procedures for diagnosing brakes that stop the vehicle poorly, pull, or drag (Competencies V1, W1, X1, and Y1, Unit IV Test).

II. Identify braking problems caused by contaminated brake fluid (Competencies V1, W1, X1, and Y1, Unit IV Test).

III. Identify causes and corrections of brake problems using a brake troubleshooting chart (Competencies V1, W1, X1, and Y1, Unit IV Test).

Lesson 2.

I. Identify terms and definitions associated with the diagnosis of brake systems (Competencies V1, W1, X1, and Y1, Unit IV Test).

II. Identify safety precautions for dealing with asbestos (Competencies V1, W1, X1, and Y1, Unit IV Test).

III. Identify safety precautions for lifting a vehicle (Competencies V1, W1, X1, and Y1, Unit IV Test).

IV. Identify brake service equipment (Competencies V1, W1, X1, and Y1, Unit IV Test).

V. Identify the procedures for road testing a vehicle (Competencies V1, W1, X1, and Y1, Unit IV Test).

VI. Identify the procedures for inspecting the master cylinder (Competency V1, Part I of the Unit IV Test).

VII. Identify the procedures for diagnosing power assist brake systems (Competency Y1, Part III of the Unit IV Test).

VIII. Identify the procedures for visually inspecting the drum brake system (Competency W1, Parts II and IV of the Unit IV Test).

IX. Identify the procedures for inspecting and adjusting drum parking brakes (Competency W3, Part VI of the Unit IV Test).

X. Identify the procedures for visually inspecting the disc brake system (Competency X1, Parts II and V of the Unit IV Test).

XI. Identify the procedures for determining the cause of pulsating pedal or brake fade in disc brake systems (Competency X1, Parts II and V of the Unit IV Test).

XII. Identify the procedures for inspecting and adjusting disc parking brakes (Competency X3, Part VI of the Unit IV Test).

XIII. Identify the procedures for testing the brake light circuit and brake-warning indicator light (Competencies W1 and X1, Parts II, IV, and V of the Unit IV Test).

XIV. Demonstrate the ability to:

a. Inspect the master cylinder for leaks and operation (Competency V1, JS1-L2-UIV).

b. Test power brake system components (Competencies Y1 and Y2, JS2-L2-UIV).

c. Inspect drum brakes (Competency W1, JS3-L2-UIV).

d. Inspect disc brakes (Competency X1, JS4-L2-UIV).

e. Test brake warning light (Competencies W1 and X1, JS5-L2-UIV).

f. Test brake lights (Competencies W1 and X1, JS6-L2-UIV).

Lesson 3.

I. Identify terms and definitions associated with wheel bearing service (Competencies W3 and X3, Part VI of the Unit IV Test).

II. Identify the principles of wheel bearing service and adjustment (Competencies W3 and X3, Part VI of the Unit IV Test).

III. Identify the procedures for inspecting and servicing nonsealed wheel bearings (Competencies W3 and X3, Part VI of the Unit IV Test).

IV. Identify the procedures for adjusting nonsealed wheel bearings (Competencies W3 and X3, Part VI of the Unit IV Test).

V. Identify the procedures for inspecting and servicing sealed wheel bearings (Competencies W3 and X3, Part VI of the Unit IV Test).

VI. Demonstrate the ability to:

a. Inspect, replace, and adjust serviceable bearings (Competencies W3 and X3, JS1-L3-UIV).

b. Inspect and replace nonadjustable or nonserviceable bearings (Competencies W3 and X3, JS2-L3-UIV).

MODULE: BRAKES

UNIT IV: DIAGNOSING AND DETERMINING NEEDED REPAIRS ON AUTOMOTIVE BRAKE SYSTEMS

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT IV: DIAGNOSING AND DETERMINING NEEDED REPAIRS ON AUTOMOTIVE BRAKE SYSTEMS

LESSON 1: TROUBLESHOOTING VARIOUS BRAKE SYSTEM PROBLEMS

I. Diagnosing brakes that pull, drag, or stop the vehicle poorly

A. Poor stopping (sometimes described as "hard pedal" or "excessive pedal effort") is usually the result of a reduction of the friction coefficient between the brake lining and the drum or disc. In power brake systems, poor stopping may also be the result of an ineffective booster. In a vehicle that stops poorly, the brake pedal travel may be normal, but if the pedal bottoms (reaches the end of its travel), stopping ability is reduced. Below is a procedure for diagnosing a brake problem that results in less than perfect stopping.

(**NOTE**: If a vehicle is equipped with power brakes, poor stopping may be caused by a faulty power booster. The technician should always examine the power booster before checking other components of the brake system. Procedures for checking power boosters will be described later in this module.)

1. Check the fluid level in both master cylinder reservoirs. If either reservoir is low, one of the systems may be defective, thus reducing the braking power. (Procedures for repair will be covered later in this module.)

   (**NOTE**: In order to turn the brake warning light off, the technician may have to reset the differential pressure valve, depending on what type of valve is used.)

2. If the fluid level in the master cylinder reservoir is normal, then the entire brake system should be checked for the following problems.

   a. Check for oil contamination of the brake assemblies.

   b. Check for glazing of brake friction material.

   c. Check for evidence of drum or rotor overheating. Overheating will discolor the drum or rotor and the brake pads or shoes. Overheating may also cause small heat cracks to appear in the friction area of the drum or rotor.

   d. Make sure that all pistons in the calipers, master cylinder, or wheel cylinders are free to travel in their bores.

   e. Make sure that the brake pedal is free to move on its shaft.

   f. Check all hydraulic lines and ports for blockages. Look for kinks in the brake lines, especially where lines run close to the frame or axle.

B. Brake problems can cause a vehicle to pull to the left or right either as the brakes are applied or as the vehicle travels down the road.

1. Before examining the brakes, make sure the suspension is not causing the vehicle to pull. Listed below are problems that can cause vehicle pull.

a. Broken springs

b. Loose control arms

c. Loose steering linkages

d. Severe alignment problems

e. Dissimilar tires on either side of the vehicle

f. Uneven tire pressure

2. One of two brake problems can cause vehicle pull: a grabbing brake on the side to which the vehicle is pulling; or an ineffective brake on the side opposite to which the vehicle is pulling. Check the brakes for the following indications of a grabbing or dragging brake.

(**NOTE**: The following problems will likely cause vehicle pull if they are limited to one wheel.)

a. Check for oil, grease, or brake fluid on the brake friction surfaces.

b. Check for severely worn shoes or pads. Thebrake lining material should be less than 1/16 of an inch above the rivets or 1/8 of an inch above the bonding surface.

c. Check for discoloration of the drum or rotor. Discoloration is a sign of overheating or burning.

d. Check for binding of the brake caliper in the adapter.

e. Check for binding of the pistons in the wheel cylinder or caliper.

f. Check for distorted or worn brake parts.

C. Brakes drag when either the shoes or pads will not completely release. One or more of the pads or shoes may drag.

1. If all brakes are dragging, the problem is usually in or around the master cylinder. Check for the following problems.

a. Check for contaminated or improper brake fluid (oil, power steering fluid, or some other inappropriate substance mixed with or substituted for brake fluid). Contaminated or improper brake fluid will cause rubber parts of the brake assembly to swell, thus blocking the fluid passages. Then, either the fluid will be unable to return to the master cylinder or the master cylinder piston will be unable to return to its rest position. Both problems will cause all brakes to drag.

(**NOTE**: If improper or contaminated fluid is found, the entire brake system must be flushed and all rubber parts replaced.)

b. Make sure the master cylinder operating rod (which connects the brake pedal and the master cylinder) is not out of adjustment. If the rod is too long, it will prevent the master cylinder piston from returning to its rest position, thus maintaining pressure on fluid in the brake lines. If brake fluid remains under pressure, the brakes may drag. Adjusting rod length will correct this problem.

c. If the master cylinder is found to be severely damaged or worn, it should either be overhauled or replaced.

2. If only one brake is dragging, check for the following problems.

(**NOTE**: As was stated above, a single dragging brake may cause the vehicle to pull to the left or right, either as the brakes are applied or as the vehicle moves down the road.)

a. Make sure the hydraulic system in any one wheel is not blocked.

b. Check for a broken or distorted return spring in the drum brake on any one wheel.

c. Check for binding or distorted caliper or caliper adapter on any one wheel.

d. Check for a binding or distorted parking brake linkage in the rear-brake system.

e. Check for a defective adjuster in a drum brake on any one wheel.

f. Check for severe contamination (oil, leaking brake fluid, or other such substances) on the brake assembly.

g. Check for binding of the brake shoes on the backing or anchor plate on any one wheel.

II. Contaminated or poor-quality brake fluid may cause the brake pedal to feel soft or spongy after hard braking. For example, moisture in brake fluid will boil and form gas bubbles in the wheel cylinders or calipers. The bubbles are easily compressed and thus cause the pedal to feel soft or spongy. Check for the following problems that may cause spongy or soft pedal.

(**NOTE**: If brake fluid is found to be contaminated, the brake system must be drained, flushed, and refilled and all rubber parts must be replaced.)

A. Check for soft spots in brake hoses. Soft spots can cause hoses to swell under pressure. If soft spots are found, replace all hoses and check for contaminated fluid.

B. Check for air in the hydraulic system. If air is found, bleed the system.

(**NOTE**: See Unit III of this module for bleeding procedures.)

III. Brake troubleshooting charts

POOR STOPPING

POSSIBLE CAUSE	CORRECTION
Power brake malfunction	Check power brake and make necessary repairs.
Failure of one hydraulic system (in a dual hydraulic system)	Check front and rear systems for hydraulic failure and make necessary repairs.
Brake linings worn beyond specification	Recondition pads and shoes.
Sticking or frozen pistons in calipers or wheel cylinders	Check action of calipers and wheel cylinders and make necessary repairs.
Brake linings contaminated with grease, oil, or brake fluid	Replace contaminated parts and eliminate source of contamination.
Brake fade	Make sure that pads and shoes are of correct quality. Change driver technique.
Glazed linings	Lightly sand friction lining or replace and recondition brake linings.

DRAGGING BRAKES

POSSIBLE CAUSE	CORRECTION
Broken or weak return springs on drum brakes	Replace return springs.
Frozen or sticking wheel cylinder pistonsor caliper pistons	Recondition wheel cylinders and calipers.
Plugged master cylinder port or incorrect valving	Check master cylinder port action. Make sure that no residual check valve is on the disc brake system.
Power brake malfunction	Check operation of power brake booster.
Sticking or binding pedal linkage	Free and lubricate pedal linkage.
Incorrect master cylinder push rod adjustment	Adjust push rod.
Frozen or improper parking brake adjustments	Free up and lubricate (or replace) brake cables. Check parking brake adjustment .
Restriction in hydraulic system	Check lines/hoses for blockage. Check soft parts for possible contamination damage.

PULLING (UNEVEN) BRAKING

POSSIBLE CAUSE	CORRECTION
Front end out of alignment	Check alignment. Replace worn parts. Realign front end.
Incorrect tire pressure	Inflate tires to recommended pressure.
Unmatched tires	Make sure tires on the same axle have approximately the same amount of tread. Tires on the same axle should also be of the same type of construction.
Restriction in hydraulic system	Check hoses and lines for damage and replace as necessary.
Loose caliper mounting	Replace hardware on single-piston calipers. Torque mounting bolts to specification.
Improper, contaminated, or damaged lining pad	Recondition and repair shoes and pads as necessary.
Malfunctioning metering or proportioning valve	Replace metering or proportioning valve.
Power brake unit defective	Repair or replace power brake unit.
Malfunctioning caliper or wheel cylinder assembly	Recondition caliper and wheel cylinder assembly. Flush hydraulic system with brake fluid if seals are swollen.

SOFT (SPONGY) PEDAL

POSSIBLE CAUSE	CORRECTION
Air in hydraulic system	Bleed system and fill master cylinder.
Leaky wheel cylinders and caliper seals	Repair or replace seals.
Internal leak in master cylinder	Recondition and repair master cylinder.
Leak in brake lines	Check and replace brake lines.
Soft spot in rubber brake line	Inspect rubber brake lines.
Cracked or very thin brake drums	Check and replace drums as necessary.

EXCESSIVE PEDAL TRAVEL

POSSIBLE CAUSE	CORRECTION
No fluid in master cylinder	Fill master cylinder. Check for leaks. Bleed system.
Air in hydraulic system	Bleed system.
Hydraulic leak in the system	Locate and repair leak.
Excessive clearance between shoes and drums	Check brake adjustment. Check brake adjusters.

EXCESSIVELY HOT BRAKES OR FAILURE OF BRAKES TO RELEASE

POSSIBLE CAUSE	CORRECTION
Broken brake return springs on drum brakes	Replace return springs in axle sets.
Frozen or sticking caliper pistons	Recondition calipers.
Driver's foot riding brake pedal	Instruct driver not to rest foot on pedal.
Master cylinder or power brake malfunction	Repair or replace master cylinder or power brake unit.
Sticking or binding pedal linkage	Free up and lubricate linkage.

PREMATURE REAR-WHEEL LOCKUP DURING HARD BRAKE APPLICATIONS

POSSIBLE CAUSE	CORRECTION
Proportioning valve malfunctioning	Replace proportioning valve and bleed system.

FRONT DISC BRAKES VERY SENSITIVE TO LIGHT BRAKE APPLICATION

POSSIBLE CAUSE	CORRECTION
Metering valve malfunctioning	Replace metering valve and bleed system.

BRAKE PEDAL CAN BE DEPRESSED WITHOUT ACTIVATING BRAKES

POSSIBLE CAUSE	CORRECTION
No fluid in master cylinder reservoir	Check for leaks and make repairs. Fill master cylinder and bleed system.
Air in hydraulic system	Bleed system and fill master cylinder.
Rear brakes out of adjustment	Check and repair self-adjusting system. Adjust rear brakes.
Leaking wheel cylinders	Recondition or replace wheel cylinder.
Internal leak in master cylinder	Recondition or replace master cylinder.
Leaking caliper seals	Recondition calipers.

BRAKE SYSTEM WARNING LIGHT WILL NOT LIGHT

POSSIBLE CAUSE	CORRECTION
Bulb burned out	Replace bulb.
Open circuit in warning switch	Check circuit and repair.
Damaged warning light switch	Replace switch.

BRAKE WARNING LIGHT STAYS ON

POSSIBLE CAUSE	CORRECTION
One section of dual brake system inoperative	Check for leaks and make repairs.
Differential pressure valve not centered	Center valve.
Grounded wire to warning light switch	Correct grounded wire.
Damaged warning light switch	Replace switch.

BRAKE SCRAPING

POSSIBLE CAUSE	CORRECTION
Loose wheel bearings	Adjust to specifications.
Rotor rubbing caliper housing or splash shield	Check for rust or mud buildup on caliper or splash shield next to rotor. Check for bent splash shield.
Loose caliper mounting	Replace hardware on single-piston caliper. Torque mounting bolts to specifications.
Broken return spring on drum brakes	Replace return springs in axle set.

BRAKE CHATTER, ROUGHNESS, OR PULSATION

POSSIBLE CAUSE	CORRECTION
Loose wheel bearings	Adjust wheel bearings to specifications.
Front end out of alignment	Check alignment. Replace worn parts. Re-align front end.
Rear drums out of round	Resurface or replace rear drums.
Lining contaminated with grease, oil, or brake fluid	Recondition calipers.
Excessive lateral runout of rotor	Check runout with dial indicator. Resurface or replace motor.
Rotor excessively out of parallel	Check rotor and resurface or replace.

RATTLE IN BRAKE SYSTEM

POSSIBLE CAUSE	CORRECTION
Loose caliper mounting	Replace hardware on single piston caliper. Torque mounting bolts to specification.
Brake shoe anti-rattle spring weak or missing	Replace anti-rattle springs.
Excessive shoe to caliper or shoe to piston clearance	Recondition calipers.

MODULE: BRAKES

UNIT IV: DIAGNOSING AND DETERMINING NEEDED REPAIRS ON AUTOMOTIVE BRAKE SYSTEMS

LESSON 2: BRAKE INSPECTION PROCEDURES

I. Terms and definitions

A. **Brake lights (stop lights)** — Red lights on the rear of a vehicle. Brake lights illuminate when the brakes are applied, thus warning other drivers that the vehicle is slowing down or stopping.

B. **Brake warning light** — A light in the dash that warns the driver of a problem in the brake system.

C. **Encapsulation** — The act of capturing and holding harmful brake dust.

D. **Hot spots** — Spots or raised areas on a brake drum friction surface. Hot spots are created by heat or defects on the friction surfaces of the drum.

E. **Knockout** — A place in a metal that is intentionally weakened by the manufacturer so it can be knocked out.

F. **Maximum drum diameter** — The maximum diameter a drum should obtain before being discarded.

G. **Brake fade** — The loss of brake effectiveness due to heat created during prolonged hard braking.

H. **Brake pedal free play** — The distance the brake pedal can travel before activating the brakes.

I. **Brake pedal pulsation** — A condition in which the brake pedal pulsates (moves up and down) when depressed. The frequency of the pulsations is related to vehicle speed.

J. **Brake wear indicators** — A small metal plate riveted to one of the brake pads. When the shoe becomes excessively worn, the indicator contacts the rotor and makes a harsh noise, which indicates that the brakes should be checked.

K. **Minimum rotor thickness** — The minimum thickness that a rotor must maintain to operate safely. A dimension imprinted on the rotor or its hub indicates its minimum thickness.

L. **Rotor parallelism** — A state in which both sides of a brake rotor are parallel when the rotor turns. If rotor sides are not parallel, the brake pedal will pulsate.

M. **Rotor runout** — A condition in which the brake rotor wobbles as it turns. Rotor runout may occur even if the rotor is parallel.

N. **Power brake system** — A brake system that lowers driver braking effort by hydraulic means (hydro-boost) or a combination of vacuum and atmospheric pressures.

O. **Parking brake** — A mechanical brake system that can be locked on to prevent the movement of a vehicle when it is unattended.

P. **Pressurized** — A condition in which the pressure within a system or component is greater than the pressure outside of it. The brake system is pressurized when the brake pedal is depressed.

Q. **Rivets** — Metal fasteners. Some brake friction materials are fastened by rivets.

R. **Star wheel** — An adjustment wheel that can be turned by a tool that fits into the notches of the wheel. These notches cause the wheel to look like a star.

S. **Self adjuster** — A system of linkages that automatically adjusts the position of the brake shoes.

T. **Support stands** — Adjustable metal stands designed to support the weight of a vehicle during service.

U. **Warping** — The bending or distorting of a component. Brake drums are sometimes distorted by extreme heat.

II. Safety precautions for dealing with asbestos

A. At one time brake lining material consisted largely of asbestos. The federal government identifies asbestos as a carcinogen (a cancer-causing substance) and thus prohibits its use in new vehicles. Technicians, however, must still deal with asbestos in older vehicles and in some replacement parts. The automotive industry will not be free of asbestos for many years. Mismanagement of asbestos in the shop is against federal law. Offenders can be fined, imprisoned, or both.

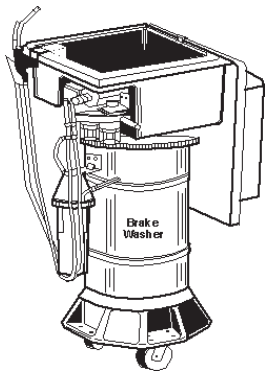
B. Asbestos brake lining material creates asbestos dust, which must be captured by special equipment and disposed of according to federal regulations. The process of capturing and containing asbestos dust is called encapsulation. The automotive industry generally uses two methods of encapsulation: the dry method and the wet method.

1. The dry method of encapsulation

a. The dry method requires that the technician place a metal and plastic enclosure over the brake. This enclosure contains built-in rubber gloves, with which the technician can handle brake parts during cleaning.

b. Using the built-in gloves, the technician blows dust from the brakes with an air hose (within the enclosure). The dust is contained in the enclosure and removed by a special vacuum cleaner. The brake dust is then collected in a plastic bag for disposal.

(CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)



(CAUTION: Federal law dictates precise procedures for disposing of encapsulated dust. Be sure that the federal procedures are followed.)

(CAUTION: Never use a household vacuum cleaner to remove asbestos from the enclosure. A household vacuum cleaner cannot adequately filter small asbestos particles.)

(CAUTION: Never breathe brake dust or allow it to escape into the environment. Asbestos dust can cause cancer.)
(CAUTION: If encapsulating equipment is unavailable or in poor working order, do not do brake or clutch work.)

2. The wet method of encapsulation

a. The wet method also requires that the technician place a metal and plastic enclosure over the brake. As in the dry method, this enclosure contains built-in rubber gloves with which the technician can handle brake parts during cleaning.

b. Using the built-in gloves, the technician uses a specially designed brake parts washer (within the enclosure) that sprays a special fluid. This fluid washes the dust from the brake parts. A special vacuum cleaner moves the dust and fluid to a proper holding tank. The brake dust is then collected in a plastic bag for disposal.

(CAUTION: Never breathe brake dust or allow it to escape into the environment. Asbestos dust may cause lung cancer.)

(CAUTION: If encapsulating equipment is unavailable or in poor working order, do not do brake or clutch work.)

(CAUTION: Federal law dictates precise procedures for disposing of encapsulated dust. Be sure that the federal procedures are followed.)

(CAUTION: Never use a household vacuum cleaner to remove asbestos from the enclosure. A household vacuum cleaner cannot adequately filter small asbestos particles.)

III. Precautions for lifting a vehicle

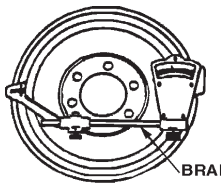
A. A vehicle is normally lifted before most brake work can be done. The technician will often have to work under a supported vehicle. When doing brake work, observe all safety rules regarding lifting a vehicle.

B. Never work under a vehicle that is supported by any type of jack. Always use solid-metal jack stands or a lift that can support the entire vehicle by its frame.

(CAUTION: Never work under or around a vehicle supported by a bumper jack. Bumper jacks are especially dangerous.)

IV. Brake service equipment

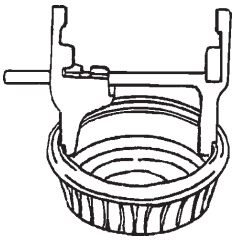
A. A brake drum micrometer is used to measure brake drum diameters. The micrometer is placed inside the drum and the dimension appears on the micrometer's dial.

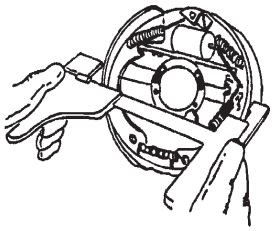


BRAKE DRUM MICROMETER

Courtesy of Wagner Division, Cooper Industries, Inc.

B. A brake drum gauge is used to adjust drum brake shoes prior to drum installation. The gauge is indexed to the brake drum and locked in; the shoes can then be adjusted to conform to the drum size.





C. The brake spoon is used to back off brake adjustment.

D. A dial indicator is used to measure rotor runout.

E. A feeler gauge is used to set brake shoe to brake drum clearances in some non-servo brake systems.

F. A micrometer is used to determine rotor thickness and parallelism.

V. A road test is the only reliable way to check the stopping abilities of the brake system. All vehicles should be road tested immediately following any brake work.

A. Procedure for preparing a vehicle for a road test

1. Make sure the brake pedal is more than 1 1/2 inches from the floorboard. The brake pedal should feel solid when depressed.
2. If the vehicle is equipped with power brakes, start the engine while the brake pedal is depressed. The pedal should move down slightly as vacuum increases. Also make sure that any other type of power-boosting devices within the brake system are operating correctly.
3. Set the parking brake and try to move the vehicle. Make sure the parking brake can hold the vehicle. Release the parking brake and note the vehicle's freedom of movement. The vehicle should move freely.
4. Let the vehicle begin to move very slowly and then apply the brakes. Make sure the brakes have adequate stopping power before driving the vehicle further.

B. Procedure for road testing the vehicle

(**NOTE**: Road tests should be conducted in areas where there is little or no traffic.)

1. Accelerate to about 5 mph and gently apply the brake pedal. Make sure the brakes work effectively and smoothly. The vehicle should not pull in either direction during braking. There should be no unusual noise or brake pedal pulsation.

2. Accelerate to about 30 mph and apply the brakes firmly. Make sure there is no wheel lockup, pulling, or unusual noise.

   (CAUTION: During a road test, never apply the brakes hard enough to lock up the wheels.)

VI. Inspecting the master cylinder

(**NOTE**: The below procedures for inspecting the master cylinder are general and may not apply to all vehicles. Always consult the proper service manual when inspecting a vehicle's master cylinder.)

A. Check the master cylinder fluid (see Lesson 1 of Unit III for the procedure).

B. Procedure for checking the master cylinder for external and internal leaks

1. Thoroughly clean and dry the exterior of the master cylinder. Also clean and dry the brake lines and fittings near the cylinder.

2. Pump the brake pedal a number of times (at least 10) and then look for signs of leakage around the brake lines, the cap, or the power booster mounting bracket (if present).

   (**NOTE**: In manual brake systems, external leaks at the input rod end of the master cylinder will deposit brake fluid on the passenger compartment floor. In power brake systems, external leaks at the input rod end of the master cylinder will deposit brake fluid on the power booster. The passenger compartment floor and power boosters should, therefore, be checked for traces of brake fluid.)

C. Procedure for checking the master cylinder for internal leaks

1. When the vehicle is stopped, hold the brake pedal down. Note if the pedal slowly loses firmness.

2. If the pedal regains firmness after it is released and pressed down again, there may be an internal leak in the master cylinder.

   (**NOTE**: A soft or spongy pedal may indicate a leak in the master cylinder.)

3. The loss of firmness may also indicate an external leak in the brake lines or brake actuators. To confirm the possibility of an internal master cylinder leak, have an assistant hold down the brake pedal, and check for external leaks at the wheel cylinders, calipers, brake lines, and fittings. If no leaks are found, the loss of firmness may indicate an internal leak in the master cylinder.

D. Procedure for checking operation of the master cylinder

1. Place the reservoir cap loosely on the master cylinder.

2. Have an assistant quickly pump the brake pedal at least ten times.

3. Have the assistant hold the pedal down with medium pressure (25 to 35 pounds).

4. Remove the cap from the reservoir and have an assistant release the brake pedal. Reservoir fluid should gush up noticeably (about 1/4 of an inch) from the reservoir. If fluid does not gush, air may be present in the system; therefore, the system should be bled.

(CAUTION: Wear safety glasses. Keep face away from the master cylinder.)

(**NOTE**: If fluid still does not gush after bleeding, either the master cylinder vent port or compensating port are plugged or the brakes are not releasing.)

VII. Diagnosing power assist brake systems

(**NOTE**: The below procedures for diagnosing power assist brake systems are general and may not apply to all vehicles. Always consult the proper service manual when diagnosing power assist brake systems.)

A. Diagnosing vacuum-power-boosted brake systems

1. Hard pedal (insufficient boost)

a. Use a vacuum gauge to measure manifold vacuum. Gauge should read at least fifteen inches when vehicle is idling. If reading is low, determine why engine is losing vacuum and correct the problem.

b. Make sure vacuum check valve (located at the vacuum booster) is allowing air to pass from the booster toward the manifold while preventing air from traveling from the engine manifold toward the booster. Check the valve by blowing through it in both directions.

c. Check for a blocked vacuum line to the booster.

d. Using a hand vacuum pump, pull a vacuum through a hose connected to the booster diaphragm while the brake is both released and applied. If diaphragm does not hold the vacuum, it should be replaced.

e. When the vacuum pulls the diaphragm to boost brake action, air enters the booster through an atmospheric breather (essentially a filter). If the filter is plugged, then the diaphragm cannot move to apply pressure to the brake. When the brake is applied with the engine running, a hissing sound can be heard as the diaphragm moves. If the hissing continues while the brake pedal is held down, a leak in the diaphragm or a control valve is indicated.

f. If the source of the vacuum is a belt-driven vacuum pump, check the condition of the belt and its adjustment.

(**NOTE**: Hard pedal in powered brake systems can have the same causes as in non-powered brake systems. Check for glazed or oil-saturated brake linings.)

2. A brake pedal that travels completely to the floor may be caused by a problem in the brake system rather than in the power assist system. Check the master cylinder fluid level, the hydraulic system, brake friction material, adjusters, etc. Check for air in brake hydraulic system. Bleed brakes if necessary. Check master cylinder for internal leaks.

3. Brakes fail to release (or brakes release too slowly).

(**NOTE**: Brakes may fail to release due to problems unrelated to the power assist system. Check the general braking system first. Consult the troubleshooting charts in Lesson 1 of this unit.)

a. If the regular braking system is functioning normally, unbolt the master cylinder from the booster and gently move it away from the booster. If moving the master cylinder releases the brakes, replace the booster.

b. Make sure the atmospheric breather of the booster is not plugged.

4. If brakes are overly sensitive, disconnect the booster from the vacuum and reapply brakes. If brakes work normally, replace the booster.

(**NOTE**: Brakes may fail to release due to problems unrelated to the power assist system. Check the general braking system first. Consult the troubleshooting charts in Lesson 1 of this unit.)

5. Brake pedal chatter (vibration) can be caused by a defective booster. The problem may also be caused by poor adjustment of pedal free travel or severely out of round drums or warped rotors.

B. Diagnosing hydro-boost brakes (hydraulic power brakes)

1. Hard pedal

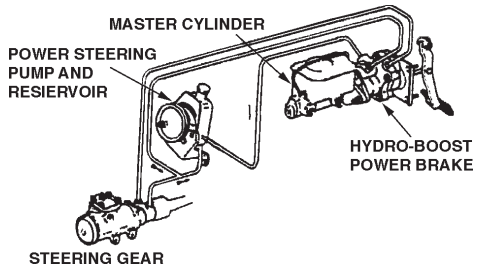
(**NOTE**: Hard pedal may develop due to problems unrelated to the power assist system. Check the general braking system first. Consult troubleshooting charts in Lesson 1 of this unit.)

a. Check for a loose or glazed power steering belt.

b. A problem in the power steering system can cause trouble in the power brake system. Check power steering fluid level. Check for kinks or pinches in power steering pump hoses. Make sure the power steering is functioning properly.

c. Check for external leakage in the brake hydraulic system.

d. Check power booster for defects. Repair or replace booster as necessary.



VIII. Visually inspecting the drum brake system

(**NOTE**: A visual inspection is the only reliable method of determining the condition of brake components. The brake drum must be removed before a visual inspection is made.)

A. Following the procedures outlined above in Lessons 1 and 2 of this unit, check the fluid level in the master cylinder and inspect the brake hydraulic system.

B. Lift the vehicle and remove the wheels.

(CAUTION: Working under a vehicle that is not properly supported can result in fatal injuries. Never work under a vehicle that is supported by a jack of any type. Only work under a vehicle that is supported by either proper support stands or a lift that supports the vehicle by its frame. If safe lifting and support equipment is unavailable, do not work under the vehicle.)

C. Encapsulate and thoroughly clean the drum.

(CAUTION: Asbestos dust from the brake assembly has been identified as a cancer-causing substance. Extreme care must be exercised to prevent any of the dust from escaping into the environment. As noted earlier in this unit, special equipment is available to encapsulate the dust and prepare it for safe disposal. If this equipment is unavailable or in poor working order, do not do brake work.)

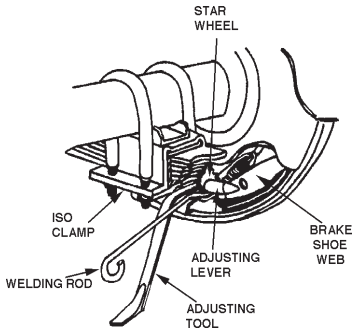
D. After making sure that the encapsulator is in place and the vacuum and compressed air are on, remove the brake drum. In some systems, the drum can be removed from the wheel hub; in other systems, the wheel bearing must be disassembled before removing the drum. See Lesson 3 of this unit for wheel bearing assembly and disassembly procedures.

(**NOTE**: If the wheel bearing is disassembled, be sure that it is cleaned and repacked prior to reassembling the hub.)

(CAUTION: Do not remove the brake drum until the encapsulator is in place. Be sure that the encapsulator vacuum is on and running and that the compressed air is on.)

1. If brake drums are grooved by brake shoe rivets (as a result of badly worn shoes), the grooves may mate with the rivets, making brake drum removal difficult. If this is the case, the brake adjuster must be backed off.

    a. The adjuster plate can be backed off by turning the star wheel with a brake spoon.



    b. An opening in the backing plate or the brake drum will provide access to the adjuster. These openings may be closed with rubber plugs. In the brake drum, the opening may be a "knockout" in the drum. In either case, be sure to close the opening with specially designed rubber plugs.

    (**NOTE**: The encapsulator may have to be removed to make this adjustment. If so, be sure to reinstall the encapsulator and clean it out prior to removing the brake drum.)

2. When the brake drum is removed, lay it down inside the encapsulator housing and blow off all the dust. Turn it over and finish blowing off the dust.

3. Blow all the dust off the brake assembly. Make sure all dust—even that which is behind the parts—is blown off.

    a. Using the gloves in the encapsulator, position unattached brake parts so they can be thoroughly cleaned with compressed air.

    b. Vacuum the enclosure thoroughly, using the compressed air to get all of the dust out.

4. After the encapsulator enclosure and all of the brake parts are completely free of brake dust, remove the encapsulator from the wheel.

E. Inspect the brake.

1. Carefully inspect the brake assembly and note any indication of fluid leaks. Identify the source of any leaks.

   (**NOTE**: If the rear brake on a rear-wheel-drive vehicle is contaminated with heavy lubricant, the axle seals as well as the brake shoes will have to be replaced.)

   (**NOTE**: Do not use engine solvent on brake parts. Use only solvent made specifically for use on brakes. Engine solvents or gasoline will contaminate brake parts and may cause brake failure.)

2. Inspect the brake lining.

   a. Check thickness of brake lining. Some linings are riveted to the shoe. Rivet heads should be at least 1/64 of an inch below the lining surface. Lining that is bonded to the shoe should be at least as thick as the shoe itself. Replace any shoes that do not clearly meet thickness standards.

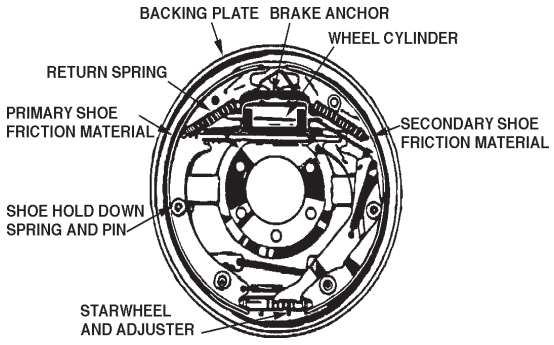
      (**NOTE**: Brake lining on all vehicles should be checked periodically. Annual checks are recommended for vehicles with more than forty thousand miles. Friction material should also be checked if unusual sounds are heard during braking, or if brakes fade, pull, vibrate, or lose power.)

   b. Check the brake lining for cracks, loose rivets, missing or damaged areas, or any other problems.

3. Inspect the backing plate for cracks and distortions; replace the plate if cracks or distortions are found. Make sure the plate is securely mounted. Also check the backing plate shoe contact locations. If these locations are grooved, it will be necessary to file the areas or replace the backing plate.

4. Inspect the brake shoe return springs for cracks and distortion. Make sure the springs are attached at both ends.

5. Make sure the hold-down springs are not distorted and the pins are not bent.



6. Brake inspection points

a. Make sure that the lever is not rounded at the point where it contacts the star wheel. Make sure that the wheel is not missing any teeth and that the adjuster threads are free to turn.

b. Make sure that the adjuster lever is positioned properly for its adjustment. (**NOTE**: Remove, disassemble, and clean the self-adjuster if it is dirty or hard to rotate. In servo brakes, the adjuster can be removed and cleaned without disassembling the entire brake.)

7. Inspect the anchor.

   a. Make sure the anchor is firmly attached. Return springs should hold both shoes firmly against the anchor.

   b. If either shoe is not held against its anchor, determine the reason why.

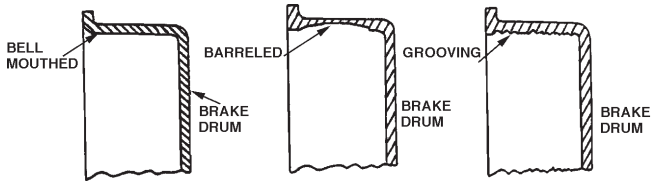
   c. If the parking brake is applying pressure to the rear-wheel brake shoes, remove the pressure by adjusting the parking brake cable adjustment.

      (**NOTE**: When the parking brake is released, the parking brake cable should never move either shoe off the anchor.)

8. Look for wetness around the wheel cylinder dust boots. Look for any other signs of leaks.

9. Inspect the brake drum.

   a. Inspect the general condition of the drum. Note if the drum is belled or barrelled or grooved. Also note if the drum is warped or distorted. Look for cracks or blue spots on the drum.

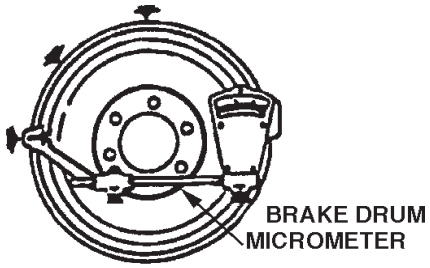


TYPES OF DRUM FRICTION SURFACE DEFECTS

Courtesy of Wagner Division, Cooper Industries, Inc.

   b. Determine the discard diameter of the drum. The discard diameter is often stamped on the drum. The discard diameter may also be found in the manufacturer's service manual.

   c. Using a drum micrometer, measure the diameter of the drum. Always measure from the inside rims of the



ACCURATELY MEASURING
THE DRUM DIAMETER

d. If all the micrometer measurements vary less than .010 of an inch, the drum is concentric and should next be checked for grooving. If the drum is not concentric, it can be machined if its lowest micrometer reading is below .010 of an inch. Follow the machining procedure developed in JS3-L2-UVII. If the lowest micrometer reading of the drum is above .010 of an inch, discard the drum.

e. Check the drum for grooves. Estimate the depth of any grooves. Determine if machining grooves will cause the drum to exceed its discard diameter. See JS3-L2-UVII for machining procedures.

(**NOTE**: A groove will increase the diameter of the drum by twice the depth of the groove.)

(**NOTE**: Minor grooving is acceptable if the drum does not exceed its discard diameter.)

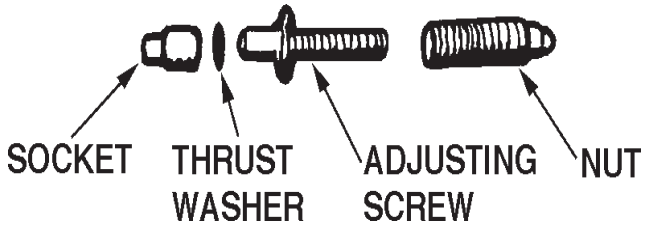
(**NOTE**: On some vehicles, the wheel hub is an integral part of the drum. When inspecting the wheel bearings on these vehicles, make sure that the bearing cups are in good condition and are firmly pressed into the hub. For wheel bearing service procedure, see Lesson 3 of this unit.)

F. During brake inspection, the adjuster can be removed and cleaned without taking apart the entire brake assembly. Below is a procedure for disassembling, cleaning, and reassembling the adjustor.

1. Using a large screwdriver or similar tool, pry apart the adjuster end of the shoes enough to allow adjuster removal.

2. Unscrew the link and clean the threads with a wire brush.

3. Remove the socket. Do not lose the thrust washer located between the socket and adjusting screw.



4. Lightly lubricate the threads of the adjuster screw and the socket with an approved lubricant. Make sure that the thrust washer is in place.

5. Reassemble the adjuster. Screw the adjuster link to its shortest adjustment.

6. Spread the brake shoes sufficiently to replace the link. Make sure that the adjuster lever is properly positioned to turn the star wheel.

7. Using a brake shoe gauge, adjust the link to fit the drum.

G. After the brake is inspected and all necessary repairs are made, replace the drum and wheel.

IX. Inspecting and adjusting drum parking brakes

(**NOTE**: This procedure is very general in nature. Consult a repair manual for specified procedures.)

A. Procedures for inspecting integral parking brakes

1. Make sure cables and linkages work freely and are in good physical condition; check the cables especially closely for fraying.

2. Make sure the parking lever and strut operate properly and exhibit no signs of excessive wear. Also make sure components are assembled properly.

3. Inspect the activating components of the parking brake. Check all friction surfaces of each brake shoe for thickness and contamination.

(**NOTE**: The brake drum must be removed before the activating components and friction components of the integral parking brake can be inspected.)

4. Repair components as necessary.

B. Procedure for inspecting auxiliary drum parking brake

1. Remove the rotor/drum from the rear axle.

2. Inspect the activating components of the parking brake. Check all friction surfaces of each brake shoe for thickness and contamination.

3. Repair components as necessary.

C. Procedures for adjusting integral and auxiliary parking brake systems

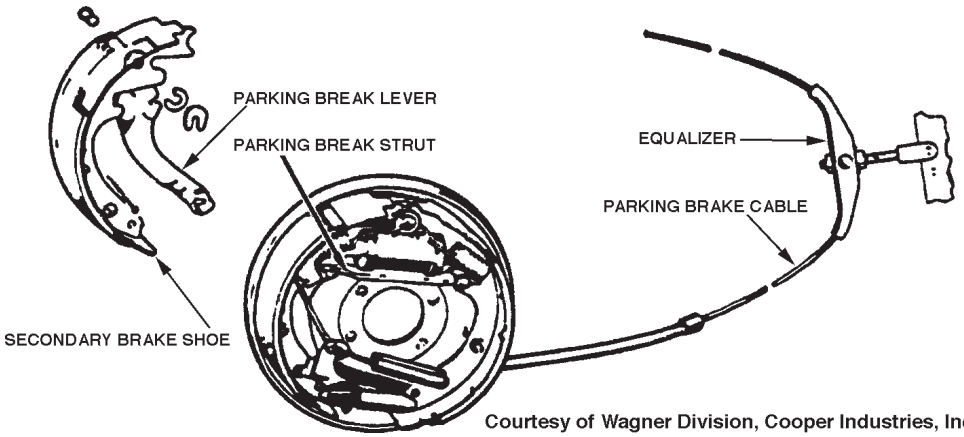
(**NOTE**: The below procedure is very general in nature. Always consult the proper service manual to obtain the specific procedures for the parking brake system to be serviced. Also the below procedure is intended for systems that are in proper working order.)

1. Make sure the parking brake is off. Adjust the brakes to make sure resting clearance (adjustment) is correct. See JS4-L2-UVII for brake adjustment procedures.

2. Engage the parking brake lever (pedal handle) two notches.

3. Lift and secure the vehicle.

4. Reduce or increase the slack in the parking brake cables by moving the equalizer up or down the adjustment rod.



Courtesy of Wagner Division, Cooper Industries, Inc.

5. Turn the equalizer nut one turn at a time in order to increase or reduce cable slack. After each turn of the nut, try to spin the rear wheels.

6. When the parking brake is adjusted correctly, there will be a slight drag on the wheel/tire assembly. After the slight brake drag is felt, release the parking brake lever.

7. To ensure the parking brake is adjusted correctly, make sure the wheels spin freely.

X. Visually inspecting the disc brake system

(**NOTE**: A visual inspection is the only reliable method of determining the condition of brake components.)

A. Following procedures outlined above in Lessons 1 and 2 of this unit, check the fluid level in the master cylinder and inspect the brake hydraulic system.

B. Safely lift and secure the vehicle; then remove the wheels.

(**NOTE**: If both brake pads are not visible after the wheel is removed, the caliper must be removed.)

(CAUTION: Working under a vehicle that is not properly supported can result in fatal injuries. Never work under a vehicle that is supported by a jack of any type. Only work under a vehicle that is supported by either proper support stands or a lift that supports the vehicle by its frame. If safe equipment is not available, do not work under the vehicle.)

C. Encapsulate and thoroughly clean the disc and rotor.

(CAUTION: Asbestos dust from the brake assembly has been identified as a cancer-causing substance. Extreme care must be exercised to prevent any dust from escaping into the environment. As noted in Lesson 2 of this unit, special equipment is available to encapsulate the dust and prepare it for safe disposal. If this equipment is unavailable or in poor working order, do not attempt brake work.)

D. Inspect brake.

1. Carefully inspect the brake assembly and note any indication of leaks. Identify the source of any leaks.

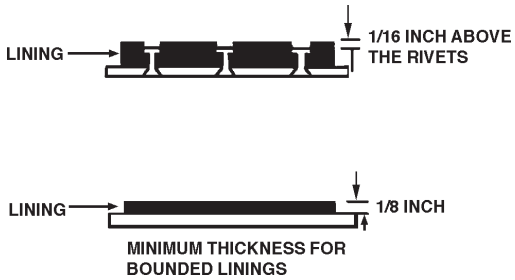
2. Inspect brake lining.

a. Check thickness of brake lining on pads. If brake lining is riveted to the pad, rivet heads should be at least 1/16 of an inch below the lining surface to prevent contact with the rotor surface. Brake lining that is bonded to the pad should be at least as thick as the pad itself. Replace any pads that do not clearly meet the thickness standards.

(**NOTE**: Brake lining on all vehicles should be checked periodically. Annual checks are recommended for vehicles with more than forty thousand miles. Brake lining should also be checked if unusual sounds are heard during braking, or if brakes fade, pull, vibrate, or lose power.)

(**NOTE**: If there is any doubt about the condition of the friction material, the caliper should be removed to allow for more careful inspection.)

b. Replace pads if brake lining is cracked, worn, glazed, distorted, or saturated with fluid. Also replace pads if backing plates are distorted or saturated with fluid.



XI. Determining the cause of pulsating pedal or brake fade in disc brake systems

(**NOTE**: The procedures outlined below are general and may vary from vehicle to vehicle. Consult the proper service manual when diagnosing pedal pulsation or brake fade in disc brake systems.)

A. An inadequately thick rotor may cause a pulsating pedal or brake fade. Outlined below is a procedure for determining rotor thickness.

1. Safely lift and secure the vehicle. Remove the wheel.

2. Using a micrometer, measure rotor thickness at several points.

(**NOTE**: The number of measurement points varies from 8 to 12. Check an appropriate service manual to determine how many measurements must be made.)

3. Compare this measurement with the minimum thickness specification imprinted on the rotor or its hub. If thickness is less than the specification, discard the rotor.

4. Check the rotor for grooves at this time. If significant grooves are not found, check rotor for parallelism according to item "B" below. If significant grooves are found, measure the depth of rotor grooving. If grooving causes the rotor to fall below minimum thickness at any point, discard the rotor. If the rotor is still above minimum thickness, machine the grooves out of the rotor. Do not machine rotor below minimum thickness, however.

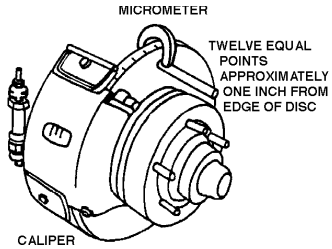
(**NOTE**: For rotor machining procedures, see JS3-L2-UVI.)

(**NOTE**: The rotor can possibly be reworked if it exceeds specified thickness. To determine what rotor thickness will be after reworking, measure to the bottom of the deepest grooves on both sides. If reworking will cause thickness to drop below the specification, the rotor should be discarded.)

(**NOTE**: Grooves are machined into some discs by the manufacturer. These grooves should not be measured in the above procedure.)

B. Rotors that are not parallel may cause pulsating pedal or brake fade. Outlined below is a procedure for determining if rotors are parallel.

1. Using a micrometer, measure the thickness of the rotor at twelve different locations. Record each measurement. If any one reading exceeds any of the others by .001 inch, the rotor is not parallel.



2. If the rotor is parallel, proceed to item "C" below and measure rotor runout. If rotor is not parallel, calculate what the rotor's thickness would be if it were machined to the smallest micrometer measurement. Discard the rotor if machining would drop it below its minimum thickness. If machining would not drop the rotor below its minimum thickness, machine the rotor so that there is never more than a .001-inch variation between any two points.

   (**NOTE**: For rotor machining procedures, see JS3-L2-UVI.)

   (**NOTE**: Some minor grooving in rotor after reworking is acceptable.)

C. Rotors with too much runout may cause a pulsating pedal or brake fade. Outlined below is a procedure for determining if rotors are parallel.

   (**NOTE**: If rotor is not integral with the hub assembly, rotor runout cannot be checked.)

   1. With vehicle properly supported and the wheel off, fasten the dial indicator base to the spindle, knuckle, or some other solid area that will allow the indicator to touch the disc.

   2. Adjust the dial indicator in such a manner that it will contact the rotor somewhere near the center of the friction surface.

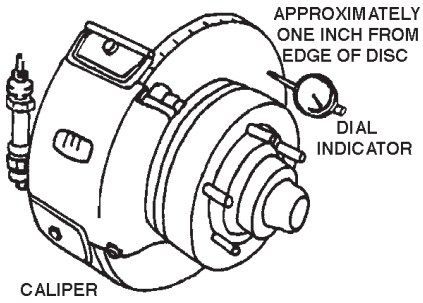
   3. Rotate the rotor while watching the dial indicator.

   4. Stop and zero the dial indicator at the point of its lowest reading.

   5. Continue turning the rotor. Stop the dial indicator at its highest reading. Subtract the lowest reading from the highest reading; the difference is the rotor runout. If there is no difference between the lowest and highest reading, then the runout is zero. If the difference is greater than .005 inch, then the rotor will need to be machined.

      (**NOTE**: For rotor machining procedures, see JS3-L2-UVI.)

(**NOTE**: Excessive rotor runout can be caused by a worn or poorly adjusted bearing. Inspect bearing for excessive wear and check bearing adjustment before machining rotors. Use procedures outlined in Lesson 3 of this unit.)



6. In order to remove runout, the rotor thickness will have to be reduced by one-half of the runout measurement. For example, if the runout is .006 inch, then the rotor thickness will have to be reduced by .003 inch.

7. Calculate what the thickness of the rotor would be if it were machined. If the thickness would be less than the minimum thickness specifications, discard the rotor. If the thickness would still exceed minimum thickness specifications, machine the rotor until runout is under .001 inch.

XII. Inspecting and adjusting disc parking brakes

(**NOTE**: Because the activating device is located inside the caliper, inspection can only occur if the caliper is disassembled. To inspect the activators in these systems, consult the manufacture caliper repair procedures.)

A. Visually inspect the friction material thickness by looking through the caliper to determine the thickness of the brake pads. Make repairs as needed.

B. Completely disengage the parking brake and safely lift and secure the vehicle.

C. Make sure cable levers on the calipers are on their off stops.

D. Adjust the cable length at the equalizer.

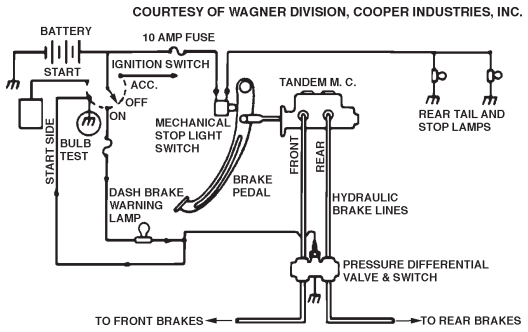
E. When the brake is adjusted correctly, it should give about 15 clicks (notches) of travel with approximately 150 lbs of force.

XIII. Testing the brake light circuit and brake warning indicator light

(**NOTE**: The procedures outlined below are general and may vary from vehicle to vehicle. Consult the proper service manual before testing the brake light and brake-warning indicator light circuits.)

A. The brake light

1. The brake light circuit is controlled by a switch, which is usually located at the brake pedal. Sometimes the switch is hydraulically activated when the brake system is pressurized.



2. The lights are always at the rear of the vehicle. There may be as few as two or as many as seven brake lights. On many newer vehicles, a single "Cyclops" brake light is mounted high and centered at the rear of the vehicle. The Cyclops brake light is usually mounted inside the vehicle and shines out through the rear window.

3. The brake light circuit is powered by the battery. This circuit receives power even when the ignition switch is off.

4. Procedure for diagnosing the brake light

   a. Have an assistant hold the brake pedal down and observe the lights at the rear of the vehicle. All brake lights should come on.

   b. If none of the brake lights come on, have the assistant turn on the ignition switch. (Some brake lights are powered by the accessory bus.) If the lights come on, then the system is working.

   c. If brake lights still do not come on, check at least one brake light bulb to be sure it is operable.

   d. If the bulbs are operable, then check the taillights and the directional signals. If none of these lights operate, then the system is probably grounded.

   e. If the taillights and the directional signals are operable, then check the switch at the brake pedal or master cylinder. When the brake pedal is depressed, the brake pedal linkage should activate the switch. Activate the switch with a small screwdriver or similar tool. If the brake lights come on, reposition the switch or make any other repairs that will allow the linkage to activate the switch.

f. If the brake lights do not come on when activated with a small screwdriver, check to see that the circuit has voltage. If no voltage is found, repair the circuit.

g. If the lights do not come on after the circuit is repaired, then repair or replace the switch.

B. Procedures for diagnosing a brake warning light that remains on even though no problem exists in the brake system

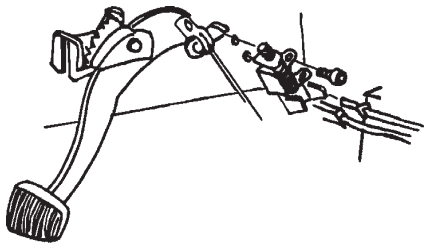
(CAUTION: If the brake warning light is on, search for a fault in the brake hydraulic system first. Inspect the light itself only after the brake system is proven to be in proper working order. Failure to inspect the brake system thoroughly may result in a complete failure of the vehicle's brakes.)

(**NOTE**: The brake warning light is usually powered by the accessory circuit and can be activated only when the ignition switch is on. The brake light switch controls this warning light by grounding the circuit.)

(**NOTE**: As was said above, the primary purpose of the brake warning light is to indicate brake system failure. On many vehicles, however, the brake warning light also indicates that the parking brake is on.)

1. The parking brake linkage turns on the brake warning light when the parking brake is set. The linkage turns off the light when the parking brake is released. With the parking brake off, use a small screwdriver to move the switch's activating device at the parking brake. If the light goes out, then make sure the parking brake linkage is in a position for activating the switch.

2. If the warning light does not go off when the switch is activated with a small tool, unplug the wiring from the switch. If the light goes out, adjust or replace the switch as required.



3. If the light remains on after switch replacement, then replace the differential pressure valve (or combination valve). If the light stays on, there is probably a short in the wiring between the differential pressure valve and the light.

   (**NOTE**: To locate the differential pressure valve, follow a brake line leading from the master cylinder. Remember that, on most vehicles, the differential pressure valve is contained within the combination valve. In order to replace the differential pressure valve, the entire valve must be replaced.)

JS1-L2-UIV

MODULE: BRAKES

INSPECTING THE MASTER CYLINDER FOR LEAKS

Equipment:

Safety glasses
Common hand tools
Lifting device and safety stands

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, check master cylinder for external leaks.

   Using a service manual or other information source, locate a procedure for detecting external leaks in the master cylinder. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect the master cylinder for external leaks. Record results below.

   (**NOTE**: If the vehicle is equipped with manual brakes, check the carpet inside the passenger compartment. If the vehicle is equipped with power brakes, inspect the vacuum line for traces of brake fluid.)

3. Following the procedure outlined below, check for internal leaks in the master cylinder.

   Using a service manual or other information source, locate a procedure for detecting internal leaks in the master cylinder. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, inspect the master cylinder for internal leaks. Record results below.

4. Following the procedure outlined below, make sure the master cylinder is operating properly.

Using a service manual or other information source, locate a procedure for checking the operation of the master cylinder. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, check the operation of the master cylinder. Record results below.

JS2-L2-UIV

MODULE: BRAKES

TESTING POWER BRAKE SYSTEM COMPONENTS

Equipment:

Common hand tools
Vacuum gauge
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for testing the vacuum power brake booster. The procedure needs to involve the brake pedal and engine of the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, test the vacuum booster. (Make sure to include a test of the brake pedal and the engine in the procedure.) Record results below.

3. Using a service manual or other information source, locate a procedure for testing the vacuum supply using the vacuum gauge. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, test the vacuum supply using the vacuum gauge. Record results below.

4. Using a service manual or other information source, locate a procedure for testing the vacuum brake booster for leaks and proper general operation. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, test the vacuum brake booster for leaks and proper general operation. Record results below.

5. Using a service manual or other information source, locate a procedure for testing the hydraulic power brake booster. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

Following the procedure, test the hydraulic power brake booster. Record results below.

JS3-L2-UIV

MODULE: BRAKES

INSPECTING DRUM BRAKES

Equipment:

Common hand tools
Brake drum micrometer
Brake shoe gauge
Brake spoon
Brake encapsulator
Suitable lifting equipment
Compressed air
Safety glasses

(CAUTION: The following procedures are for drum brakes only. Most vehicles use drum brakes only on the rear wheels. Both front and rear brakes must always be inspected before a vehicle's brakes can be determined to be in good working order.)

Procedure:

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Following the procedure outlined below, prepare the vehicle for brake inspection.

    a. Remove the wheel or wheels to be checked.

    (CAUTION: Asbestos dust is harmful. Do not allow any asbestos dust to be released into the environment.)

    (CAUTION: Carefully follow manufacturer's instructions when using the encapsulator.)

    b. Install the encapsulator and connect it to the compressed air supply and electricity.

    c. Using the encapsulator to maintain the cleanliness of the work, remove the drum.

    d. Clean the drum and the brake assembly thoroughly.

    e. Clean out the encapsulator and remove it from the brake.

4. Using a service manual or other information source, locate a procedure for inspecting the components of the drum brake assembly. Be sure to include procedures for backing off adjusters and measuring maximum drum diameter. Also include the critical dimensions of all the components to be checked. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect drum brake components and answer the following questions.

   a. Does the brake assembly or surrounding area show any evidence of leaks? Record any evidence of leaks.

   b. Are there any defects in the brake lining? Is the lining thick enough? Record any problems with the brake lining.

   c. Are the drum friction surfaces in good condition? Record any problems with the drum friction surfaces.

   d. Recommend steps needed to correct any problems recorded in items a through c above.

5. Attempt to rotate the drum if it is not a part of the wheel hub. Note how easily the drum rotates.

   a. If, during rotation, the hub showed evidence of binding, or if the wheel has been shimmying or making unusual noise, disassemble the hub and correct the wheel bearing.

   b. If the hub is part of the drum, carefully clean and examine the wheel bearings for damage.

   (**NOTE**: For wheel bearing service, see Lesson 3 of this unit.)

6. Determine the discard diameter of the drum. The discard diameter is often stamped on the drum. The discard diameter may also be found in the manufacturer's service manual. Record discard diameter.

7. Using a drum micrometer, measure the diameter of the drum. Always measure from the inside rims of the drum. Take measurements at several points on the drum. Record measurements.

8. If all the micrometer measurements vary less than .010 of an inch, the drum is concentric and should next be checked for grooving. If the drum is not concentric, it can be machined if its lowest micrometer reading is below .010 of an inch. Follow the machining procedure developed in JS3-L2-UVII. If the lowest micrometer reading of the drum is above .010 of an inch, discard the drum. Record whether the drum should be reworked or discarded.

9. Check the drum for grooves. Estimate the depth of any grooves. Determine if machining grooves will cause the drum to exceed its discard diameter. See JS3-L2-UVII for machining procedures. Record the estimated depth of the grooves and indicate if the drum can be machined.

    a. A groove will increase the diameter of the drum by twice the depth of the groove.

    b. Minor grooving is acceptable if the drum does not exceed its discard diameter.

    c. On some vehicles, the wheel hub is an integral part of the drum. When inspecting the wheel bearings on these vehicles, make sure that the bearing cups are in good condition and are firmly pressed into the hub. For wheel bearing service procedure, see Lesson 3 of this unit.

10. If the wheel hub was not removed during drum removal, remove and service the wheel bearings, if possible. Refer to Lesson 3 of this unit for wheel bearing procedures.

    a. The rear hub bearings in front-wheel-drive vehicles usually cannot be serviced. If the bearings are excessively worn or damaged, replace the hub assembly.

    b. If installing new brake shoes, carefully compare the new ones with the old. Check the spring holes and arc diameter of the shoes; also check the shape of the shoes' ends and length of the friction material of the shoes.

    (**NOTE:** A technician should take apart only one drum brake assembly at a time. Doing so prevents the technician from confusing parts from one assembly with those from another. The technician can also use the assembled brake components as a guide for reassembly.)

11. Reinstall brake drum and adjust the brakes.

12. Using a service manual or other information source, locate a procedure for inspecting and adjusting the parking brake. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, check and/or adjust the operation of the parking brake. Record observations.

13. Reinstall the wheel/tire assembly and torque the wheel nuts to specification.

JS4-L2-UIV

MODULE: BRAKES

INSPECTING DISC BRAKES

Equipment:

Common hand tools
Micrometer
Brake encapsulator
Dial indicator
Eight-inch C-clamp
Suitable lifting equipment
Compressed air
Safety glasses

(CAUTION: The following procedures are for disc brakes only. Many vehicles use disc brakes only on the front wheels. Both front and rear brakes must always be inspected.)

Procedure:

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Safely lift and secure the vehicle.

3. Following the procedure outlined below, prepare the vehicle for brake inspection.

    a. Remove the proper wheel or wheels.

    (CAUTION: Asbestos dust is harmful. Do not allow any asbestos dust to be released into the environment.)

    (CAUTION: Carefully follow manufacturer's instructions when using the encapsulator.)

    b. Install the encapsulator on the disc brake assembly.

    c. Clean the disc brake assembly thoroughly.

    d. Clean out the encapsulator and remove it from the brake.

4. Using a service manual or other information source, locate a procedure for inspecting the components of the drum brake assembly. Be sure to include procedures for removing the caliper and checking its thickness, parallelism, and runout. Also include the critical dimensions for all components to be checked. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, inspect disc brake system components and answer the following questions.

a. Does the brake assembly or surrounding area show any evidence of leaks? Record any evidence of leaks.

b. Are there any defects in the brake lining on the pads? Is the lining thick enough? Record any problems with the brake lining.

c. Are the rotor surfaces in good condition? Record any problems with the rotor surfaces.

d. Recommend steps to correct any problems recorded under items "a" through "c" above.

5. Rotate the rotor and observe its freedom of movement.

   a. If the rotor is difficult to rotate or if it seems loose, check the wheel bearing. Record observations.

      (**NOTE**: A problem with the parking brake may also cause the rotor to be difficult to turn. Check the parking brake if it is integral with the caliper. Refer to item 13 of JS3-L2-UIV for this procedure.)

   b. If the vehicle shimmies, vibrates, or makes unusual noise, check the wheel bearing.

      (**NOTE**: For wheel bearing service, see Lesson 3 of this unit.)

6. Following the procedure outlined below, inspect the rotor for deep grooves.

   a. Locate the specification for minimum rotor thickness. Minimum rotor thickness is usually printed on the rotor or its hub. Record the specification.

b. Check the rotor for grooves. If significant grooves are not found, check rotor for parallelism according to item 4 of this job sheet. If significant grooving is found, measure groove depth. If grooving causes the rotor to fall below minimum thickness at any point, discard the rotor. If the rotor is still above minimum thickness, machine the grooves out of the rotor. However, do not machine rotor below minimum thickness. Record observations.

(**NOTE**: For rotor machining procedures, see JS3-L2-UVI.)

(**NOTE**: Some grooving in the rotor is acceptable after machining.)

(**NOTE**: Some rotors are grooved as part of the manufacturing process. Disregard these grooves.)

7. Following the procedure outlined below, determine if rotor is sufficiently parallel.

a. Using a micrometer, measure the thickness of the rotor at twelve different locations. Record each measurement. If any one reading exceeds any of the others by .001 inch, the rotor is not parallel. Record observations.

b. If the rotor is parallel, measure rotor runout according to the procedure under item 9 below. If rotor is not parallel, calculate what the thickness of the rotor would be if it were machined to the smallest micrometer measurement. Discard the rotor if machining would drop it below its minimum thickness. If machining would not drop the rotor below its minimum thickness, machine the rotor so that there is never more than a .001-inch variation between any two points. Record observations.

(**NOTE**: For rotor machining procedures, see JS3-L2-UVI.)

(**NOTE**: Some minor grooving in rotor after reworking is accept able.)

8. Following the procedure outlined below, check for rotor runout.

a. Attach a dial indicator to either the knuckle, the adapter, or some other frame or suspension component.

b. Adjust the dial indicator in such a manner that it will contact the rotor somewhere near the center of the friction surface.

c. Rotate the rotor watching the dial indicator.

d. Stop and zero the dial indicator at the point of its lowest reading. Record the lowest reading.

(**NOTE**: If the rotor is not integral with the hub, the wheel nuts will usually have to be tightened onto their studs to keep the rotor in place.)

e. Continue turning the rotor. Stop the dial indicator at the point of its highest reading. Subtract the lowest reading from the highest reading; the difference is the rotor runout. If there is no difference between the lowest and highest reading, then the runout is zero. If the difference is greater than .005 inch, then the rotor will need to be machined. Record observations.

(**NOTE**: For rotor machining procedures, see JS3-L2-UVI).

(**NOTE**: Excessive rotor runout can be caused by a worn or poorly adjusted bearing. Inspect bearing for excessive wear and check bearing adjustment before machining rotors. Use procedures outlined in Lesson 3 of this unit for bearing inspection and adjustment procedures.)

f. In order to remove runout, the rotor thickness will have to be reduced by one-half of the runout measurement. For example, if the runout is .006 inch, then the rotor thickness will have to be reduced by .003 inch.

g. Calculate what the rotor's thickness would be if it were machined. If the thickness would be less than the minimum thickness specifications, discard the rotor. If the thickness would still exceed minimum thickness specifications, machine the rotor until runout is under .001 inch. Record observations.

(**NOTE**: For rotor machining procedures, see JS3-L2-UVI).

9. Reinstall the wheel/tire assembly and tighten the wheel nuts to the correct torque.

JS5-L2-UIV

MODULE: BRAKES

TESTING THE BRAKE WARNING LIGHT

Equipment:

Common hand tools
Safety glasses

Procedure:

(CAUTION: The brake warning light switch is designed to indicate low fluid pressure in one of the vehicle's brake systems. The light may come on, however, due to a faulty switch or a problem with the parking brake. If the brake warning light comes on, make sure that both the brake systems of the vehicle have adequate pressure and are working properly before inspecting the brake warning light switch or parking brake.)

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Following the procedure outlined below, check brake warning light.

   a. Turn the ignition switch to the on position and observe the brake warning light. If the light is off, then the system is functioning normally. If the light is on, then continue the diagnosis.

   b. Using a service manual or other information source, locate a procedure for determining the location of the brake warning light switch. Write a brief description of the switch location. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, determine the location of the brake warning light switch. Make sure the brake linkage is properly deactivating the brake warning light switch. Record results.

c. If parking brake linkage is properly deactivating the switch, then move the switch's deactivating device with a small screwdriver or similar tool. If the light does not go off, then unplug the switch. Record results.

d. If unplugging the switch causes the light to go off, then replace the switch.

e. Using a service manual or other information source, locate a procedure for locating the differential valve as well one for locating the brake light switch. Make sure the procedures are appropriate for the make and model of the vehicle to be serviced. Submit the procedures to the instructor. Have the instructor check the box below to indicate his or her approval of the procedures.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

If the light remains on after switch replacement, follow the above procedures (letter "e") and use the information to locate and replace the differential pressure valve (or combination valve). Record observations.

(**NOTE**: In many vehicles, the differential valve is a part of the combination valve.)

f. If the light remains on after valve replacement, then check for shorts in the wiring between the switch and the valve. Record observations.

JS6-L2-UIV

MODULE: BRAKES

TESTING BRAKE LIGHTS

Equipment::

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Following the procedure outlined below, inspect the brake light switch.

    a. Have an assistant depress the brake pedal and observe the brake lights at the rear of the vehicle. Record results.

    b. If all the lights are on, the switch is operating normally. If some of the lights are on and some are not, check the bulbs on the lights that are not functioning. Record observations.

    c. If all the lights on one side are inoperative, check the directional signal switch on the inoperative side.

3. If the brake lights are not functioning even though the bulbs are operational, inspect the brake light switch according to the procedure outlined below.

    a. Using the procedure developed in item 2-e of JS5-L2-UIV, locate the brake light switch near the brake pedal and unplug the attached wire. Connect a jumper wire between its terminals.

    b. If the light comes on, replace the switch. Record observations.

    c. If the light still does not come on, look for faults in the brake light wiring. Record observations.

MODULE: BRAKES

UNIT IV: DIAGNOSING AND DETERMINING NEEDED REPAIRS ON AUTOMOTIVE BRAKE SYSTEMS

LESSON 3: WHEEL BEARING SERVICE AND ADJUSTMENT

I. Terms and definitions

A. **Ball bearing** — An antifriction bearing that uses steel balls to support a rotating load.

B. **Caliper** — The part of the disc brake that does not rotate and contains the brake pads.

C. **Dust cap** — A small cap located at the center of a nondriven wheel hub, which protects the bearing.

D. **Encapsulator** — A piece of equipment with which a technician can control asbestos dust during brake work.

E. **Flat** (on a nut) — One of the hex faces on a nut.

F. **Friction surface** (on a rotor) — In a disc brake, a rotor surface to which the brake pads are applied.

G. **Grease** — A solid lubricant.

H. **Hub** (on a rotor) — The center of the brake rotor. All the wheel bearings are located in the hub. The hub may or may not be a part of the rotor.

I. **Knuckle** — The front suspension part that allows for steering.

J. **Lubricant** — A compound that reduces friction between two surfaces.

K. **Packing a wheel bearing** — The act of forcing a lubricant (grease) into a wheel bearing.

L. **Roller bearing** — An antifriction bearing that uses steel rollers to support a rotating load.

M. **Rotor** (brake) — A disc brake part that rotates with the wheel.

N. **Sealed bearing** — Either a ball or a roller bearing that is lubricated and sealed during manufacture. These bearings are not to be serviced.

O. **Spindle** — A stationary shaft around which the wheel turns. The spindles on nondriven wheels are often part of the knuckle.

P. **Wheel bearing** — An antifriction bearing that supports the wheels of the vehicle. Most wheels are supported by both an inner and an outer bearing.

Q. **Wheel bearing cup** (race) — Wheel bearing component that is pressed into the hub.

R. **Wheel bearing packer** — A device that forces grease into a wheel bearing.

II. Wheel bearing service and adjustment

A. The vehicle must be lifted when the wheel bearings are being serviced. Lift the vehicle with a jack and support the vehicle with jack stands.

(CAUTION: If the vehicle is raised with a jack for wheel bearing service, make sure that it is supported by jack stands or safety stands.)

B. Special tools are available for removing the hub cap. Wheel bearing packers can also be used to force grease into the wheel bearing. For most wheel bearing service, however, a torque wrench and common hand tools are sufficient.

C. There are many brands of quality wheel bearing lubricants on the market. Improper lubricants may break down when exposed to heat, stiffen when exposed to cold, or simply lack the lubricating capability needed for high-speed driving. Always use a high-quality wheel bearing grease. Wheel bearing grease that is identified as suitable for use in disc brake systems is usually acceptable for all applications.

D. Some wheel bearings on late-model front-wheel-drive vehicles are not serviceable. Do not attempt to lubricate nonserviceable bearings. When found defective, the entire bearing assembly must be replaced. In some cases, the entire knuckle may also have to be replaced.

E. All serviceable wheel bearings have scheduled service intervals ranging from 20,000 to 30,000 miles under normal driving conditions.

III. Inspecting and servicing nonsealed wheel bearings

(**NOTE**: Before servicing a wheel bearing, determine whether the bearing is sealed or nonsealed. Though most four-wheel-drive vehicles use sealed bearings, the bearings are individually serviceable once they are removed. Consult the proper service manual for inspecting and replacing these bearings.)

A. Procedure for inspecting nonsealed wheel bearings

1. Lift and safely support the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to.005 inch as measured by a caliper on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If, however, the bearings are not noisy but slightly loose, adjustment may be necessary (adjustment will be discussed below). If the bearings are noisy or excessively loose or tight, then service will be required.

B. Procedure for servicing nonsealed wheel bearings

1. Safely lift and secure the vehicle.

2. Remove the wheel.

3. Encapsulate the brake assembly and remove all asbestos dust.

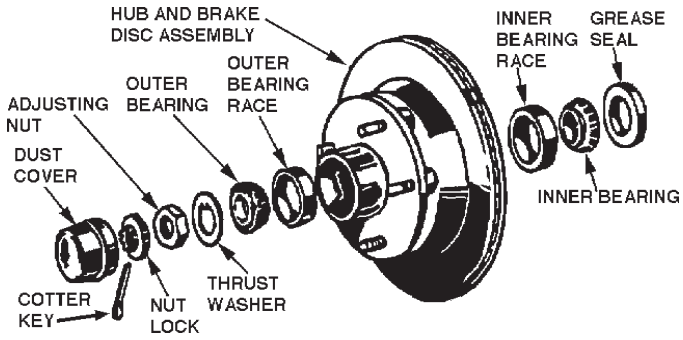
   (CAUTION: Do not allow brake dust to escape into the environment. Brake dust contains asbestos which can cause cancer if exhaled.)

4. Remove the brake caliper or drum.

   a. If the caliper is not to be serviced at this time, the hydraulic hose may be left connected.

   b. If the hydraulic hose is left connected, care should be taken to prevent the caliper from hanging on the hose.

5. Examine the hub assembly. Look for a dust cap at the center of the hub.



6. Remove the dust cap.

7. Remove the cotter pin from the spindle nut.

8. Remove the spindle nut. Carefully remove the washer and the outer wheel bearing from the center of the wheel.

   (CAUTION: Be careful not to drop the bearing.)

9. Slide the rotor off the spindle.

(CAUTION: Do not place fingers on the friction surface of the rotor. Do not allow the rotor to drag heavily across the spindle threads.)

10. Using a brass or wooden drift, reach through the hub and tap the inner grease seal out of the hub.

11. Remove the inner wheel bearing.

12. Using a clean shop towel, wipe the grease out of the hub. Avoid getting grease on the friction surfaces of the rotor.

    (**NOTE**: If the rotor is in two pieces, work on the hubs with the friction disk removed.)

    (CAUTION: Keep all wheel bearings in sets, and return them to the spindle from which they were taken. Do not replace defective wheel bearings with used wheel bearings.)

13. Thoroughly wash the wheel bearings (and all of the other parts removed with them) in solvent. Using compressed air, blow all old grease out of the bearing. Make sure all grease is removed from the inside of the bearing. Rewash the bearings and accompanying parts.

    (CAUTION: Do not allow the bearing to spin on the finger or fingers while blowing the bearing dry; doing so may result in personal injury.)

14. Examine each bearing carefully and note any imperfections such as chips, pits, scratches, etc. Also examine bearing for discoloration, which indicates overheating. If any problems are found, replace the bearing.

    (**NOTE**: Always replace the bearing and its race if there is any doubt about its condition.)

15. Repack each bearing with fresh grease, pushing it into the larger side of the bearing assembly by hand until it is forced out of the smaller side of the bearing.

    (**NOTE**: Make sure bearings are repacked with a grease designed to withstand the high temperatures and extreme pressures to which it will be exposed.)

16. Place the equivalent of 3 or 4 table spoons of grease in the center of the hub.

17. Install the inner wheel bearing and a new grease seal.

18. Carefully slide the hub assembly onto the spindle.

19. Install the outer wheel bearing, washer, and spindle nut.

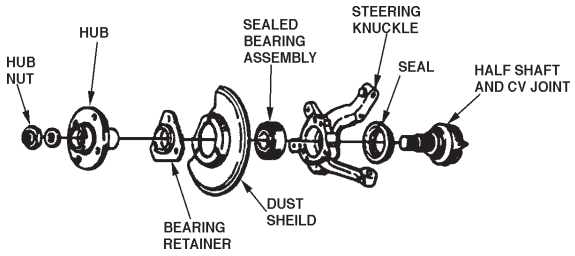
    (CAUTION: If solvent or grease gets on the drum or disc friction surface, the surfaces should be cleaned with an acceptable brake cleaning solvent.)

20. Adjust the bearing. Procedures for bearing adjustment are described below.

21. Reassemble the remaining brake and wheel assembly components.

IV. Adjusting nonsealed wheel bearings

(**NOTE**: Adjustment procedures for nonsealed bearings differ greatly from adjustment procedure for sealed bearings. What is sometimes called an adjustment procedure for sealed bearings is actually a tightening procedure.)



A. Procedure for adjusting nonsealed bearings (typical front-wheel-drive wheel bearing arrangement)

1. Safely lift and secure vehicle.

2. Remove wheel cover (hub cap).

3. Remove dust cap from wheel hub.

4. Remove cotter pin and/or nut locking device.

5. Tighten the spindle nut to manufacturer's specifications.

6. Loosen the lock nut to manufacturer's specifications.

7. Using a dial indicator, check the play in the bearings at the rotor or hub.

8. Reinstall a new cotter pin or nut holding device and then reinstall the dust cover.

9. Reassemble the remaining components of the brake and wheel assemblies.

B. Sealed bearings are not really adjusted but merely tightened. Most four-wheel-drive or front-wheel-drive vehicles have sealed bearings. If a sealed bearing makes noise or does not turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and, if necessary, replaced. If sealed bearings are replaced, the new bearings must be adjusted (or tightened) according to manufacturer's specifications. Procedures for adjusting (tightening) sealed bearings vary from vehicle to vehicle. The technician must, therefore, consult the proper repair manual for the correct procedure.

(**NOTE**: Some Chrysler and foreign front-wheel-drive vehicles use bearings that cannot be adjusted even though they are not sealed. If these bearings make noise or fail to turn smoothly, the entire unit must be disassembled so the bearings can be evaluated and packed.)

V. Inspecting and servicing sealed bearings

A. Procedure for inspecting sealed wheel bearings

1. Safely lift and secure the vehicle.

2. Spin the wheel. The wheel should turn freely without binding or making any noise.

3. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to.005 inch as measured by a caliper on the drum or rotor).

4. If spinning the wheel and moving the tire in and out reveals no problems, then no other inspection is required. If the bearings are noisy or excessively loose or tight, then the bearing will probably have to be replaced.

B. Procedures for removing and replacing sealed wheel bearings vary greatly. Refer to the proper service manual for the procedure that applies to the vehicle to be serviced.

(**NOTE**: Some front-wheel-drive vehicles may have wheel bearings that are incorporated into the knuckles. This design requires that the drive axles and bearings be removed from the knuckle. See proper service manual for this procedure.)

(**NOTE**: Most sealed wheel bearings are non-adjustable.)

JS1-L3-UIV

MODULE: BRAKES

INSPECTING, REPLACING, AND ADJUSTING SERVICEABLE BEARINGS

Equipment:

Common hand tools
Compressed air
Torque wrench
Safety glasses

(**NOTE**: Before servicing a wheel bearing, always determine whether it is adjustable or nonadjustable.)

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, inspect adjustable wheel bearings.

   a. Safely lift and secure the vehicle.

   b. Spin the wheel. The wheel should turn freely without binding or making any noise.

   c. Grasp the wheel by the top and bottom of the tire and try to move it in and out. The wheel should move slightly (.001 to.005 inch as measured by a dial indicator on the drum or rotor). Record results below.

   d. Will the bearings have to be removed and examined further?

      Yes _____ No_____

3. Following the procedure outlined below, remove and examine adjustable wheel bearings.

   a. Safely lift and secure the vehicle.

   b. Remove the hubcap. Look for a dust cover at the center of the hub.

      (**NOTE**: If a dust cover is not present, the wheel bearings are not adjustable.)

   c. Remove the wheel.

   d. Encapsulate the brake assembly and remove all asbestos dust.

      (CAUTION: Do not allow brake dust to escape into the environment. Brake dust contains asbestos which can cause cancer if exhaled.)

   e. Remove the caliper.

   f. Remove the hub assembly.

      (**NOTE**: If the caliper is not to be serviced at this time, the hydraulic hose may be left connected. If the hydraulic hose is left connected, care should be taken to prevent the caliper from hanging by the hose.)

   g. Examine the hub. Look for a dust cap at the center of the hub.

   h. Remove the dust cap.

   i. Remove the cotter pin from the spindle nut.

   j. Remove the spindle nut.

   k. Carefully remove the washer and the outer wheel bearing from the center of the wheel.

      (CAUTION: Be careful not to drop the bearing.)

   l. Slide the hub assembly off the spindle.

      (CAUTION: Do not place fingers on the friction surfaces of the brake. Do not allow the hub assembly to drag heavily across the spindle threads.)

   m. Using a brass or wooden drift, reach through the hub and tap the inner grease seal out of the hub.

   n. Remove the inner wheel bearing.

   o. Using a clean shop towel, wipe the grease out of the hub. Avoid getting grease on the friction surfaces of the brake.

      (**NOTE**: If the rotor is in two pieces, work on the hubs with the friction disk removed.)

(**NOTE**: Keep all wheel bearings in sets, and return them to the spindle from which they were taken. Do not replace wheel bearings with used wheel bearings.)

p. Thoroughly wash the wheel bearings (and all of the other parts removed with them) is solvent. Using compressed air, blow all old grease out of the bearing. Make sure all grease is removed from the inside of the bearing. Rewash the bearings and accompanying parts, and again blow dry the parts.

(CAUTION: Do not allow the bearing to spin on the finger while blowing dry the bearing; doing so may result in personal injury.)

q. Examine each bearing carefully and note any imperfections such as chips, pits, scratches, etc. Also examine bearing for discoloration, which indicates overheating. If any problems are found, replace the bearing. Record observations.

(**NOTE**: Always replace the bearing if there is any doubt about its condition.)

4. Following the procedure outlined below, repack the bearing with grease and replace the bearings.

(**NOTE**: Use procedure 5 below to adjust the wheel bearings.)

a. Repack each bearing with fresh grease, pushing it into the larger side of the bearing assembly by hand until it is forced out of the smaller side of the bearing.

b. Install the inner wheel bearing and a new grease seal.

c. Carefully slide the hub onto the spindle.

d. Install the outer wheel assembly components.

5. Using a service manual or other information source, locate a procedure for tightening (adjusting) nonserviceable (usually nonadjustable) bearings. Be sure to include the manufacturer's torque specifications. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

Following the procedure, adjust the wheel bearings.

a. Safe lift and secure vehicle (if not already done).

b. Remove hub cap (if not already off).

c. Remove dust cap from wheel hub (if not already off).

d. Remove cotter pin and/or nut locking device (if not already removed).

e. Loosen the lock nut to manufacturer's specifications.

f. Loosen the lock nut to manufacturer's specifications.

g. Using a dial indicator, check the play in the bearings at the rotor or hub.

h. Reinstall a new cotter pin or nut holding device and then reinstall the dust cover.

i. Reassemble the remaining brake and wheel assembly components.

JS2-L3-UIV

MODULE: BREAKS

INSPECTING AND REPLACING NONADJUSTABLE OR NONSERVICEABLE BEARINGS

Equipment:

Common hand tools
Compressed air
Torque wrench
Safety glasses

(**NOTE:** Before servicing a wheel bearing, always determine whether the bearing is adjustable or nonadjustable.)

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for inspecting and replacing nonserviceable (usually nonadjustable) bearings. Be sure to include procedures for disassembling and reassembling the appropriate brake and suspension components. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   If the wheel bearings on the vehicle are nonadjustable, follow the procedure and inspect and replace the nonadjustable wheel bearings as necessary. Record observationsl.

3. Using the procedure developed in item 5 of JS1-L3-UIV, adjust (torque) newly installed wheel bearings.

MODULE: BRAKES

UNIT V: REPAIRING, REPLACING, AND ADJUSTING HYDRAULIC SYSTEM COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to service master cylinders, brake plumbing, and brake valves. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with the master cylinder and brake hydraulic components (Competency V2, Part II of the Unit V Test).

II. Identify the procedures for removing, bench bleeding, and replacing the master cylinder (Competency V2, Part II of the Unit V Test).

III. Identify the procedures for inspecting and adjusting brake pedal free height and travel (Competency V1, Part I of the Unit V Test).

IV. Demonstrate the ability to:

a. Remove, bench bleed, and reinstall a master cylinder (Competency V2, JS1-L1-UV).

b. Inspect and adjust the brake pedal (Competency V1, JS2-L1-UV).

Lesson 2.

I. Identify the procedures for inspecting and replacing brake lines and hoses (Competency V2, Part II of the Unit V Test).

II. Demonstrate the ability to:

a. Inspect and replace brake lines and hoses (Competency V2, JS1-L2-UV).

Lesson 3.

I. Identify terms and definitions associated with switches and valving devices in the brake hydraulic system (Competency V3, Part III of the Unit V Test).

II. Identify the procedures for inspecting and testing hydraulic brake switches and valving devices (Competency V3, Part III of the Unit V Test).

III. Demonstrate the ability to:

a. Diagnose, adjust, and repair brake valves (Competency V3, JS1-L3-UV).

MODULE: BRAKES

UNIT V: REPAIRING, REPLACING, AND ADJUSTING HYDRAULIC SYSTEM COMPONENTS

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT V: REPAIRING, REPLACING, AND ADJUSTING HYDRAULIC SYSTEM COMPONENTS

LESSON 1: SERVICING THE MASTER CYLINDER

I. Terms and definitions

A. **Bench bleeding** — A process by which all trapped air is removed from a master cylinder before it is installed.

B. **Brake fluid** — Hydraulic fluid designed for use in brake systems.

C. **Calipers** — Disc brake component to which the brake pads are attached.

D. **Master cylinder** — A cylinder that produces hydraulic pressure in the brake or clutch system.

E. **Piston** — A moveable part in the master cylinder. The piston applies pressure to fluid, thus creating hydraulic pressure in the brake system.

F. **Push rod** — A rod connecting the brake pedal to the master cylinder. When the brake pedal is applied, the push rod activates the master cylinder piston, thus creating hydraulic pressure throughout the brake system.

G. **Reservoir** — A chamber in which brake fluid is stored in the brake system.

H. **Vacuum** — A situation when the pressure is less than atmospheric pressure. A vacuum is a negative pressure.

II. Removing, bench bleeding, and replacing the master cylinder.

(CAUTION: Always check and refill the master cylinder after hydraulic system components are tested or serviced.)

(CAUTION: Always make sure the hydraulic system is free from air after the hydraulic system components are tested or serviced.)

(**NOTE**: Below is a general procedure for bench bleeding master cylinders. The procedure may vary from vehicle to vehicle. Consult the appropriate service manual to obtain the correct procedure for the vehicle to be serviced.)

A. Removing the master cylinder

(**NOTE**: Below is a general procedure for removing a master cylinder. The procedure may vary from vehicle to vehicle. Consult the appropriate manual for the vehicle to be serviced.)

1. Disconnect the hydraulic tubing from the master cylinder.

2. Remove the bolts that hold the master cylinder to the brake booster and remove the cylinder from the vehicle.

   (**NOTE**: On some nonpower brake systems, the master cylinder push rod is secured to the piston with a locking device. On these cylinders, the push rod is disconnected from the brake pedal and removed with the master cylinder and the push rod is removed from the piston on the workbench.)

3. Remove the cylinder cover or covers and drain as much fluid from the cylinder as possible.

   a. Some cylinders have reservoirs that are mounted in a remote location and connected to the master cylinder by hoses. These reservoirs can be disconnected from the master cylinder and remain in the vehicle.

   b. Some reservoirs have only one chamber, which contains a separator to feed both hydraulic systems.

   c. Other systems have separate reservoirs for each hydraulic system.

B. Bench bleeding

(**NOTE**: Below is a general procedure for bleeding a master cylinder. The procedure may vary, depending on the vehicle. Consult the appropriate manual to obtain the correct procedure for the vehicle to be serviced.)

1. All master cylinders should be bench bled immediately prior to installation.

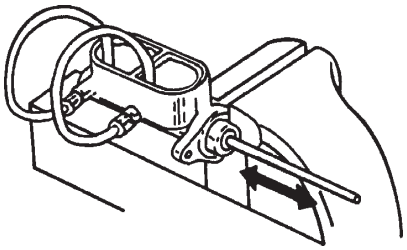
2. Air easily enters dual master cylinders. Normal bleeding will not always purge this air.

3. Procedure for bench bleeding the master cylinder

   a. Attach two short pieces of brake line to the master cylinder outlet ports. This brake line will direct fluid into the reservoirs.

   b. Fill all reservoirs with clean brake fluid so that the ends of the return lines are submerged.

   c. Using a short dowel or other such tool, slowly pump the master cylinder piston until bubbles stop forming in the reservoir.



C. To reinstall the master cylinder, simply reverse the removal procedure. Bleed the brakes and add new brake fluid to the system, check and adjust the push rod (if necessary), and test drive the vehicle.

III. Inspecting and adjusting brake pedal free height and travel

A. Procedure for determining brake pedal free height and travel

(CAUTION: Make sure that the parking brake is set and properly adjusted before performing this procedure.)

1. Push a sharp metal probe through the passenger compartment carpeting under the brake pedal. Make sure the probe contacts the floorboard metal.

2. Measure the distance between the sharp end of the probe (contacting the floorboard metal) and the point at which the probe touches the top of the brake pedal pad. This measurement is the brake pedal free height.

   (**NOTE**: On most vehicles, the brake pedal free height should be between seven and eight inches. Incorrect free height indicates worn, bent, or improperly installed parts. Free height is not adjustable.)

3. If servicing a power brake system, start the vehicle's engine. If servicing a nonpower brake system, leave the vehicle's engine off.

4. Apply about twenty-five pounds of pressure to the brake pedal. While the pressure is applied, once again measure the distance between the sharp end of the probe (contacting the floorboard metal) and the point at which the probe touches the top of the brake pedal pad.

5. The difference between the first and second measurements is called pedal travel. On nonpower brakes, pedal travel should be between three and one-half and four and one-half inches. On powered brakes, the pedal travel should be between two and three inches.

B. Procedure for adjusting brake pedal free travel

1. Excessive brake pedal travel may indicate a problem with the brake pedal push rod. A spongy pedal may indicate that air is trapped in the system. Brake pedal travel is not adjustable; therefore, the cause of excessive brake pedal travel must be corrected.

2. Many brake systems use nonadjustable push rods. When correcting excessive brake pedal travel on these systems, the technician should make sure that the master cylinder piston is allowed to return to its release position when the brakes are disengaged. There should be a small amount of clearance between the push rod and the piston when the brakes are not applied.

3. Procedure for correcting excessive brake pedal travel on systems with adjustable push rods

    a. Make sure that when the brakes are disengaged, the master cylinder piston is at the proper release position.

    b. Make sure that when the brakes are disengaged, the brake pedal is at its proper release position.

    c. Check pedal free height and correct it if required.

    d. With the push rod installed and the master cylinder piston and brake pedal at their proper release positions, adjust the rod length so that there is a slight clearance between the end of the push rod and the piston.

JS1-L1-UV

MODULE: BRAKES

REMOVING, BENCH BLEEDING, AND REINSTALLING THE MASTER CYLINDER

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for removing the vehicle's master cylinder. Be sure to include detailed instructions for removing the master cylinder push rod and draining master cylinder reservoirs . (Also describe the design of the master cylinder—how many reservoirs it uses and where they are located, etc.) Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, remove the master cylinder from the vehicle. Record observations.

3. Using a service manual or other information source, locate a procedure for bench bleeding the vehicle's master cylinder. Make sure the procedure is appropriate for the type of master cylinder being serviced. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, bench bleed the master cylinder. Record observations.

4. Using a service manual or other information source, locate a procedure for installing the master cylinder. Be sure to include detailed instructions for adjusting the push rod and bleeding the entire brake system. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, install the master cylinder, check and adjust the push rod. Bleed the brakes. After obtaining the instructor's permission, road test the vehicle. Record observations.

(CAUTION: Always check and refill the master cylinder after the hydraulic system components are tested or serviced.)

(CAUTION: Always make sure the hydraulic system is free from air after the hydraulic system components are tested or serviced.)

JS2-L1-UV

MODULE: BRAKES

INSPECTING AND ADJUSTING THE BRAKE PEDAL

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, determine the brake pedal free height and travel.

   a. Push a sharp metal probe through the passenger compartment carpeting under the brake pedal. Make sure the probe contacts the floorboard metal.

   b. Measure the distance between the sharp end of the probe (contacting the floorboard metal) and the point at which the probe touches the top of the brake pedal pad. This measurement is the brake pedal's free height. Record observations. Is the brake pedal at its correct free height?

      (**NOTE:** On most vehicles, the pedal free height should be between seven and eight inches. Incorrect free height indicates worn, bent, or improperly installed brake system components. Free height is not adjustable.)

   c. If servicing a power brake system, start the vehicle's engine. If servicing a nonpower brake system, leave the vehicle's engine off.

   d. Apply about twenty-five pounds of pressure to the brake pedal. While the pressure is applied, once again measure the distance between the sharp end of the probe (contacting the floorboard metal) and the point at which the probe touches the top of the brake pedal pad. Record the measurement.

   e. Subtract the first measurement from the second to determine the brake pedal travel. Record pedal travel.

f. Pedal travel on nonpower brakes should be between three and one-half and four and one-half inches. On powered brakes, pedal travel should be between two and three inches. Does brake pedal travel require adjustment? Record observations.

3. If brake pedal has inappropriate free travel, check for air trapped in the hydraulic system and inspect master cylinder push rod. Follow the procedure outlined below.

a. Is air trapped in the system?

Yes _____ No_____

b. If hydraulic system is free of air, make sure master cylinder push rod returns to its proper release position. Record observations and make necessary repairs.

c. If push rod is adjustable, make sure the rod returns to its proper release position; then adjust the rod so that there is a slight clearance between the end of the push rod and the piston.

MODULE: BRAKES

UNIT V: REPAIRING, REPLACING, AND ADJUSTING HYDRAULIC SYSTEM COMPONENTS

LESSON 2: SERVICING HYDRAULIC BRAKE PLUMBING

I. Inspecting and replacing brake lines and hoses

A. Inspect all metal brake lines for cracks, dents, corrosion, and leakage around fittings. Replace any damaged lines.

1. Corrosion can "freeze" the flare nut to the brake line. Apply penetrating oil to the nut before attempting to free it. If the nut cannot be easily freed, cut the line, remove the frozen fitting, and replace the entire line.

(CAUTION: Always check and refill the master cylinder after the hydraulic system components are tested or serviced.)

(CAUTION: Always make sure the hydraulic system is free from air after the hydraulic system components are tested or serviced.)

(CAUTION: Do not attempt to patch or add sections to brake lines. If a line is damaged, replace the whole line.)

(**NOTE**: When replacing brake lines, be sure to use two wrenches on the flare nuts to avoid damaging the fittings.)

2. Any leaks at a fitting or a flare must be repaired.

a. Disconnect the fitting.

b. Cut off the leaking flare.

c. Reflare the fitting (double flare only).

d. Reconnect the fitting.

e. Check for more leakage.

f. Make sure all replacement lines and fittings are clear of any moving suspension components.

B. Inspect all brake hoses for deterioration, chafing, swelling, cracking, or twisting. Also inspect for cuts.

(CAUTION: Always replace damaged or worn brake hoses. Do not attempt to repair them.)

1. Replace any hose showing signs of leaking.

2. Replace hoses that are oil soaked or soft or spongy.

3. Replace hoses that have deeply cracked covers.

4. If the brake on one wheel drags (does not release), the brake hose on that wheel may have to be replaced. Sometimes an internal failure in a brake hose can cause a brake to drag. (All other possible causes of dragging should be explored before replacing the hose.)

5. To prevent chafing, brake hoses are usually fastened to the vehicle chassis with a sheet metal clip. Disconnect the flare nut from the hose before removing the sheet metal clip.

6. Make sure replacement hoses are sufficiently long. Suspension movement or steering action should not stretch hoses.

JS1-L2-UV

MODULE: BRAKES

INSPECTING AND REPLACING BRAKE LINES AND HOSES

Equipment:

Common hand tools
Double flaring tool
Tubing cutter
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Inspect all metal brake lines for cracks, dents, corrosion, and leaks around the fittings. Record observations.

3. If any damage or excessive wear to brake lines is found, replace the lines. Following the procedure outlined below, repair any leakage at a fitting or a flare.

   a. Disconnect the fitting.

   b. Cut off the leaking flare.

   c. Reflare the fitting (double flare only).

   d. Reconnect the fitting.

   e. Check for more leakage.

   f. Make sure all replacement lines and fittings are clear of any moving suspension components.

4. Inspect brake hoses. Follow the checklist outlined below.

   a. Do hoses show signs of leaking?

      Yes _____ No _____

   b. Are any of the hoses oil soaked, or soft and spongy?

      Yes _____ No _____

c. Do any hoses have cracked covers?

Yes _____ No _____

5. Replace any hoses that are damaged or excessively worn.

a. To prevent chafing, brake hoses are usually fastened to the vehicle chassis with a sheet metal clip. Disconnect the flare nut from the hose before removing the sheet metal clip.

b. Make sure replacement hoses are sufficiently long. Suspension movement or steering action should not stretch hoses.

MODULE: BRAKES

UNIT V: REPAIRING, REPLACING, AND ADJUSTING HYDRAULIC SYSTEM COMPONENTS

LESSON 3: SERVICING BRAKE SYSTEM SWITCHES AND VALVES

I. Terms and definitions

A. **Bleeder hose** — A short piece of rubber hose used in bleeding the brake system.

B. **Bleeder valve** — A valve located in the brake master cylinder, wheel cylinder, and brake caliper.

C. **Brake fluid** — A special fluid manufactured for use in automotive brake systems.

D. **Brake warning light** — A warning light located on the vehicle's dash. The brake warning light indicates either that one of the hydraulic brake systems has lost pressure or that the parking brake is on.

II. Inspecting and testing hydraulic brake switches and brake valves

(CAUTION: Never attempt to repair a pressure differential valve, a metering valve, a proportioning valve, or a combination valve. If the valves are found to be defective, replace them.)

(CAUTION: Always check and refill the master cylinder after the hydraulic system components are tested or serviced.)

(CAUTION: Always make sure the hydraulic system is free from air after the hydraulic system components are tested or serviced.)

A. Procedure for testing the differential pressure valve

1. Make sure the brake warning light and circuit are functioning before testing the valve. Follow the procedure outlined below.

a. Disconnect the differential pressure valve wire and ground it. Use a jumper wire, if necessary.

b. Turn the ignition switch to the on position. The brake warning light should come on.

c. If the light fails to come on, then the circuit or bulb may be defective.

d. Replace the bulb and repair the circuit.

e. Retest the circuit to ensure it is operational.

2. After ensuring that the brake warning light circuit is operational, test the differential pressure valve switch circuit. Follow the procedure outlined below.

   (**NOTE**: The below procedure is general and may vary, depending on the vehicle. Consult the proper service manual to obtain the specific procedures for the vehicle to be serviced.)

   a. Make sure the differential pressure valve switch is properly connected to the circuit.

      (**NOTE**: The differential pressure valve switch is an integral part of the switch and cannot be separated from it.)

   b. Connect a bleeder hose to one of the rear-wheel bleeder valves. Put the other end of the bleeder hose in a container of clean brake fluid.

   c. Open the bleeder valve.

   d. Have an assistant apply moderate pressure to the brake pedal and observe the brake warning light.

      (**NOTE**: Be sure to apply a reasonable amount of pressure to the brake pedal. If too little pressure is applied, the valve will not shift, and the light will stay on. If too much pressure is applied, the valve will move too far and will have to be recentered by applying pressure to the other system.)

   e. If the brake warning light comes on, the switch and valve are functioning normally.

   f. If the brake warning light does not come on (and the light circuit was determined to be operational), replace the differential pressure valve.

   g. Reconnect bleeder hoses and once again apply pressure to the brake pedal to ensure that the brake warning light comes on.

   (**NOTE:** If differential pressure valve is suspected of being defective, it may be simpler to replace the valve and performance test the system than to perform the above test procedure. Ask the instructor if replacing the valve is acceptable.)

3. If the differential pressure valve has no centering springs, reset the switch after the brake warning light is activated. Follow the procedure outlined below.

   a. Install a bleeder hose to the rear-wheel bleeder valve of the hydraulic system that was not involved in the first differential pressure valve test.

   b. Immerse the other end of the bleeder hose in a container of clean brake fluid.

   c. Open the bleeder valve.

d. Have an assistant apply pressure to the brake pedal while watching the brake warning light. When the warning light goes off, the valve should be centered.

(**NOTE**: Relatively heavy brake application will be required to center the piston.)

e. As soon as the light goes out, close the valve.

B. Procedure for testing the metering valve

(**NOTE**: The below procedure may vary, depending on the vehicle. Consult the proper service manual to obtain the specific procedure for the vehicle to be serviced.)

1. Inspect the metering valve for damage and leaks. Make sure the valve's mounting is sufficiently tight.

2. Tighten the valve's mounting if loose.

3. Metering valves are not adjustable or repairable. If valve is suspected of leaking or of being damaged, replace it.

4. Install a high-pressure hydraulic gauge set to the line leading to the rear brakes and to the line leading from the master cylinder outlet port (which, in turn, leads from the rear brake side of the master cylinder to the metering valve).

(CAUTION: Gauge sets used to test metering valves must be capable of withstanding pressures up to 1500 psi.)

5. After connecting gauge set, apply heavy pressure to the brake system and compare the readings of the two gauges with the manufacturer's specifications. If the reading does not meet the specification, replace the valve.

C. Procedure for testing the proportioning valve

(**NOTE**: The below procedure is general and may vary, depending on the vehicle. Consult the proper service manual to obtain the specific procedures for the vehicle to be serviced.)

1. Inspect the proportioning valve for damage and leaks.

2. Proportioning valves are not adjustable or repairable. If the valve is suspected of leaking or of being damaged, replace it.

3. Be sure to mount the new proportioning valve in the same position as the old valve.

4. Some proportioning valves are adjusted according to the vehicle's suspension height. Any alteration in suspension height will interfere with the proportioning valve's performance. Suspension or brake system maintenance (as well as normal wear) can slightly alter a vehicle's suspension height. After such maintenance (or if a suspension height is suspected of being altered as a result of wear), check and adjust the proportioning valve linkage according to the procedure outlined below.

   (**NOTE**: Equipment such as helper springs, air shocks, or trailer towing packages should not be added to vehicles using proportioning valves. Such modifications may stiffen the rear suspension and interfere with the valve's performance.)

   a. Make sure suspension is at rest and the vehicle is carrying its normal load. Make sure that the fuel tank is full, the spare tire and normal tools are in the trunk, and the rear seat is vacant.

   b. Adjust bracket so that all slack is removed from the linkage and spring that connect the valve to the suspension.

5. Install high-pressure hydraulic gauge set to the line leading to the rear brakes and to the line leading from the master cylinder outlet port (which, in turn, leads from the rear brake side of the master cylinder to the proportioning valve).

   (CAUTION: Gauge sets used to test proportioning valves must be able to withstand pressures up to 1500 psi.)

6. After connecting the gauge set, apply heavy pressure to the brake system and compare the two gauge readings with the manufacturer's specifications. If the reading does not meet the specification, replace the valve.

   (**NOTE**: If the proportioning valve is suspected of being defective, it may be simpler to replace the valve and performance test the system than to perform the above test procedure. Ask the instructor if replacing the valve is acceptable.)

D. The combination valve includes the differential pressure valve, metering valve, and proportioning valve. When testing individual valves in the combination valve, use the same procedure for testing the valves separately.

   (**NOTE**: If any valve within the combination valve is suspected of being defective, it may be simpler to replace the combination valve and performance test the system than to test the individual valve. Ask the instructor if replacing the valve is acceptable.)

JS1-L3-UV

MODULE: BRAKES

DIAGNOSING, ADJUSTING, AND REPAIRING BRAKE VALVES

Equipment:

Common hand tools
High-pressure gauge set
Safety glasses

(**NOTE**: If the vehicle to be serviced uses an individual differential pressure valve, metering valve and proportioning valve, do only items 1, 2, 3, and 4 below. If the vehicle to be serviced uses a combination valve, do only items 1 and 5 below.)

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for testing the vehicle's differential pressure valve. If the valve has no return spring, be sure to include procedures for resetting the valve. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, test the differential pressure valve. Record observations.

3. Using a service manual or other information source, locate a procedure for testing the vehicle's metering valve. Be sure to include manufacturer's specifications for the valve. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, test the metering pressure valve. Record observations.

4. Using a service manual or other information source, locate a procedure for testing the vehicle's proportioning valve. Be sure to include manufacturer's specifications for the valve. Indicate if the valve operated in accordance with vehicle suspension height. If the valve is sensitive to suspension height, be sure to include procedures for adjusting the valve. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure outlined below, test the proportioning valve.

a. Is the proportioning valve sensitive to vehicle suspension height?

Yes _____ No _____

b. Following the above procedure, test the proportioning valve. If the valve is sensitive to vehicle suspension height, make sure it is properly adjusted. Record observations.

5. Using a service manual or other information source, locate a procedure for testing the combination valve in a vehicle's brake system. Make sure the procedure covers all tests prescribed by the manufacturer. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, test the combination valve. Record observations.

MODULE: BRAKES

UNIT VI: REPAIRING, REPLACING, AND ADJUSTING DISC BRAKE COMPONENTS

UNIT OBJECTIVE

After completing this unit, the student should be able to remove, service, and replace disc brake caliper and rotor assemblies. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with disc brake calipers (Competencies X2 and X3, Unit VI Test).

II. Identify procedures for removing disc brake calipers (Competency X2, Part I of the Unit VI Test).

III. Identify procedures for inspecting and repairing calipers (Competency X2, Part I of the Unit VI Test).

IV. Identify procedures for installing and adjusting disc brake calipers (Competency X3, Part II of the Unit VI Test).

Lesson 2.

I. Identify terms and definitions associated with disc brake rotors (Competencies X2 and X3, Unit VI Test).

II. Identify procedures for determining rotor thickness, parallelism, and runout (Competency X3, Part II of the Unit VI Test).

III. Identify procedures for machining rotors (Competency X3, Part II of the Unit VI Test).

IV. Demonstrate the ability to:

a. Remove, disassemble, and inspect calipers (Competency X2, JS1-L2-UVI).

b. Determine rotor thickness, parallelism, and runout (Competency X3, JS2-L2-UVI).

c. Machine rotors (Competency X3, JS3-L2-UVI).

d. Reassemble and reinstall calipers (Competency X3, JS4-L2-UVI).

MODULE: BRAKES

UNIT VI: REPAIRING, REPLACING, AND ADJUSTING DISC BRAKE COMPONENTS

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT VI: REPAIRING, REPLACING, AND ADJUSTING DISC BRAKE COMPONENTS

LESSON 1: REMOVING, REPAIRING, AND REPLACING DISC BRAKE CALIPERS

I. Terms and definitions

A. **Adapter** — A metal component that fastens the caliper to the knuckle. Some brake systems do not use adapters.

B. **Attachment hardware** — Metal parts (such as bolts, pins, nuts, etc.) that connect the caliper to the knuckle.

C. **Banjo fitting** — A hydraulic fitting that uses a hollow bolt to transfer fluid from a brake component to a line or hose.

D. **Brake rotor** — A metal disc that rotates with the wheel. Many rotors are integral with the wheel hub.

E. **Brake pads** (brake blocks) — Caliper components that are forced against the rotor by the caliper piston. When applied to the rotor, the brake pads stop the vehicle. Brake lining is mounted on the pads.

F. **C-clamp** — A clamp that is shaped like the letter "C".

G. **Caliper** — A component containing a piston (or pistons) that applies the brake pads to the rotor. Calipers may be either fixed (in which case they contain one piston) or floating (in which case they contain four pistons).

H. **Crocus cloth** — An extremely fine grade of emery cloth that is used to polish metal.

I. **Cylinder bore** — A chamber that encloses a piston.

J. **Hub** — A component that contains the wheel bearings and that is located at the center of the wheel.

K. **Encapsulator** — One of several devices that is used to capture asbestos dust during brake work.

L. **Independent rear suspension** — A rear suspension system that allows each rear wheel to move independently of the others.

M. **Knuckle** — A front wheel hub component that allows the wheels to be steered.

N. **Parallelism** — A condition in which both sides of the rotor (i.e. the friction surfaces) run parallel to each other.

O. **Piston** — A hydraulically activated caliper component that applies the brake pads to the rotor.

P. **Runout** — A condition in which the brake rotor friction surfaces are not perpendicular to the rotational axis of the rotor. Excessive runout causes the rotor to wobble.

Q. **Soft parts** — All non-metal caliper parts, including seals and gaskets.

R. **Transfer passage** — A passage within a fixed brake caliper. The transfer passage channels the fluid to the outer pistons. Some calipers transfer fluid through an external metal line.

II. Removing disc brake calipers

A. Safely lift and secure the vehicle.

(CAUTION: Always use proper lifting equipment. Never work under a vehicle that is supported by any type of jack. Bumper jacks are especially dangerous. Always use solid-metal jack stands or a lift that can support the entire vehicle by its frame. Always use extreme caution when lifting a vehicle.)

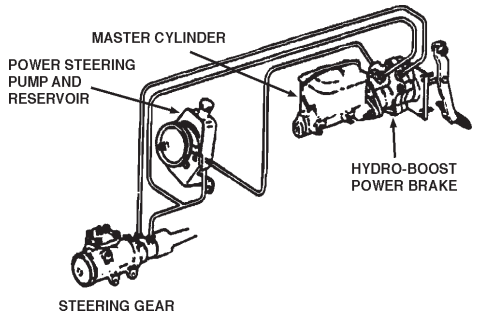
B. Remove wheels.

1. Mark the wheels for reinstallation in their original locations.

2. Inspect the wheels for cracks and check the tires for unusual wear patterns. Store wheels so that the wheel covers will not be damaged.

3. Encapsulate and clean all brakes to be serviced.

(CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)



C. Identify whether calipers to be serviced are fixed or floating. A floating caliper contains only one piston. Fixed calipers usually contain four pistons—two on each side.

D. Take off the master cylinder cover and remove a small amount of fluid from each chamber. Doing so will prevent fluid overflow when the caliper pistons are compressed.

(CAUTION: Brake fluid can harm a vehicle's finish. Do not let the fluid overflow or spill.)

E. Compress the caliper pistons. Outlined below are procedures for compressing pistons on both fixed and floating calipers.

1. Procedures for compressing pistons on fixed calipers

   a. Fixed caliper pistons must be compressed one at a time. Insert a small pry bar or similar tool between the brake pads and pry them apart. Doing so will force the pistons into the caliper bores.

   b. If one piston is stuck in its bore, compress the other three and force the caliper off the rotor.

   c. If more than one piston is stuck (and if the stuck pistons are located across from each other), attempt to force the caliper off the rotor.

      (**NOTE**: Though it may be difficult to force off a caliper in which three pistons are stuck, make the best effort possible. Forcing the caliper off is usually the easiest and quickest removal method.)

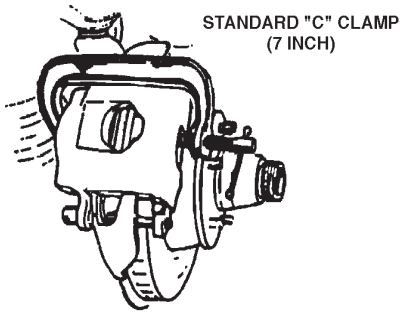
   d. If the rotor is deeply grooved, or if the caliper cannot be forced off the rotor, the caliper and rotor can be removed together.

      (**NOTE**: A caliper and rotor that must be removed together need to be replaced.)

2. Procedures for compressing pistons on floating calipers

   a. Place a large (8-inch) clamp on the caliper. The clamp screw should be placed against the outer brake pad.

   b. Turn the screw so that the outer pad is forced against the rotor. As a result, the caliper will slide and force itself against the inside of the rotor. This pad and caliper movement will force the piston into the caliper.



Courtesy of Wagner Division, Cooper Industries, Inc.

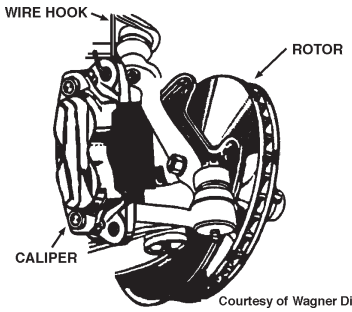
F. Remove the caliper from the adapter.

1. Be sure to disconnect the correct caliper fasteners.

   (**NOTE**: A common mistake is to remove the adapter from the knuckle.)

2. Inspect all attachment hardware and note any broken or worn parts. Be sure to mark parts for replacement.

3. Hang the caliper by using a piece of wire or welding rod. Never allow a caliper to hang by the brake line.



Courtesy of Wagner Division, Cooper Industries, Inc.

G. Disconnect the hydraulic system from the caliper.

1. If the brake hose is connected with a "banjo" bolt, disconnect the hose at the caliper.

2. If a disconnecting device is located at the end of the brake hose opposite the caliper, leave the hose on the caliper.

3. If the cover has been off the reservoir thus far during the procedure, cap the brake lines.

   (NOTE: On rear-wheel disc brakes, no hose may be connected to the caliper. These calipers use a hose above the rear axle to accommodate suspension movement. If the vehicle has independent rear suspension, then a hose will be provided to each rear-wheel caliper.)

   (**NOTE**: If the lines will be left open for a long time, tape them to avoid dirt and moisture contamination.)

III. Inspecting and repairing calipers

A. Clean all brake components.

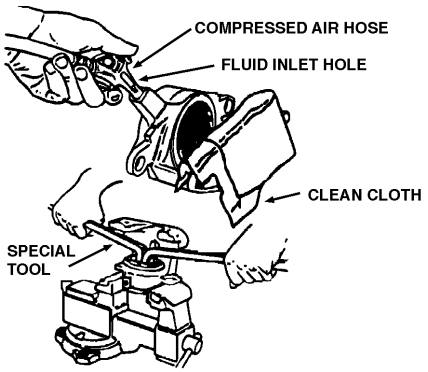
   (**NOTE**: Use only brake cleaning solvent to clean brake components. Never use engine solvent or gasoline.)

B. Disassemble the caliper and remove its pistons.

1. When servicing a floating caliper, use compressed air to blow out the piston.

2. When servicing a fixed caliper, insert a rag pad between the pistons for protection and apply compressed air to the hydraulic port. In most cases, only the freest piston will move. After one of the pistons leaves its bore, no more air can be trapped. The other pistons can be removed one at a time with special pullers.

   (CAUTION: The piston will be blown out of the caliper with enough force that may cause personal injury. Make sure that the rag pad is between the piston and the other side of the caliper. Cover the caliper with another pad to prevent parts from flying. Do not place fingers between the pistons and the caliper.)



Courtesy of Wagner Division, Cooper Industries, Inc.

   (**NOTE**: Do not use heat or machine tools to remove pistons. Doing so may ruin the caliper.)

   (**NOTE**: Considerable time can be spent in removing stuck caliper pistons. If pistons are stuck so securely that normal removal procedures cannot free them, then the bores are probably corroded and the entire caliper must be replaced.)

C. Inspect the caliper components.

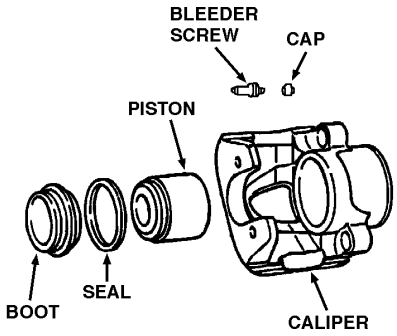
1. After cleaning all the internal parts with approved brake solvent, inspect pistons for pitting, rusting, cracks, chipping, and scoring. If any of these problems are found, replace the pistons.

   (**NOTE**: Whether damaged or not, plastic pistons should always be replaced after removal.)

2. Remove all seals and boots from the caliper bores. Check the bores for pitting and scoring. Clean bores with fine crocus cloth or caliper hone if doing so will not increase bore diameter by more than .002 inch. If any bore damage deeper than .001 inch is found, replace the caliper.

   (**NOTE**: Discard all seals, boots, and any other rubber caliper parts.)

3. Remove and clean the bleeder valve; replace it if necessary.

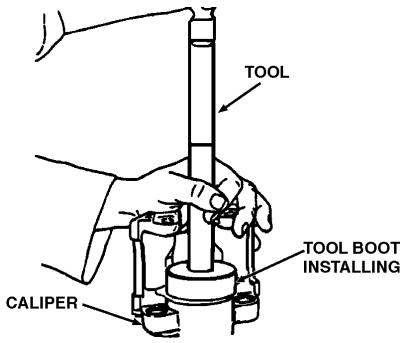


4. Reassemble the caliper.

   a. During reassembly, lubricate all parts liberally with clean brake fluid or other appropriate lubricant. All parts should freely move into their proper positions; inspect any part that does not fit into its position easily. Do not force the pistons into their bores.

   b. Using only new soft parts, manually insert all seals and pistons into the caliper bores. Do not use excessive pressure. Press pistons to the bottom of their respective bores.

   c. Install a new dust seal according to manufacturer's directions.



   d. If the transfer passage is drilled into the body of a fixed caliper, clean the passage and make sure it is free of obstructions. If the transfer passage is a separate tube, clean the tube and make sure it is free of obstructions before installation.

      (**NOTE**: Floating calipers do not have transfer passages.)

   e. On fixed caliper brakes, reassemble the caliper halves, using new gaskets or seals where indicated.

   f. Inspect all hoses and replace any that show evidence of leaking or deterioration.

g. Reinstall all bleeder valves.

IV. Installing and adjusting disc brake calipers

A. Inspect the caliper attachment hardware. If servicing a floating caliper, inspect the surface upon which the caliper will float. Repair any worn areas and thoroughly clean the adapter and knuckle.

B. Clean and lightly lubricate all attachment hardware.

C. Inspect the rotors for proper parallelism, runout, and minimum thickness. Make sure rotors are not grooved in excess of allowable limits. Repair or replace rotors as necessary.

(**NOTE**: Service or replace rotors before the calipers are reinstalled. For rotor inspection and service, see Lesson 2 of this unit.)

D. Following the manufacturer's directions, install the brake pads securely in the caliper. (Fit the pads, if necessary.)

E. Following the manufacturer's directions, install the caliper.

(**NOTE**: When servicing fixed caliper brake systems, make sure that the caliper is adjusted to the rotor. Adjustments are usually made with shims. Be sure to follow manufacturer's procedures.)
(**NOTE**: Floating calipers used on front wheels require no adjustment.)

F. Install the brake hoses.

(CAUTION: Until the pistons return to their operating positions, the brakes will be inoperative. The brakes will have to be applied several times before the pistons resume their operating positions. Make sure brakes are operative prior to driving the vehicle.)

G. Bleed all air from the lines and the calipers; check the level of brake fluid in the master cylinder.

(**NOTE**: For brake bleeding procedures, see Lesson 2, Unit 3 of this module.)

H. If a rear-wheel caliper has been installed, connect the parking brake cable and adjust the parking brake according to manufacturer's directions.

I. Reinstall the wheel/tire assembly and torque the wheel nuts to specification.

(CAUTION: Always check and refill the master cylinder after hydraulic system components have been tested or serviced.)

(CAUTION: Always make sure the hydraulic system is free from air after hydraulic components have been tested or serviced.)

MODULE: BRAKES

UNIT VI: REPAIRING, REPLACING, AND ADJUSTING DISC BRAKE COMPONENTS

LESSON 2: SERVICING DISC BRAKE ROTORS

I. Terms and definitions

A. **Arbor** — The brake lathe shaft. During machining, the rotor is attached to the arbor.

B. **Bezel** — A piece that surrounds an instrument's dial. The dial indicator's bezel is used to index the dial.

C. **Brake lathe** — A machine tool that is designed to refinish brake rotors and brake drums.

D. **Cross feed lever** — A brake lathe lever that controls the movement of the cross slide. The cross feed lever determines the start and speed of the cut.

E. **Cross slide** — Brake lathe component that moves perpendicularly to the arbor. The lathe cutting tools are attached to the cross slide.

F. **Depth of cut** — The amount of rotor material removed by one cut.

G. **Dial indicator** — An instrument that measures the distance of change (movement).

H. **Minimum thickness (discard thickness)** — The thickness at which the rotor will not be able to perform adequately.

I. **Encapsulator** — One of several devices that is used to capture asbestos dust during brake work.

J. **Handwheel** — A hand-operated adjustment wheel.

K. **Inboard** — A term used to identify the area closest to the rotor's center.

L. **Indexing collar** — A moveable collar on an adjuster. A scale printed on the collar indicates the distance that an adjuster has been turned.

M. **Locking knobs** — Knobs that can lock a moveable part.

N. **Micrometer** — An instrument that measures extremely small dimensions.

O. **Perpendicular** — A term which designates the relationship between two objects which are at a ninety-degree angle to each other.

P. **Rotor** — A metal disc that turns with the wheel.

Q. **Silencer** — A rubber strap or band that eliminates or reduces vibrations in brake rotors during reworking.

R. **Tool bit** — Brake lathe component that does the cutting.

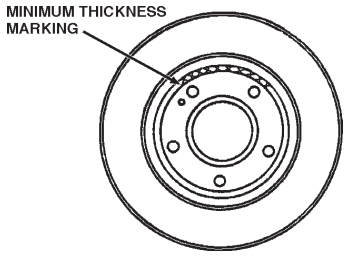
S. **Tool bit control (depth of cut) knob** — A lathe knob which positions the tool bit.

II. Determining rotor thickness, parallelism, and runout

(**NOTE**: The vehicle should be safely lifted, the wheels removed, and the brake parts encapsulated and cleaned, according to the procedures in Lesson 2 of Unit IV before performing the below procedures.)

A. Procedures for inspecting rotor for deep grooves

1. Locate the specification for minimum rotor thickness. Minimum rotor thickness is usually printed on the rotor or its hub.

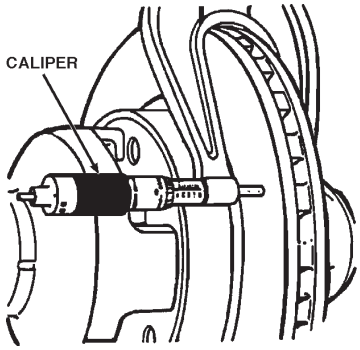


2. Check the rotor for grooves. If significant grooves are not found, check rotor for parallelism according to item "B" below. If significant grooves are found, measure the depth of rotor grooving. If grooving causes the rotor to fall below minimum thickness at any point, discard the rotor. If the rotor is still above minimum thickness, machine the grooves out of the rotor. Do not machine rotor below minimum thickness, however.
(**NOTE**: Some light grooving after machining is acceptable.)

(**NOTE**: Some rotors have grooves machined into them during manufacture. Disregard these grooves.)

B. Procedures for determining if rotor is sufficiently parallel

1. Using a micrometer, measure the thickness of the rotor at twelve different locations. Record each measurement. If any one reading exceeds any of the others by .001 inch, the rotor is not parallel.



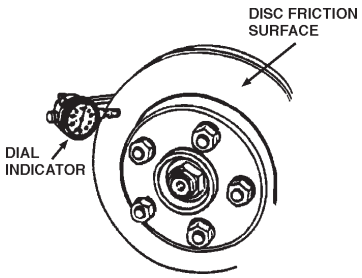
2. If the rotor is parallel, proceed to item "C" below and measure rotor runout. If rotor is not parallel, calculate what the rotor's thickness would be if it were machined to the smallest micrometer measurement. Discard the rotor if machining would drop it below its minimum thickness. If machining would not drop the rotor below its minimum thickness, machine the rotor so that there is never more than a .001-inch variation between any two points.

   (**NOTE**: Some minor grooving in rotor after reworking is acceptable.)

C. Procedures for checking rotor runout

(**NOTE**: If rotor is not integral with the hub assembly, wheel nuts must be retightened onto the hub to hold the rotor in place.)

1. Attach a dial indicator to either the knuckle, or the adapter, or some other frame or suspension components.



2. Adjust the dial indicator in such a manner that it will contact the rotor somewhere near the center of the friction surface.

3. Rotate the rotor while watching the dial indicator.

4. Stop and zero the dial indicator at the point of its lowest reading.

5. Continue turning the rotor. Stop the dial indicator at its highest reading. Subtract the lowest reading from the highest reading; the difference is the rotor runout. If there is no difference between the lowest and highest reading, then the runout is zero. If the difference is greater than .005 inch, then the rotor will need to be machined.

(**NOTE**: Excessive rotor runout can be caused by a worn or poorly adjusted bearing. Inspect bearing for excessive wear and check bearing adjustment before machining rotors. Use procedures for bearing inspection and adjustment outlined in Lesson 3 of Unit IV.)

6. In order to remove runout, the rotor thickness will have to be reduced by one-half of the runout measurement. For example, if the runout is .006 inch, then the rotor thickness will have to be reduced by .003 inch.

7. Calculate what the rotor's thickness would be if it were machined. If the thickness would be less than the minimum thickness specifications, discard the rotor. If the thickness would still exceed than minimum thickness specifications, machine the rotor until runout is under .001 inch.

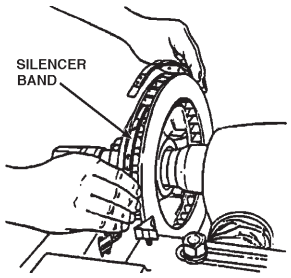
III. Machining rotors

(**NOTE**: The below machining procedures are applicable in most cases; however, always be sure to follow the lathe manufacturer's procedures.)

A. Mount the rotor on the machine's arbor.

(**NOTE**: Be sure that the rotor is centered between the arbor's two cones. If the rotor wobbles when turned, make sure the rotor is correctly attached to the arbor. Also make sure that there is no dirt or chips between the rotor and the arbor.)

B. Install the rotor silencer. In most cases, the silencer is a rubber band, which is stretched around the rotor's edge. However, the silencer may be a pad, which contacts the rotor's face.



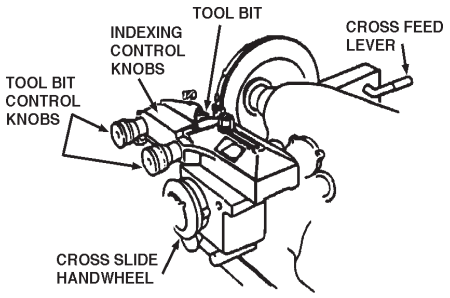
C. Install the cutting tool. Make sure that the rotor is centered between the cutting tool. Also make sure that the cutting tool is perpendicular to the arbor.

D. Using hand pressure, rotate the rotor at least one complete turn. Make sure that the rotor turns freely and that both tool bits are clear of the rotor's face.

E. Turn on the lathe.

(CAUTION: Make sure that all controls are in neutral or at zero before turning on the lathe.)

F. Turn one of the tool bit control knobs clockwise until the tool bit makes contact with the rotor's face. Turn the indexing collar on the knob to zero. Repeat this procedure on the other tool bit control knob. After the collars are set, do not change their position. **(Collar positions must remain the same during the entire machining process.)** The collars will indicate how much material is being removed.



G. Using either of the tool bits, make a scratch cut on the rotor.

1. If the scratch cut is all of the way around, then the rotor can be reworked without further adjustments.

2. A scratch cut going only part of the way around the rotor may indicate that the rotor is not square on the arbor. Loosen the rotor and rotate the arbor 180 degrees. Move the tool sightly and scratch the rotor again. If the two scratches run side by side, then the wobble is in the rotor (and thus can be reworked). If the scratches are located across the rotor from each other, then the wobble is in the machine or in the space between the rotor and the arbor. Correct any problems with the machine or recheck the rotor mounting.

H. Machine the rotor after making sure it is correctly installed on the arbor.

1. Turn the cross-slide handwheel clockwise until the tool bits are on the most inward edge of the rotor's face.

2. Turn the depth of cut knobs (tool bit control knobs) until they indicate the depth of the first cut; then, lock them in this position with the locking knobs.

   (**NOTE**: If the first cut will be made at high speed, the depth should not exceed .010 inch. If rework will be less than .010 inch, then set the depth at the rework dimension, and run the first cut at low speed.)

3. Engage the cross feed lever. The lever has two positions: high and low. High speed is for a rough cut and low speed is for a finish cut.

(**NOTE**: The depth of cut should never be less than .004 inch. Cuts less than this will not allow heat to transfer from the tool bit to the rotor. Excessive heat build-up in the tool bit may cause damage.)

4. Continue taking cuts until the rotor is smooth and true. Check the rotor's thickness, parallelism, and runout after the final cut has been made but before the rotor is removed from the arbor.

I. Using a sanding block or other abrasives, put a nonsymmetrical finish on the rotor's friction surface.

1. Turn the brake lathe on.

2. Lightly drag the abrasive across the machined surface of the rotor.

3. Turn the brake lathe off.

J. Remove the rotor from the arbor.

JS1-L2-UVI

MODULE: BRAKES

REMOVING, DISASSEMBLING, AND INSPECTING CALIPERS

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Safely lift and secure the vehicle; remove the wheels of the calipers to be serviced.

   a. Mark the wheels for reinstallation.

   b. Inspect the wheels for cracks and the tires for unusual wear patterns. Record observations.

   c. Store the wheels and the wheel covers so they will not be damaged.

3. Identify the calipers to be serviced.

   a. Record the number of pistons in each caliper.

   b. Describe how each caliper is attached to the knuckle.

   c. Indicate if the caliper is fixed or floating.

4. Encapsulate and clean all the brakes to be serviced. Be sure to follow the latest federal procedures when encapsulating and cleaning brakes.

   (CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)

5. Take off the master cylinder cover and remove a small amount of fluid from each master cylinder chamber.

   (CAUTION: Brake fluid can harm a vehicle's finish. Do not let the fluid overflow or spill.)

6. If servicing a fixed caliper, compress the pistons according to the procedure outlined below.

   a. Fixed caliper pistons must be compressed one at a time. Insert a small pry bar or similar tool between the brake pads and pry them apart. Doing so will force the pistons into the caliper bores.

   b. If one piston is stuck in its bore, compress the other three and force the caliper off the rotor.

   c. If more than one piston is stuck (and if the stuck pistons are located across from each other), attempt to force the caliper off the rotor.

      (**NOTE**: Though a caliper with three stuck pistons may be difficult to force off, make the best effort possible. Forcing the caliper off the rotor is the easiest and quickest removal procedure.)

   d. If the rotor is deeply grooved, or if the caliper cannot be forced off the rotor, the caliper and rotor can be removed together. If the caliper and rotor have to be removed together, they will probably have to be replaced. Record observations.

7. If servicing a floating caliper, compress the pistons according to the procedure outlined below.

   a. Place a large (8-inch) clamp on the caliper so that the screw is positioned against the outer brake pad.

   b. Turn the screw so that the outer pad is forced against the rotor. As a result, the caliper will slide and force itself against the inside of the rotor. This pad and caliper movement will force the piston into the caliper.

8. Following the procedure outlined below, remove the caliper from the adapter.

   a. Be sure to disconnect the correct caliper fasteners. A common mistake is to remove the adapter from the knuckle.

   b. Inspect, clean, and lightly lubricate all attachment hardware; note any broken or worn parts. Be sure to mark parts for replacement.

   c. Support the caliper with a piece of wire or welding rod. Never allow a caliper to hang by the brake line.

9. Disconnect the hydraulic system from the caliper.

   a. If the brake hose is connected with a "banjo" bolt, disconnect the hose at the caliper.

   b. If a disconnecting device is located at the end of the brake hose opposite the caliper, leave the hose on the caliper.

   c. If the cover has been off the master cylinder thus far during the procedure, put it back on.

   d. Cap the brake lines.

      (**NOTE**: On some rear-wheel disc brakes, steel brake lines are connected to the caliper. These calipers use a flexible hose above the rear axle to accommodate suspension movement. If the vehicle has independent rear suspension, then a flexible hose will be provided to each rear-wheel caliper.)

      (**NOTE**: If the lines are to be left open for a long time, tape them to avoid brake fluid contamination.)

10. Clean all brake components.

    (**NOTE**: Use only brake cleaning solvent to clean brake components. Never use engine solvent or gasoline.)

11. Disassemble the caliper.

    a. When servicing a floating caliper, use compressed air to blow out the piston. Always insert a rag between the piston and the other side of the caliper.

    b. When servicing a fixed caliper, insert a rag pad between the pistons and the caliper before applying compressed air to the hydraulic port. In most cases, only the freest piston will move. After one of the pistons leaves its bore, no more air can be trapped. The other pistons can be removed one at a time with special pullers.

       (CAUTION: The piston will be blown out of the caliper with enough force that may cause personal injury. Make sure the rag pad is in place. Cover the caliper with another pad to prevent parts from flying. Do not place fingers between the pistons and the caliper.)

       (**NOTE**: Do not use heat or machine tools to remove pistons. Doing so may ruin the caliper.)

       (**NOTE**: Considerable time may be spent in removing stuck caliper pistons. If pistons are stuck so securely that normal removal procedures cannot free them, then the bores are probably corroded and the entire caliper must be replaced.)

12. Following the procedure outlined below, inspect the caliper components.

a. After cleaning all the internal parts with approved brake solvent, inspect metal pistons for pitting, rusting, or scoring. If any of these problems are found, replace the pistons.

(**NOTE**: Whether damaged or not, plastic pistons should always be replaced after removal.)

b. Remove all seals and boots from the caliper bores. Check the bores for pitting and scoring. Clean bores with fine crocus cloth or caliper hone if doing so will not increase bore diameter by more than .002 inch. If any bore damage deeper than .001 inch is found, replace the caliper.

(**NOTE**: Discard all seals, boots, and any other rubber caliper parts.)

c. Remove and clean the bleeder valve. Replace it if necessary.

JS2-L2-UVI

MODULE: BRAKES

DETERMINING ROTOR THICKNESS, PARALLELISM, AND RUNOUT

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Safely lift and secure the vehicle, remove the wheels, and encapsulate and clean the brake assembly to be serviced. Follow the procedures in Lesson 2 of Unit IV.

3. Following the procedure outlined below, inspect the rotor thickness for deep grooves.

   a. Locate the specification for minimum rotor thickness. Minimum rotor thickness is usually printed on the rotor or its hub. Record the specification.

   b. Check the rotor for grooves. If significant grooves are not found, check rotor for parallelism according to item 4 of this job sheet. If significant grooving is found, measure groove depth. If grooving causes the rotor to fall below minimum thickness at any point, discard the rotor. If the rotor is still above minimum thickness, machine the grooves out of the rotor. Do not machine rotor below minimum thickness, however. Record observations.

      (**NOTE**: Some light grooving in the rotor is acceptable after machining.)

      (**NOTE**: Some rotors are grooved as part of the manufacturing process. Disregard these grooves.)

4. Following the procedure outlined below, determine if rotor is sufficiently parallel.

   a. Using a micrometer, measure the thickness of the rotor at twelve different locations. Record each measurement. If any one reading exceeds any of the others by .001 inch, the rotor is not parallel. Record observations.

b. If the rotor is parallel, measure rotor runout according to the procedure under item 5 below. If rotor is not parallel, calculate what the rotor's thickness would be if it were machined to the smallest micrometer measurement. Discard the rotor if machining would drop it below its minimum thickness. If machining would not drop the rotor below its minimum thickness, machine the rotor so that there is never more than a .001-inch variation between any two points. Record observations.

(**NOTE**: Some minor grooving in rotor after reworking is acceptable.)

5. Following the procedure outlined below, check for rotor runout.

(**NOTE**: If rotor is not integral with the hub assembly, rotor runout cannot be checked.)

a. Attach a dial indicator to either the knuckle, or the adapter, or some other frame or suspension component.

b. Adjust the dial indicator in such a manner that it will contact the rotor somewhere near the center of the friction surface.

c. Rotate the rotor, watching the dial indicator.

d. Stop and zero the dial indicator at the point of its lowest reading. Record the lowest reading.

e. Continue turning the rotor. Stop the dial indicator at the point of its highest reading. Subtract the lowest reading from the highest reading; the difference is the rotor runout. If there is no difference between the lowest and highest reading, then the runout is zero. If the difference is greater than .005 inch, then the rotor will need to be machined. Record observations.

(**NOTE**: Excessive rotor runout can be caused by a worn or poorly adjusted bearing. Inspect bearing for excessive wear and check bearing adjustment before machining rotors. Use procedures outlined in Lesson 3 of Unit IV.)

f. In order to remove runout, the rotor thickness will have to be reduced by one-half of the runout measurement. For example, if the runout is .006 inch, then the rotor thickness will have to be reduced by .003 inch.

g. Calculate what the rotor's thickness would be if it were machined. If the thickness would be less than the minimum thickness specifications, discard the rotor. If the thickness would still exceed minimum thickness specifications, machine the rotor until runout is under .001 inch. Record observations.

h. Suggest any needed repairs for the rotor.

6. Reinstall the wheel/tire assembly and torque the wheel nuts to the proper specification.

JS3-L2-UVI

MODULE: BRAKES

MACHINING ROTORS

Equipment:

Common hand tools
Safety glasses

(**NOTE**: The below machining procedures are applicable in most cases; however, always be sure to follow the lathe manufacturer's procedures.)

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Mount the rotor on the lathe's arbor. In most cases, the silencer is a rubber band, which is stretched around the rotor's edge. However, the silencer may be a pad, which contacts the rotor's face.

   (**NOTE**: Be sure that the rotor is centered between the arbor's two cones. If the rotor wobbles when turned, recheck the attachment of the rotor to the arbor. Also make sure that there is no dirt or chips between the rotor and the arbor.)

3. Install the cutting tool. Make sure that the rotor is centered between the cutting tool. Also make sure that the cutting tool is perpendicular to the arbor.

4. Using hand pressure, rotate the rotor at least one complete turn. Make sure that the rotor turns freely and that both tool bits are clear of the rotor's face.

   (CAUTION: Make sure that all controls are in neutral or at zero before turning on the lathe.)

5. Turn one of the tool bit control knobs clockwise until the tool bit makes contact with the rotor's face. Turn the indexing collar on the knob to zero. Repeat this procedure on the other tool bit control knob. After the collars are set, do not change their position. (Collar positions must remain the same during the entire machining process.) The collars will indicate how much material is being removed.

6. Following the procedure outlined below, make a scratch cut on the rotor with either one of the tool bits.

   a. If the scratch cut is all of the way around, then the rotor can be reworked without further adjustments.

b. A scratch cut going only part of the way around the rotor may indicate that the rotor is not square on the arbor. Loosen the rotor and rotate the arbor 180 degrees. Move the tool sightly and scratch the rotor again. If the two scratches run side by side, then the wobble is in the rotor (and thus can be reworked). If the scratches are located across the rotor from each other, then the wobble is in the machine or in the space between the rotor and the arbor. Correct any problems with the machine or recheck the rotor mounting. Record observations.

7. Following the procedure outlined below, machine the rotor after it is correctly installed on the arbor.

   a. Turn the cross-slide handwheel clockwise until the tool bits are on the most inward edge of the rotor's face.

   b. Turn the depth of cut knobs (tool bit control knobs) until they indicate the depth of the first cut; then, lock them in this position with the locking knobs.

      (**NOTE**: If the first cut will be made at high speed, the depth should not exceed .010 inch. If rework will be less than .010 inch, then set the depth at the rework dimension, and run the first cut at low speed.)

   c. Engage the cross feed lever. The lever has two positions: high and low. High speed is for a rough cut and low speed is for a finish cut.

      (**NOTE**: The depth of cut should never be less than .004 inch. Cuts less than .004 inch will not allow heat to transfer from the tool bit to the rotor. Excessive heat built in the tool bit may cause damage.)

   d. Continue taking cuts until the rotor is smooth and true. Check the rotor's thickness, parallelism, and runout after the final cut has been made but before the rotor is removed from the arbor.

JS4-L2-UVI

MODULE: BRAKES

REASSEMBLING AND REINSTALLING CALIPERS

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, reassemble the caliper.

   a. During reassembly, lubricate all parts liberally with clean brake fluid or some other appropriate lubricant. All parts should freely move into their proper positions; inspect any part that does not fit into its position easily. Do not force the pistons into their bores.

   b. Using only new soft parts, manually insert all seals and pistons into the caliper bores. Do not use excessive pressure. Press pistons to the bottom of their respective bores.

   c. Install a new dust seal according to manufacturer's directions.

   d. If the transfer passage is drilled into the body of a fixed caliper, clean the passage and make sure it is free of obstructions. If the transfer passage is a separate tube, clean the tube and make sure it is free of obstructions before installation.

      (**NOTE**: Floating calipers do not have transfer passages.)

   e. On fixed caliper brakes, reassemble the caliper halves, using new gaskets or seals where indicated.

   f. Inspect all hoses and replace any that show evidence of leaking or deterioration.

   g. Clean and reinstall all bleeder valves. If necessary, replace the bleeder valves.

3. Following the procedure outlined below, install and adjust disc brake calipers.

   a. Inspect, clean, and lightly lubricate the caliper attachment hardware. If servicing a floating caliper, inspect the surface upon which the caliper will float. Repair any worn areas and thoroughly clean the adapter and knuckle.

b. Using a service manual or other information source, locate a procedure for installing brake pads on the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

c. Using a service manual or other information source, locate a procedure for installing the vehicle's calipers. Indicate whether the caliper is fixed or floating; note how many cylinders the caliper has; and describe the manner in which the caliper is attached to the knuckle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

d. Using a service manual or other information source, locate a procedure for adjusting the calipers to the rotors once the calipers are installed. Make sure the procedure describes how shims can be used to make the adjustments. (If any calipers on the vehicle do not require adjustment, indicate this in the procedure.) Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

e. Using a service manual or other information source, locate a procedure for connecting the parking brake cable and adjusting the parking brake after rear-wheel caliper installation. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

f. Following the procedures developed in items "3-b" through "e" of this job sheet, install brake pads on the vehicle. (Fit the pads if necessary.) Record observations.

g. Install the brake hoses.

(CAUTION: Until the pistons return to their operating positions, the brakes will be inoperative. The brakes will have to be applied several times before the pistons return to their operating positions. Make sure brakes are operative prior to driving the vehicle.)

h. Bleed all air from the lines and the calipers.

(**NOTE**: For brake bleeding procedures, see Unit 3, Lesson 2.)

i. If the rear-wheel caliper has been installed, follow the procedures developed in items "3-b" through "e" of this job sheet and connect the parking brake cable and adjust the parking brake according to manufacturer's directions. Record observations.

(CAUTION: Always check and refill the master cylinder after hydraulic system components have been tested or serviced.)

(CAUTION: Always make sure that the hydraulic system is free from air after hydraulic components have been tested or serviced.)

j. Install the wheel/tire assembly and torque the wheel nuts to the proper specifications.

MODULE: BRAKES

UNIT VII: DRUM BRAKE SERVICE AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to remove, inspect, service, and replace drum brake components. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with drum brake inspection (Competency W2, Part I of the Unit VII Test).

II. Identify the procedures for disassembling, inspecting, and servicing drum brakes (Competency W2, Part I of the Unit VII Test).

III. Identify the procedures for disassembling and inspecting the wheel cylinder (Competency W3, Part II of the Unit VII Test).

IV. Identify the procedures for installing and adjusting drum brake components (Competency W3, Part II of the Unit VII Test).

Lesson 2.

I. Identify terms and definitions associated with servicing brake drums (Competency W3, Part II of the Unit VII Test).

II. Identify the procedures for machining brake drums (Competency W3, Part II of the Unit VII Test).

III. Demonstrate the ability to:

a. Disassemble and inspect drum brakes (Competency W2, JS1-L2-UVII).

b. Service wheel cylinders (Competency W3, JS2-L2-UVII).

c. Machine brake drums (Competency W3, JS3-L2-UVII).

d. Reinstall drum brake assemblies (Competency W3, JS4-L2-UVII).

MODULE: BRAKES

UNIT VII: DRUM BRAKE SERVICE AND REPAIR

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT VII: DRUM BRAKE SERVICE AND REPAIR

LESSON 1: SERVICING DRUM BRAKE SYSTEMS

I. Terms and definitions

A. **Brake shoe gauge** — A tool used to adjust brake shoes prior to drum installation.

B. **Brake spring tools** — Any number of tools designed to manipulate the brake shoe return springs or hold-down springs.

C. **Encapsulator** — A piece of equipment that captures and holds brake dust.

D. **Micrometer (brake drum)** — A tool that measures the brake drum's diameter.

E. **Primary brake shoe** — The brake shoe located toward the front of the vehicle. Primary shoes are identified only on dual servo brake assemblies.

F. **Secondary brake shoe** — The brake shoe located toward the rear of the vehicle. Primary shoes are identified only on dual servo brake assemblies.

G. **Star wheel** — A notched wheel found on some brake adjusters. When turned, the star wheel activates the adjuster.

II. Disassembling, inspecting, and servicing drum brakes

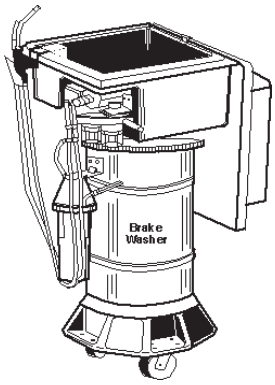
A. Procedures for disassembling and inspecting a drum brake assembly

1. Safely lift and secure the vehicle to be serviced.

(CAUTION: Always use proper lifting equipment. Never work under a vehicle that is supported by any type of jack. Bumper jacks are especially dangerous. Always use solid-metal jack stands or a lift that can support the entire vehicle by its frame. Always use extreme caution when lifting a vehicle.)

2. Encapsulate and clean all brake drum assemblies to be serviced. Be sure to follow the latest federal procedures when encapsulating and cleaning brake assemblies. Refer to Lesson 2 of Unit 4 for encapsulation procedures.

(CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)

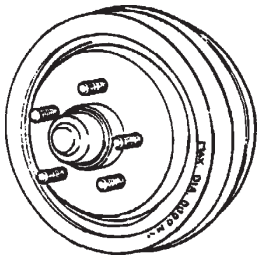


3. With the encapsulator still attached to the brake assembly, remove the brake drum and once again clean the drum and brake assembly components.

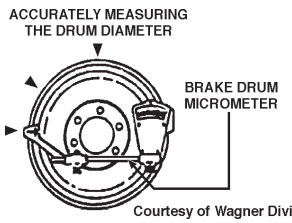
   (**NOTE**: In most cases, the brake adjusters will have to be loosened before the drum can be removed. Refer to Lesson 2 of Unit 4 for procedures for loosening the adjusters.)

4. Inspect the general condition of the drum. Note if the drum is belled or barrelled or grooved. Also note if the drum is warped or distorted. Look for cracks or blue spots on the drum. For procedures for drum inspection, refer to Lesson 2 of Unit 4.

5. Determine the drum's discard diameter. The discard diameter is often stamped on the drum in metric measurements. The discard diameter may also be found in the manufacturer's service manual.



6. Using a drum micrometer, measure the drum's diameter. Always measure from the inside rims of the drum. Take measurements at several points on the drum.



Courtesy of Wagner Division, Cooper Industries, Inc.

7. If all the micrometer measurements vary less than .010 of an inch, the drum is concentric and should next be checked for grooving. If the drum is not concentric, it can be machined if its lowest micrometer reading is below .010 of an inch. Follow the machining procedure developed in JS3-L2-UVII. If the drum's lowest micrometer reading is above .010 of an inch, discard the drum.

8. Check the drum for grooves. Estimate the depth of any grooves. Determine if machining grooves will cause the drum to exceed its discard diameter. See JS3-L2-UVII for machining procedures.

   (**NOTE**: A groove will increase the drum's diameter by twice the depth of the groove.)

   (**NOTE**: Minor grooving is acceptable if the drum does not exceed its discard diameter.)

   (**NOTE**: On some vehicles, the wheel hub is an integral part of the drum. When inspecting the wheel bearings on these vehicles, make sure that the bearing cups are in good condition and are firmly pressed into the hub. For wheel bearing service procedure, see Lesson 3 of Unit IV.)

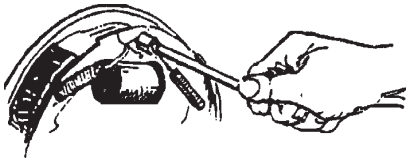
9. If the wheel hub was not removed during drum removal, remove and service the wheel bearings, if possible. Refer to Lesson 3 of Unit IV for wheel bearing procedures.

   (**NOTE**: The rear hub bearings in front-wheel-drive vehicles usually cannot be serviced. If the bearings are excessively worn or damaged, replace the hub assembly.)

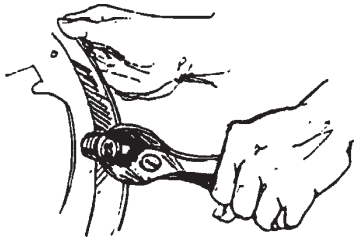
   (**NOTE**: If installing new brake shoes, carefully compare the new ones with the old. Check the shoes' spring holes and arc diameter; also check the shape of the shoes' ends and length of the shoes' friction material.)

   (**NOTE**: An inexperienced technician should take apart only one drum brake assembly at a time. Doing so prevents the technician from confusing parts from one assembly with those from another. The technician can also use the assembled brake components as a guide to reassembly.)

10. Using the brake spring tool, remove the brake shoe return springs from the anchor.



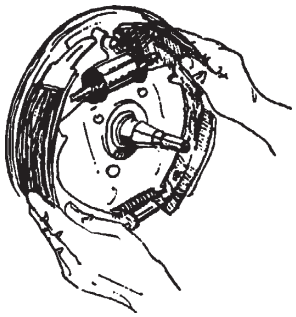
11. Using the hold-down spring tool, remove the brake shoe hold-down device on both shoes.



12. Disconnect the adjuster linkage from the anchor.

13. Grasp both shoes at their tops, and pull them away from the anchor.

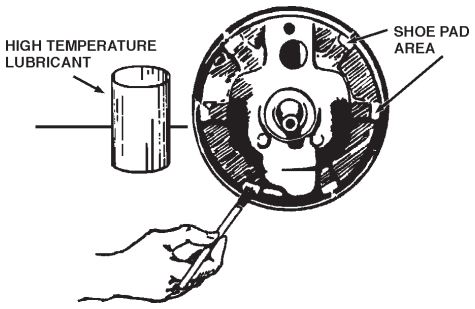
    (**NOTE**: When pulling rear-wheel brake shoes away from their anchors, the technician will have to separate the parking brake lever from the secondary shoe. In some cases, the lever will need to be disengaged from a notch. In others, a clip will have to be removed from a pin that retains the lever. In either case, the lever can be left to hang on the cable while other components are being serviced.)



14. Service the wheel cylinder. If the shoes are replaced, the pistons will run deeper into the cylinders. New shoes will also cause cylinder cups to run on a different part of the cylinder.

    (**NOTE**: Wheel cylinder service will be discussed later in this unit. Anytime the brake shoes are replaced, the wheel cylinders should be serviced.)

15. Clean the backing plate with a non-contaminating solvent. Make sure to remove all dirt, rust, and loose scale from the plate. Carefully inspect the shoe pad areas for grooves and other signs of wear. File the shoe pad areas flat or replace the backing plate as necessary. Next, lightly lubricate the backing plate shoe pad areas with a lubricant designed to withstand high temperatures.



16. Clean and lubricate all brake hardware. Check springs for corrosion and distortion. Replace any components of questionable quality.

17. Clean and lubricate the adjusters according to manufacturer's procedures.

III. Disassembling and inspecting the wheel cylinder

A. Procedure for wheel cylinder service

(**NOTE**: The following procedure is general and may not apply to all wheel cylinders. Refer to the appropriate service manual for the proper procedure.)

(**NOTE**: A wheel cylinder is not normally disassembled for inspection unless there are specific reasons for doing so. Usually, if the cylinder is not leaking and the exposed rubber parts are not deteriorated, the wheel cylinder is considered serviceable. If, on the other hand, evidence of leakage, or deterioration of the exposed rubber parts is noted, then the wheel cylinder should be removed and either replaced or reconditioned. The following steps will determine if replacement will be necessary.)

(**NOTE**: Before the wheel cylinder can be removed, the brake shoes and other components must be removed.)

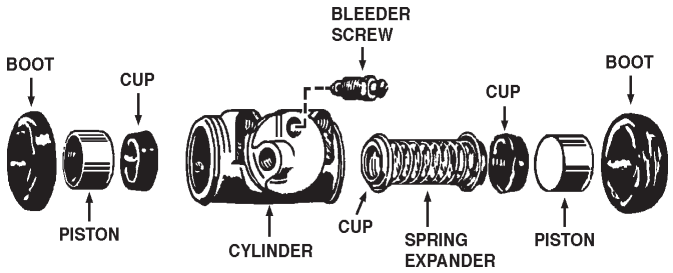
1. Disconnect the brake line or hose from the wheel cylinder. In some cases, the brake hose remains connected to the cylinder and is disconnected at the hose's other end. Check the proper service manual for the correct procedure.

2. Remove the wheel cylinder from the backing plate. Some wheel cylinders are attached to the backing plate by bolts while others are held in place by a snap ring.

3. Remove and clean out the bleeder valve. (The bleeder valve screws into the wheel cylinder.)

4. Remove the rubber dust caps from the ends of the wheel cylinder.

5. Push out all the wheel cylinder's inner components (pistons, springs, cups, etc.). In some "stepped" cylinders, the inner components must be pushed from the small end toward the large end.



6. Discard the rubber dust caps, the rubber cups, and the spring.

7. Carefully clean the wheel cylinder and the two pistons with a solvent approved for brake systems.

8. Examine cylinder bores and both pistons. Look for varnish, pitting, and scoring.

   (**NOTE**: Varnish on cylinders and pistons can be removed with alcohol or other approved solvents. Pits and scoring in cylinders can sometimes be honed out. Some manufacturers, however, discourage honing cylinders; check the proper manual for service recommendations. Pistons that are scored or pitted should be replaced.)

9. Lightly hone the wheel cylinder, if necessary. Be sure that the manufacturer indicates that the wheel can be honed; also be sure to follow the manufacturer's recommended honing procedures.

10. After honing the wheel cylinder, wash the cylinder with brake cleaning solvent. Make sure that all parts are well lubricated with clean brake fluid (or some other approved brake assembly lubricant). Install new cups and a new spring. Push both cups into the cylinder, thereby compressing the spring. The cups should face inward, toward the spring. Install both pistons, facing the flat sides toward the cups; then, push the pistons into the cylinder until they are flush with the cylinder. Install the dust caps. (The dust caps should retain the pistons.)

11. Install the bleeder valve. Make sure that the bleeder valve is clean and clear.

12. Install the wheel cylinder.

    a. Some cylinders are retained by bolts while others are retained by spring clips.

    b. Some non-servo brakes use two one-piston cylinders, which, in some cases, are adjustable; make sure that these cylinders do, in fact, adjust easily.

    c. Install the brake line or hose according to repair manual procedures.

    d. Install the pins that move the brake shoes.

IV. Installing and adjusting drum brake components

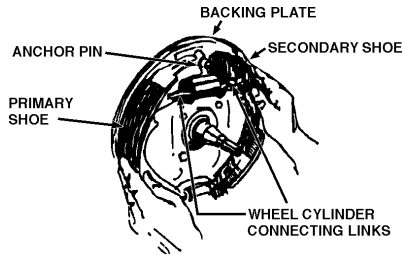
(CAUTION: Always performance test the brake system after all repairs.)

A. Install the brake shoes.

1. Examine the new brake shoes and determine if there is a difference between the shoes. Most dual servo brakes use two different shoes on each wheel. If this is the case, the brake lining on one shoe will be longer than that on the other. The shoe with the longest lining will be used in the secondary position.

2. Assemble the two shoes located on one side by connecting the adjuster end of the shoe with the spring and the adjuster. The star wheel and the secondary shoe should be located toward the rear of the vehicle.

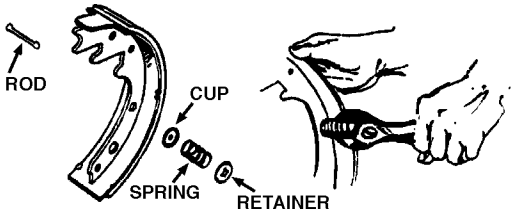
3. Spread the shoes and slip them over the anchor, making sure that they both properly engage the wheel cylinder pins.



(**NOTE**: In some cases, the adjuster linkage will need to be connected at this time.)

(**NOTE**: On rear-wheel brakes, the parking brake lever will need to be installed at this time.)

4. Install the hold-down springs.



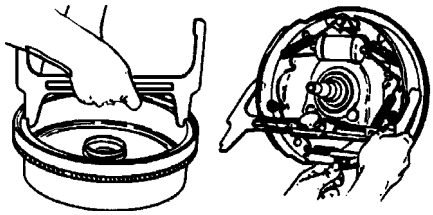
5. Using the brake spring tool, install the brake shoe return springs.

6. Examine the shoes and make sure that they both contact the anchors and that the adjuster operates properly.

B. Adjust brake shoes.

1. Adjust the brake shoe gauge to fit the drum. Tighten the knob to lock the gauge into the proper position.

2. Adjust the star wheel outward until the center of the brake shoes touch the gauge.



C. Examine the parking brake linkages.

1. Make sure that the parking brake is disengaged.

2. Make sure that the cables are free in their housings.

3. Make sure that the brake shoes are resting against their anchors. If the parking brake is preventing a brake shoe from contacting the anchor, adjust the length of the parking brake cable. (The cable adjustment mechanism can usually be found at some point on the cable.) Recheck the shoes.

D. Install the drum.

1. If the hub is part of the drum, be sure that the wheel bearing has been serviced.

   (**NOTE**: For wheel bearing service, see Lesson 3 of Unit IV.)

2. Install and torque the wheel.

3. If drum brakes are being installed on the rear wheels, adjust the parking brake at this time. Follow the manufacturer's recommendations and procedures.

MODULE: BRAKES

UNIT VII: DRUM BRAKE SERVICE AND REPAIR

LESSON 2: SERVICING BRAKE DRUMS

I. Terms and definitions

A. **Arbor** — The main brake lathe shaft upon which the brake drum is mounted.

B. **Brake lathe** — A machine tool that is designed to refinish brake drums and brake rotors.

C. **Cross slide** — Brake lathe component that moves perpendicularly to the arbor in order to establish the depth of the cut made on a drum.

D. **Depth of cut** — The amount of drum material that will be removed by one cut.

E. **Discard (maximum) diameter** — The diameter at which the drum will no longer function adequately. The discard diameter is usually stamped on the drum.

F. **Drum micrometer** — An instrument designed to measure brake drum diameters.

G. **Encapsulator** — A device designed to capture and hold brake dust during brake work.

H. **Handwheel** — An adjustment wheel designed to be turned by hand.

I. **Indexing collar** — An adjustment knob collar with which the knob's position can be marked.

J. **Locking knob** — A knob that can be used to lock the position of a lathe component, such as a slide or a handwheel.

K. **Perpendicular** — A term denoting a ninety-degree angle.

L. **Silencer** — A rubber strap that is wrapped around the brake drum while it is on the lathe.

M. **Tool bar** — On a lathe, a metal bar upon which the tool bit is fastened.

N. **Tool bit** — On a lathe, the machine part which does the cutting.

II. Machining brake drums

(**NOTE**: Before performing the below procedure, make sure to do the following as outlined earlier in this unit: properly lift and support the vehicle; encapsulate and thoroughly clean the brake dust from each brake assembly to be serviced; and remove the drum of each brake assembly to be serviced.)

(**NOTE**: The below machining procedures are applicable in most cases; however, always be sure to follow the lathe manufacturer's procedures.)

A. Mount the drum on the machine's arbor. Be sure that the proper attachment hardware is used. Follow the manufacturer's instructions.

(CAUTION: Before starting the lathe, be sure that all controls are either turned off or set at neutral or zero.)

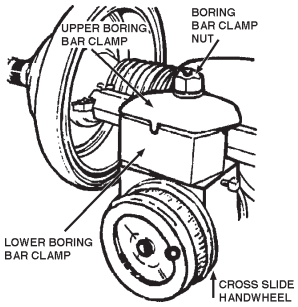
(**NOTE**: The drum should be firmly centered perpendicularly to the arbor. If drum appears to be mounted improperly, review mounting instructions. Start the lathe. If the drum wobbles or tramps excessively, reposition it on the arbor.)

B. Install the silencer band (usually a rubber strap wrapped around the drum). The silencer band prevents the drum from vibrating. Failure to use this band will result in an inferior drum finish.

C. Install the tool bar. Make sure that the cutting tool is facing the drum friction surface.

D. Position the tool bar. Move the cutting tool away from or toward the drum with the spindle feed handwheel.

E. Turn the cross slide's handwheel so that the cutting tool is positioned over the unused portion of the brake surface at the outer edge of the drum.



F. Turn the cross slide's handwheel until the cutting tool barely touches the brake drum surface; then, note the depth of cut reading. Turn the cross slide's handwheel counter clockwise 1/2 turn.

(CAUTION: Before starting lathe, be sure that all controls are either turned off or set at neutral or zero.)

G. Turn on the lathe.

H. With the drum in motion, turn the cross slide's handwheel until the cutting tool barely touches the drum. Allow the tool to scratch the drum.

1. Examine the scratch.

2. If the scratch goes all the way around the drum, then the drum is square and can be reworked as is.

3. If the scratch goes only part of the way around the drum, then the drum should be loosened and turned 180 degrees on the arbor and scratched again approximately 1/8 of inch from the original scratch.

4. If the scratches are now parallel, then the drum is distorted and can be reworked as long as doing so will not increase the drum diameter beyond the discard specification.

5. If the scratches are not parallel, then the drum is not centered on the arbor or the arbor is bent. Do not rework the drum until any problems with the arbor are corrected.

I. Following procedure outlined below, rework the drum.

1. Make sure that the machine is off and all of the levers are in neutral.

2. Using the handwheel that positions the arbor, set the cutting tool at the drum's farthest inside point.

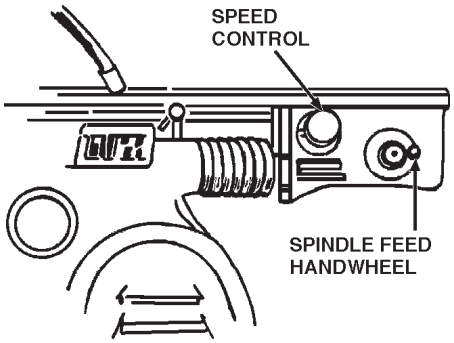
3. Using the handwheel that sets the depth of cut, move the cutting tool until it almost touches the drum's friction surface.

4. Turn on the lathe.

5. With the drum in motion, turn the handwheel that sets the depth of cut until the cutting tool touches the drum's friction surface. After the cutting tool contacts the drum, index the collar on the handwheel to zero.

6. Set the depth of cut at no more than .010 inch for rough cuts and no less than .004 inch for finish cuts.

7. Set the arbor speed control knob at the speed desired for the cut.



(**NOTE**: The final cut should be made at the slowest speed.)

8. Set the arbor travel limiting collars.

9. Lock the cross slide by tightening its locking knob.

10. Engage the arbor travel bar.

11. Continue taking cuts until the friction surface is smooth and true. Make the last (finish) cut at the slowest speed. Make sure that the drum does not exceed its discard diameter after machining. Also make sure that drums used on the same axle are as close in diameter as possible.

JS1-L2-UVII

MODULE: BRAKES

DISASSEMBLING AND INSPECTING DRUM BRAKES

Equipment:

Encapsulator
Suitable lifting equipment
Compressed air
Brake shoe gauge
Brake spring tool
Brake shoe hold-down spring tool
Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Safely lift and secure the vehicle; remove the wheels of the vehicle to be serviced.

   (CAUTION: Always use proper lifting equipment. Never work under a vehicle that is supported by any type of jack. Bumper jacks are especially dangerous. Always use solid-metal jack stands or a lift that can support the entire vehicle by its frame. Always use extreme caution when lifting a vehicle.)

3. Encapsulate and clean all brake drum assemblies to be serviced. Be sure to follow the latest federal procedures when encapsulating and cleaning brake assemblies. Refer to Lesson 2 of Unit 4 for encapsulation procedures.

   (CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)

4. With the encapsulator still attached to the brake assembly, remove the brake drum and once again clean the drum and brake assembly components.

   (**NOTE**: In most cases, the brake adjusters will have to be loosened before the drum can be removed. Refer to Lesson 2 of Unit 4 for procedures for loosening the adjusters.)

5. Inspect the general condition of the drum. Note if the drum is belled or barrelled or grooved. Also note if the drum is warped or distorted. Look for cracks or blue spots on the drum. Record observations.

6. Determine the drum's discard diameter. The discard diameter is often stamped on the drum in metric measurements. The discard diameter may also be found in the manufacturer's service manual. Record discard diameter.

7. Using a drum micrometer, measure the drum's diameter. Always measure from the inside rims of the drum. Take measurements at several points on the drum. Record measurements.

8. If all the micrometer measurements vary less than .010 of an inch, the drum is concentric and should next be checked for grooving. If the drum is not concentric, it can be machined if its lowest micrometer reading is below .010 of an inch. Follow the machining procedure developed in JS3-L2-UVII. If the drum's lowest micrometer reading is above .010 of an inch, discard the drum. Record whether the drum should be reworked or discarded.

9. Check the drum for grooves. Estimate the depth of any grooves. Determine if machining grooves will cause the drum to exceed its discard diameter. See JS3-L2-UVII for machining procedures. Record the estimated depth of the grooves and indicate if the drum can be machined.

    a. A groove will increase the drum's diameter by twice the depth of the groove.

    b. Minor grooving is acceptable if the drum does not exceed its discard diameter.

    c. On some vehicles, the wheel hub is an integral part of the drum. When inspecting the wheel bearings on these vehicles, make sure that the bearing cups are in good condition and are firmly pressed into the hub. For wheel bearing service procedure, see Lesson 3 of Unit IV.

10. If the wheel hub was not removed during drum removal, remove and service the wheel bearings, if possible. Refer to Lesson 3 of Unit IV for wheel bearing procedures.

    a. The rear hub bearings in front-wheel-drive vehicles usually cannot be serviced. If the bearings are excessively worn or damaged, replace the hub assembly.

    b. If installing new brake shoes, carefully compare the new ones with the old. Check the shoes' spring holes and arc diameter; also check the shape of the shoes' ends and length of the shoes' friction material.

(**NOTE**: An inexperienced technician should take apart only one drum brake assembly at a time. Doing so prevents the technician from confusing parts from one assembly with those from another. The technician can also use the assembled brake components as a guide to reassembly.)

11. Following the procedure outlined below, remove and inspect the brake shoes.

    a. Using the brake spring tool, remove the brake shoe return springs from the anchor.

    b. Using the hold-down spring tool, remove the brake shoe hold-down device on both shoes.

    c. Disconnect the adjuster linkage from the anchor.

    d. Grasp both shoes at their tops, and pull them away from the anchor.

    (**NOTE:** When pulling rear-wheel brake shoes away from their anchors, the technician will have to separate the parking brake lever from the secondary shoe. In some cases, the lever will need to be disengaged from a notch. In others, a clip will have to be removed from a pin, which retains the lever. In either case, the lever can be left to hang on the cable while other components are being serviced.)

    e. Service the wheel cylinder according to the procedure in JS2-L2-UVII. If the shoes are replaced, the pistons will run deeper into the cylinders. New shoes will also cause cylinder cups to run on a different part of the cylinder.

    f. Clean the backing plate with a non-contaminating solvent (denatured alcohol). Make sure to remove all dirt, rust, and loose scale from the plate. Next, lubricate the backing plate forms with a lubricant designed to withstand high temperatures.

    g. Clean and lubricate all brake hardware. Check springs for corrosion and distortion. Replace any components of questionable quality.

h. Using a service manual or other information source, locate a procedure for cleaning and lubricating the adjusters in the vehicle's drum brake assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, clean and lubricate the adjusters according to manufacturer's procedures. Record observations.

JS2-L2-UVII

MODULE: BRAKES

SERVICING WHEEL CYLINDERS

Equipment:

Common hand tools
Wheel cylinder hone
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, remove the wheel cylinder.

   a. Using a service manual or other information source, locate a procedure for disconnecting the brake lines or hoses from the wheel cylinder. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   b. Using a service manual or other information source, locate a procedure for disassembling, servicing, and reassembling the wheel cylinders. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, disconnect the brake lines or hoses from the wheel cylinder.

   (**NOTE**: In some cases, the brake hose remains connected to the cylinder and is disconnected at the hoses's other end.)

c. Remove the wheel cylinder from the backing plate. Some wheel cylinders are attached to the backing plate by bolts while others are held in place by a snap ring.

d. Remove and clean the bleeder valve. (The bleeder valve screws into the wheel cylinder.)

e. Remove the rubber dust caps from the ends of the wheel cylinder.

f. Push out all wheel cylinder's inner components (pistons, springs, cups, etc.). In some "stepped" cylinders, the inner components must be pushed from the small end toward the large end.

g. Discard the rubber dust caps, the rubber cups, and the spring.

h. Carefully clean the wheel cylinder and the two pistons with a solvent approved for brake systems.

3. Following the procedure outlined below, inspect and service the wheel cylinder.

a. Examine cylinder bores and both pistons. Look for varnish, pitting, and scoring. Record observations.

b. Varnish on cylinders and pistons can be removed with alcohol or other approved solvents. Pits and scoring in cylinders can sometimes be honed out. Some manufacturers, however, discourage honing cylinders; check the proper manual for service recommendations. Pistons that are scored or pitted should be replaced. Record whether or not the cylinder should be honed.

c. Hone the wheel cylinder, if necessary. Be sure that the manufacturer indicates that the wheel can be honed; also be sure to follow the manufacturer's recommended honing procedures.

4. Following the procedure outlined below, reassemble the wheel cylinder.

a. Make sure that all wheel cylinder parts are well lubricated with clean brake fluid (or some other approved brake assembly lubricant). Install new cups and a new spring. Push both cups into the cylinder, thereby compressing the spring. The cups should face inward, toward the spring. Install both pistons, facing the flat sides toward the cups; then, push the pistons into the cylinder until they are flush with the cylinder. Install the dust caps. (The dust caps should retain the pistons.)

b. Install the bleeder valve. Make sure that the bleeder valve is clean and clear.

5. Following the procedure outlined below, reinstall the wheel cylinder.

a. Some cylinders are retained by bolts while others are retained by spring clips.

b. Some non-servo brakes use two one-piston cylinders, which, in some cases, are adjustable; make sure that these cylinders do, in fact, adjust easily.

c. Install the brake line or hose according to repair manual procedures.

d. Install the pins that move the brake shoes.

JS3-L2-UVII

MODULE: BRAKES

MACHINING BRAKE DRUMS

Equipment:

Common hand tools
Brake drum micrometer
Brake drum lathe
Safety glasses

(**NOTE**: Before performing the below procedure, make sure to do the following as outlined earlier in this unit: properly lift and support the vehicle; encapsulate and thoroughly clean the brake dust from each brake assembly to be serviced; and remove the drum of each brake assembly to be serviced.)

(**NOTE**: The below machining procedures are applicable in most cases; however, always be sure to follow the lathe manufacturer's procedures.)

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Mount the drum on the machine's arbor. Be sure that the proper attachment hardware is used. Follow the manufacturer's instructions.

   (CAUTION: Before starting the lathe, be sure that all controls are either turned off or set at neutral or zero.)

   (**NOTE**: The drum should be firmly centered perpendicularly to the arbor. If drum appears to be mounted improperly, review mounting instructions. Start the lathe. If the drum wobbles or tramps excessively, reposition it on the arbor.)

3. Install the silencer band (usually a rubber strap wrapped around the drum). The silencer band prevents the drum from vibrating. Failure to use this band will result in an inferior drum finish.

4. Install the tool bar. Make sure that the cutting tool is facing the drum friction surface. Position the tool bar. Move the cutting tool away from or toward the drum with the feed handwheel.

5. Turn the cross slide's handwheel so that the cutting tool is positioned over the unused portion of the brake surface at the outer edge of the drum. Next, turn the cross slide's handwheel until the cutting tool barely touches the brake drum surface; then, note the depth of cut reading. Turn the cross slide's handwheel counter clockwise 1/2 turn.

6. Turn on the lathe. With the drum in motion, turn the cross slide's handwheel until the cutting tool barely touches the drum. Allow the tool to scratch the drum.

   (CAUTION: Before starting lathe, be sure that all controls are either turned off or set at neutral or zero.)

   a. Examine the scratch.

   b. If the scratch goes all the way around the drum, then the drum is square and can be reworked as is.

   c. If the scratch goes only part of the way around the drum, then the drum should be loosened and turned 180 degrees on the arbor and scratched again approximately 1/8 of inch from the original scratch.

   d. If the scratches are now parallel, then the drum is distorted and can be reworked as long as doing so will not increase the drum diameter beyond the discard specification.

   e. If the scratches are not parallel, then the drum is not centered on the arbor or the arbor is bent. Do not rework the drum until any problems with the arbor are corrected.

7. Following the procedure outlined below, rework the drum.

   a. Make sure that the machine is off and all of the levers are in neutral.

   b. Using the handwheel that positions the arbor, set the cutting tool at the drum's farthest inside point.

   c. Using the handwheel that sets the depth of cut, move the cutting tool until it almost touches the drum's friction surface.

   d. Turn on the lathe.

   e. With the drum in motion, turn the handwheel that sets the depth of cut until the cutting tool touches the drum's friction surface. After the cutting tool contacts the drum, index the collar on the handwheel to zero.

   f. Set the depth of cut at no more than .010 inch for rough cuts and no less than .004 for finish cuts.

   g. Set the arbor speed control knob at speed desired for the cut.

      (**NOTE**: The final cut should be made at the slowest speed.)

   h. Set the arbor travel limiting collars.

   i. Lock the cross slide by tightening its locking knob.

   j. Engage the arbor travel bar.

k. Continue taking cuts until the friction surface is smooth and true. Make the last (finish) cut at the slowest speed. Make sure that the drum does not exceed its discard diameter after machining. Also make sure that drums used on the same axle are as close in diameter as possible.

JS4-L2-UVII

MODULE: BRAKES

REINSTALLING DRUM BRAKE ASSEMBLIES

Equipment:

Common hand tools
Wheel cylinder hone
Safety glasses

Procedure:

1. Wear safety glasses while performing all procedures on this job sheet.

2. Following the procedure outlined below, install the brake shoes.

    a. Examine the new brake shoes and determine if there is a difference between the shoes. Most dual servo brakes use two different shoes on each wheel. If this is the case, the brake lining on one shoe will be longer than that on the other. The shoe with the longest lining will be used in the secondary position.

    b. Assemble the two shoes located on one side by connecting the adjuster end of the shoe with the spring and the adjuster. The star wheel and the secondary shoe should be located toward the rear of the vehicle.

    c. Spread the shoes and slip them over the anchor, making sure that they both properly engage the wheel cylinder pins.

        (**NOTE**: In some cases, the adjuster linkage will need to be connected at this time.)

        (**NOTE**: On rear-wheel brakes, the parking brake lever will need to be installed at this time.)

3. Install the hold-down springs.

4. Using the brake spring tool, install the brake shoe return springs.

5. Examine the shoes and make sure that they both contact the anchors and that the adjuster operates properly. Record observations.

6. Following the procedure outlined below, adjust the brake shoes.

    a. Adjust the brake shoe gauge to fit the drum. Tighten the knob to lock the gauge into the proper position.

b. Adjust the star wheel outward until the center of the brake shoes touch the gauge.

7. Following the procedure outlined below, examine the parking brake linkages.

a. Make sure that the parking brake is disengaged.

b. Make sure that the cables are free in their housings.

c. Make sure that the brake shoes are resting against their anchors. If the parking brake is preventing a brake shoe from contacting the anchor, adjust the length of the parking brake. (The cable adjustment mechanism can usually be found at some point on the cable.) Recheck the shoes.

8. Following the procedure outlined below, install the drum.

a. If the hub is part of the drum, be sure that the wheel bearing has been serviced.

(**NOTE**: For wheel bearing service, see Lesson 3 of Unit IV.)

b. Reinstall the wheel/tire assembly and torque the wheel nuts to specifications.

c. Using a service manual or other information source, locate a procedure for adjusting the parking brake. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the proce-

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

d. If drum brakes are being installed on the rear wheels, follow the above procedure and adjust the parking brake at this time. Follow the manufacturer's recommendations and procedures.

(CAUTION: Always check and refill the master cylinder after hydraulic brake components have been tested or serviced.)

(CAUTION: Always make sure the brake system is free of air after hydraulic system components have been tested or serviced.)

MODULE: BRAKES

UNIT VIII: DIAGNOSING AND REPAIRING POWER ASSISTED AND ANTILOCK BRAKE SYSTEMS

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and determine needed repairs on power assisted and anti-lock brake systems. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with power assisted brake systems (Competencies Y1-Y3, Unit VIII Test).

II. Identify different types of power brake systems (Competencies Y1-Y3, Part I of the Unit VIII Test).

III. Identify the operating principles of vacuum- and hydro-boost power brake systems (Competencies Y1-Y3, Part I of the Unit VIII Test).

IV. Identify the procedures for repairing power boosters (Competencies Y1-Y3, Part I of the Unit VIII Test).

V. Demonstrate the ability to:

   a. Remove and replace a vacuum power booster (Competency Y2, JS1-L1-UVIII).

   b. Test and replace a hydraulic power booster (Competency Y3, JS2-L1-UVIII).

Lesson 2.

I. Identify terms and definitions associated with anti-lock brake systems (Competency Y4, Part II of the Unit VIII Test).

II. Identify the three types of anti-lock brake systems used on automobiles (Competency Y4, Part II of the Unit VIII Test).

III. Identify the components of each type of the anti-lock brake system (Competency Y4, Part II of the Unit VIII Test).

IV. Identify the operating principles of each type of the anti-lock brake system (Competency Y4, Part II of the Unit VIII Test).

Lesson 3.

I. Identify the procedures for diagnosing anti-lock brake systems (Competency Y4, Par II of the Unit VIII Test).

II. Identify the procedures for repairing, replacing, and adjusting the anti-lock brake system (Competency Y4, Part II of the Unit VIII Test).

III. Demonstrate the ability to:

a. Diagnose the anti-lock brake system (Competency Y4, JS1-L3-UVIII).

b. Repair or replace the anti-lock brake system (Competency Y4, JS2-L3-UVIII).

MODULE: BRAKES

UNIT VIII: DIAGNOSING AND REPAIRING POWER ASSISTED AND ANTI-LOCK BRAKE SYSTEMS

CONTENTS OF THIS UNIT

MODULE: BRAKES

UNIT VIII: DIAGNOSING AND REPAIRING POWER ASSISTED AND ANTILOCK BRAKE SYSTEMS

LESSON 1: IDENTIFYING POWER BRAKE COMPONENTS AND THEIR REPAIR PROCEDURES

I. Terms and definitions

A. **Accumulator** — A chamber that holds a supply of fluid or gas under pressure.

B. **Atmospheric pressure** — The pressure created by the atmosphere. Approximately 14.7 psi.

C. **Check valve** — A valve that allows free flow of liquid in one direction while preventing it in the other.

D. **Diaphragm** — A flexible membrane (usually made of rubber), which reacts to different pressures while preventing pressures from interacting.

E. **Fire wall** — A bulkhead that separates the engine compartment from the passenger compartment.

F. **Intake manifold** — Part of the engine upon which the carburetor is mounted.

G. **Manifold vacuum** — A negative pressure within the intake manifold.

H. **Power assisted brake systems** — Brake systems which use pressure, other than that supplied by the driver, to assist in brake applications.

I. **Swaging** — A procedure by which a metal fitting is attached to a rubber hose. In swaging, the metal is crushed around the rubber.

J. **Vacuum** — A negative pressure. In a vacuum the pressure is less than the absolute atmospheric.

II. Vacuum- and hydro-boost power brake systems

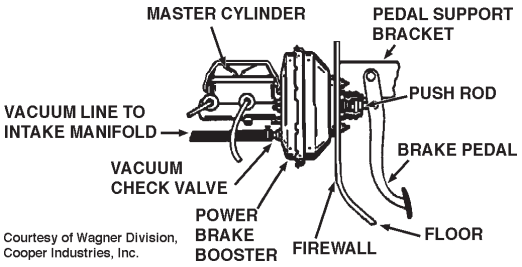
(**NOTE**: Vacuum-boost and hydro-boost are the two most common power brake systems found on modern automobiles. In most vehicles, the power assisted unit is located between the master cylinder and the fire wall. If the master cylinder is fastened directly to the fire wall, then the brake system is probably not power assisted.)

A. Vacuum-boost power brake systems

1. Vacuum-boost power brake systems use the difference between engine manifold vacuum and atmospheric pressure to provide power for brake applications.

   (**NOTE**: On engines that do not have high manifold vacuums, such as diesel and gasoline engines with high performance packages, a vacuum pump usually provides a vacuum for the power brake system.)

2. A vacuum assisted booster is usually a large round or circular unit. A single, large hose will be fastened to the booster by way of a plastic elbow unit, which often has a check valve. The hose leads from the booster to either a vacuum fitting on the intake manifold or to an engine-driven vacuum pump.

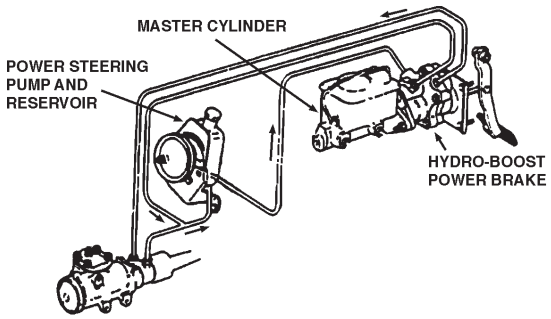


3. All vacuum brake boost systems must have a source of vacuum. Usually this is a manifold vacuum tap. Occasionally a vacuum pump is used. A hose or tube or a combination of the two will direct the vacuum to the booster. A check valve is often used to store vacuum in the booster. The check valve is normally found in the plastic elbow located on the booster itself.

B. Hydro-boost (hydraulic boosters) power brake systems

1. Hydro-boost power brake systems use a hydraulic pump to provide power for brake applications. Hydro-boost units are somewhat irregular in shape. Two hoses are attached to the power booster by metal fittings. (The metal fittings are either swaged or clamped to the hoses.) The hoses run from the booster to the power steering pump.

   (**NOTE**: In most vehicles, the power steering pump provides pressure for the power steering system.)



Courtesy of Wagner Division, Cooper Industries, Inc.

2. Like a vacuum booster, a hydro-booster applies force to the master cylinder push rod. The booster is also located between the master cylinder and the brake pedal, usually on the engine side of the fire wall. Components making up this system include the booster itself, a pump (usually the power steering pump), and the connecting hoses.

   (**NOTE**: Hydro-boosters are in no way connected to the hydraulic system that operates the brakes. Care must be taken to prevent the fluids from mixing between the brake and hydro-boost systems.)

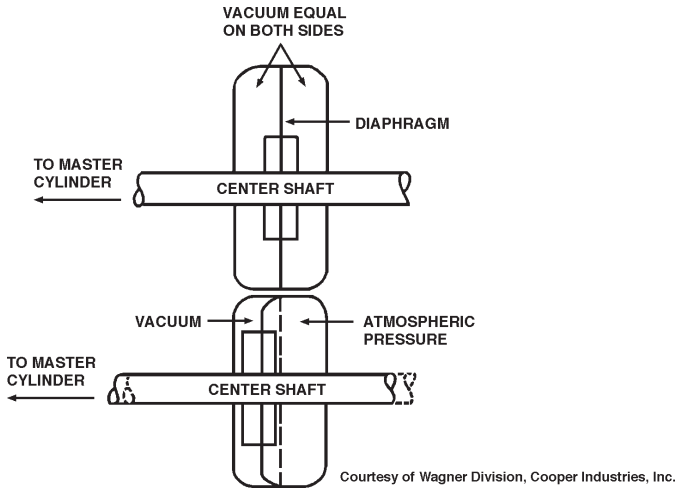
III. Operating principles of vacuum- and hydro-boost power brake systems

(**NOTE**: Brake components located between the master cylinder and the wheels are the same for both power brake and nonpower brake systems.)

A. The vacuum-boost power brake system

1. The vacuum booster receives power at anytime the engine is operating. There are two different types of vacuum boosters: vacuum suspended and atmospheric suspended. These two types of boosters are named for the manner in which their operating diaphragms are suspended when the boosters are at rest.

2. In vacuum suspended boosters, a vacuum is maintained on both sides of the diaphragm when the brakes are not applied. Upon brake application, atmospheric pressure is allowed to enter the chamber at the rear of the diaphragm. The resulting difference in pressure applies force to the brake master cylinder push rod.



3. In atmospheric suspended boosters, atmospheric pressure is maintained on both sides of the diaphragm when the brakes are not applied. Upon brake application, the manifold or vacuum pump creates a vacuum in the chamber in front of the diaphragm. The resulting difference in pressure applies force to the master cylinder push rod. When the brake pedal is depressed, a valve in the booster applies a vacuum to the master cylinder push rod.

4. In both vacuum and atmospheric suspended boosters, the check valve holds enough vacuum in the booster to apply the brakes several times after the engine stalls.

   (**NOTE**: If the power assisted system fails, the driver can still apply the brakes although greater effort will be required to do so.)

B. The hydro-boost brake system

1. The hydro-booster also receives power anytime the engine is operating. A pump (usually the power steering pump) circulates hydraulic fluid to the power booster, thus maintaining hydraulic pressure in the brake booster.

2. Upon brake application, a valve directs the circulation of hydraulic fluid from the pump to a piston, which, in turn, applies pressure to the brake master cylinder. When the brake pedal is released, the return port is opened and the pressure is returned to the power steering pump reservoir.

3. A spring-loaded accumulator holds a supply of pressurized hydraulic fluid, which will apply the brakes if the engine should stall. The accumulator holds enough fluid for several brake applications.

   (**NOTE**: If the power assisted system fails, the driver can still apply the brakes although greater effort will be required to do so.)

IV. Repairing power boosters

(**NOTE**: In power brake systems, almost all other brake components, with the exception of the booster, are serviced as they would be in a conventional brake system.)

A. Repairing a vacuum booster is a very complex task requiring special tools. Always consult the proper manual for the precise procedures. The cost of labor and parts usually dictates that a defective booster simply be replaced. If repairs are attempted, always make sure the necessary parts are available. Observe the below caution during repair.

(CAUTION: Vacuum boosters are assembled under heavy spring pressure. Any attempt to disassemble one of these boosters without the proper equipment and knowledge could result in personal injury and damage to the boosters.)

B. Most internal hydraulic booster components are unreplaceable because of their extremely tight fit. In most cases, a defective hydraulic booster is replaced rather than repaired. The booster can be disassembled for cleaning and certain parts can be replaced, however. When servicing a booster, always refer to the proper service manual and observe the below cautions.

(CAUTION: As was stated above, hydraulic boosters use an accumulator containing pressurized steering fluid. Before attempting repairs, deplete the pressure within the accumulator by applying and releasing the brake intermittently until no power boost is felt.)

(CAUTION: Do not attempt to disconnect any plumbing from a hydraulic booster unless detailed procedures are available. When disconnecting hoses, be sure that all pressure within the accumulator is depleted. Remove the power booster hose slowly, watching for evidence of pressure as the hose loosens. Expect the hose to contain pressure until absolutely certain that none is present.)

C. Power booster connecting parts

1. Replace any defective booster vacuum connections.

2. On power brake systems, the pedal push rod is usually adjusted at the rod.

3. Hydraulic hoses found to be leaking must be replaced.

JS1-L1-UVIII

MODULE: BRAKES

REMOVING AND REPLACING A VACUUM POWER BOOSTER

Equipment:

Hand tools
Safety glasses

Procedure:

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for testing a vacuum-boost power brake system. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, test the vacuum booster. Record observations.

3. Using a service manual or other information source, locate a procedure for removing and replacing a vacuum power booster. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove and replace the vacuum power booster.

JS2-L1-UVIII

MODULE: BRAKES

TESTING AND REPLACING A HYDRAULIC POWER BOOSTER

Equipment:

Hand tools
High pressure gauges
Safety glasses

Procedure:

1. Wear safety glasses while performing all of the procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for testing a hydro-boost power brake system. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, test the hydraulic booster. Record observations.

3. Using a service manual or other information source, locate a procedure for removing and replacing a hydraulic power booster. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove and replace the hydraulic power booster.

MODULE: BRAKES

UNIT VIII: ANTILOCK BRAKE SYSTEMS

LESSON 2: OVERVIEW OF ANTILOCK BRAKE SYSTEMS

I. Terms and definitions

A. **ABS** — Antilock brake systems.

B. **Braking distance** — The distance required to stop a vehicle at a given speed.

C. **CAB** — Controller Antilock Brake (Chrysler).

D. **EBCM** — Electronic Brake Control Module (GM).

E. **ECU** — Electronic Control Unit (GM).

F. **Electronic Control Unit** — A solid state electronic "box." The ECU interprets the voltages produced by the wheel sensors and sends the appropriate signal to the brake modulator. The brake modulator controls the brake application.

G. **4WAL** — Four wheel antilock brake system (GM).

H. **Hydroplaning** — A condition in which the vehicle's wheels ride on a layer of water on the road surface.

I. **Impending skid** — The point at which any increase in load on tire traction will produce tire skid.

J. **Isolation/dump valve** — Two valves which make up the control valve assembly. The isolation valve maintains brake pressure. The dump valve releases pressure into an accumulator.

K. **Modulator** — A device that changes pressures as required in the system.

L. **PSI** — Pounds per square inch (pressure).

M. **RWAL** — Rear wheel antilock system (GM).

N. **Speed sensor** — Electromagnetic device mounted to sense wheel or driveline speed..

O. **Tire adhesion** — The tire adherence (how well it sticks) to the surface it is being driven on.

P. **WSS** — Wheel speed sensor.

II. Overview of antilock brake systems

A. Antilock brake systems (ABS) help the driver to maintain control of his or her vehicle when braking. If wheels lock during braking, the vehicle may slide out of control. The antilock system prevents the brakes from being applied hard enough to lock the wheels.

B. In antilock brake systems, electronic sensors detect the signs of the lockup of individual wheels and modify brake application at the individual wheel accordingly. The antilock brake systems may modify brake applications very rapidly—up to fifteen times a second.

C. Antilock brake systems do not help maintain vehicle control during hydroplaning or radical steering maneuvers.

1. During hydroplaning, the vehicle's tires ride on a film of water and are thus separated from the road surface. Hydroplaning may cause the driver to lose control; hydroplaning cannot be corrected by antilock brakes.

2. Skids resulting from radical steering maneuvers or high-speed cornering cannot be prevented or corrected by antilock brakes.

D. Some antilock brake systems include traction assist systems. The traction assist system rapidly applies and releases brakes to reduce wheel spin and add traction during rapid acceleration.

III. Antilock brake system components

A. Antilock Brake Systems use many of the components of a conventional braking system. These components are listed below.

1. Brake booster

2. Master cylinder

3. Brake lines

4. Wheel cylinder/calipers

5. Brake drums or rotors and brake pads/shoes

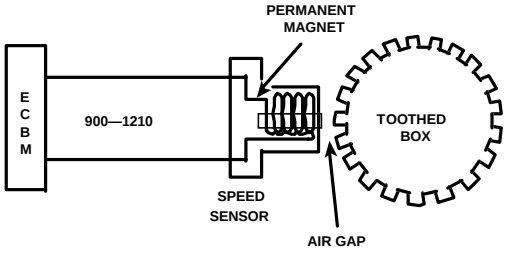
B. Antilock brake systems have a number of unique components that are classified as either speed sensors, controllers, or modulators.

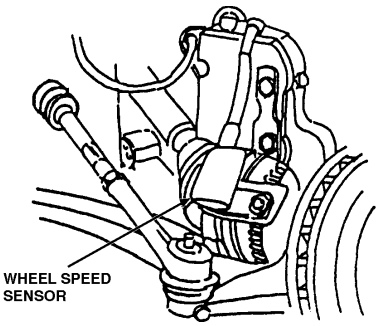
1. Speed sensor

a. As the toothed ring rotates, it induces a voltage in the pickup coils. As the wheel speed increases, so does the rotating speed of the toothed ring.

b. The voltage produced in the coil is proportional to the speed of the wheel. The electronic control unit senses this voltage.

c. Speed sensors are electromagnetic devices that determine wheel or drive line speed. The speed sensor includes a toothed ring and a magnetic pickup coil. The toothed ring is mounted on a rotating component. The magnetic pickup coil is stationary and is mounted close to the rotating toothed ring.





2. Brake modulators

a. Brake modulators are the key components of the system.

b. The most basic brake modulator control valve is two valves in one: a dump/decay valve and an isolation/build valve.

3. Controllers

a. The electronic control module (ECM) controls the dump/decay valve and the isolation/build valve (both of which make up the control valve). The ECM causes the control valve assembly to either maintain the same amount of hydraulic pressure, release hydraulic pressure through the dump valve, or increase brake pressure.

b. The electronic control module has a number of different names including ECU (Electronic Control Unit), ABCM (Antilock Brake Control Module), EBCM (Electronic Brake Control Module), CAB (Controller Antilock Brake).

c. Essentially a microcomputer, the ECM receives signals from the speed sensors. When a wheel speed sensor indicates an impending skid, the ECM closes a valve. When the valve closes, fluid is prevented from coming into the braking circuit, thus preventing the problem wheel from decelerating further.

d. The ECM then analyzes sensor signals from the problem wheel once again. If that wheel continues to decelerate, the ECM opens the dump valve and releases whatever pressure is trapped in the brake circuit. This again prevents further deceleration.

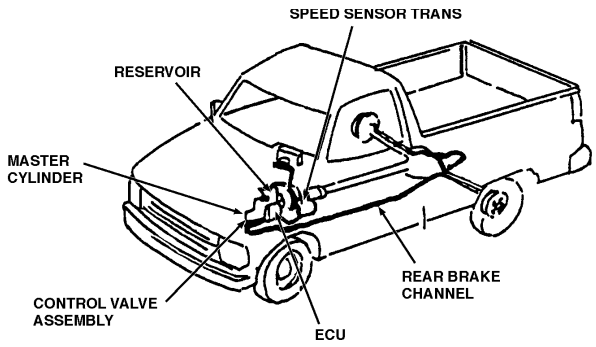
e. Once the problem wheel regains an acceptable speed, the ECM returns the valves to their normal position. Once in their normal position, fluid flow returns to the problem wheel's brake.

f. The ECM also monitors the electromechanical components of the system. Should a problem with the electromechanical components arise, the ECM will close down all or part of the system.

(**NOTE:** Even when the antilock system is closed down, normal power assisted braking remains. A warning light , usually located in the instrument panel, indicates problems.)

IV. Variations in the antilock brake system design

A. Most antilock brake systems are designed for all four wheels. Some systems, such as GM's RWAL system, are designed for the rear wheels only.



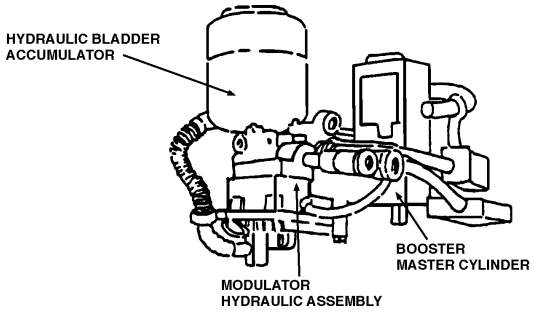
1. The RWAL uses an antilock pressure valve located under the master cylinder to regulate rear hydraulic brake line pressure.

2. The antilock pressure valve is two different valves in a single assembly: a dump valve, which relieves rear brake pressure, and an isolation valve, which maintains rear brake pressure. The valve is controlled by a microprocessor in the electric brake control module, which is usually mounted next to the master cylinder valve.

3. During hard brake application, the control module causes the valve to perform one of three functions: the module will allow the valve to maintain its current level of hydraulic pressure; the module causes the dump valve to release hydraulic pressure; or the module pulses the isolation valve to increase hydraulic pressure.

4. A vehicle speed sensor (VSS), which is located in the transmission or rear axle housing, sends signals to the control module.

B. Some antilock systems are characterized by the way in which their components are arranged. Some systems use an integral hydraulic assembly. The integral assembly is a compact unit that consists of a booster/master cylinder, modulator, hydraulic bladder accumulator, fluid reservoir and, in some applications, an electrohydraulic pump.



1. The Teves Mark II system, used by both Ford and GM cars, is made up of one common integral hydraulic assembly.

2. In the Teves Mark II system, an electrohydraulic pump delivers brake fluid under high pressure (2000 to 2600 psi) to the accumulator.

3. The accumulator acts as a holding tank for the pressurized fluid. The accumulator provides the booster with the necessary hydraulic pressure for normal power assist. The accumulator supplies the rear brake circuit with hydraulic pressure during both conventional and antilock braking.

4. If the pump fails, the accumulator holds enough pressurized fluid to provide up to 20 power assisted stops. The accumulator, therefore, acts as a kind of safety device.

5. The Teves controller monitors, compares, and analyzes the input from four wheel speed sensors. If one wheel is decelerating more quickly than the others, the controller will release pressure at the wheel (the problem wheel).

6. If a wheel increases in speed too quickly, the controller reopens the inlet valve. This causes accumulator pressure to apply the brakes. This process happens up to 15 times a second.

C. Some antilock brake systems use the nonintegral system design. Because it uses the conventional master cylinder and power booster, the nonintegral system can be easily added on to a vehicle's brake system, thus making it much cheaper to produce and install than integral systems.

1. The Bosch II nonintegral system, used by GM and several imports, functions somewhat differently from the integral type of system. The Bosch II nonintegral system contains solenoid-operated, three-positioned, spring-loaded valves to control each brake circuit.

2. During normal power-assisted braking, these valves remain open, allowing brake fluid to pass through on its way to the calipers and wheel cylinders.

3. When hard braking occurs, the controller will sense if one wheel is decelerating more quickly than the others. The controller then moves the valve into its second position. This cuts off the pressure from the master cylinder and holds pressure constant in the brake circuit to the caliper or wheel cylinder.

4. If the wheel is still slowing down too fast, the controller moves the valve to its third position. This releases pressure from the brake circuit and allows the fluid to flow to a return pump, which is used to move the fluid back to the master cylinder. If the wheel speeds up too much, the controller reopens the valve, allowing fluid pressure from the master cylinder back into the brake circuit. The hold-release-apply cycle occurs four to ten times per second.

V. Some vehicle manufacturers tailor antilock brake systems to meet their specific needs.

A. Corvettes use nonintegral systems in which a lateral acceleration signal indicates to the ABS controller that the vehicle's rear wheels are turning too fast. The controller modifies antilock operation to keep the rear tires from skidding.

B. Some Toyotas use a deceleration sensor and a vehicle speed sensor to modify antilock operation.

C. Some antilock brake systems are three-channel or four-channel systems.

1. Three-channel systems control the front wheels independently while the rear brakes are controlled on a common circuit. Three-channel systems may have a speed sensor at each wheel or have one for each front wheel and a third on the driveline to monitor the rear wheels as a pair.

2. Four-channel systems require speed sensors for each wheel and thus control each wheel independently.

(**NOTE**: The Bosch system has built-in diagnostic capabilities in its computer. Diagnosis of the system is relatively simple, but repairs and adjustment require an appropriate service manual and special diagnostic equipment.)

C. Consider the below information when repairing, replacing, and adjusting the Lucas-Gerling antilock brake system.

1. The Lucas-Gerling antilock brake system uses no electronic or electrical units. All hydraulic components in this system are the same as those found in a brake system that are not equipped with an antilock system.

2. A failure in the Lucas-Gerling system will cause the front wheels to lock up during heavy brake applications. A system failure will not, however, affect rear wheel braking. In vehicles equipped with the Lucas-Gerling system, conventional proportioning valves are used to control rear wheel brake applications.

3. Front-rear split brake systems equipped with the Lucas-Gerling system use one proportioning valve. In a diagonally split system, two proportioning valves are required.

4. In vehicles using the Lucas-Gerling system, the front wheels are not interconnected. A modulator failure in the Lucas-Gerling system will, therefore, affect only one front wheel (the single wheel will be affected consistently, however).

5. Drive belts and pulleys will be the source of most of the problems in the Lucas-Gerling system. The brake technician should thoroughly inspect the drive belts and pulleys. All of the conventional sources of brake system problems should be considered before judging the Lucas-Gerling modulator to be defective.

6. Replacement of the modulator is usually less expensive than repair. Replacement procedures can be obtained from the proper service manual and are relatively simple.

MODULE: BRAKES

UNIT VIII: ANTILOCK BRAKE SYSTEMS

LESSON 3: SERVICE PROCEDURES FOR ANTILOCK BRAKE SYSTEMS

I. Terms and definitions

A. **Air gap** — The distance between the toothed wheel and speed sensor.

B. **Brake bleeding** — A procedure which allows air to be drained from brake systems.

C. **Breakout box** — A tool used to preform a series of pin-out checks on various circuits. The breakout box is connected between the ECM and harness.

D. **DVOM** — Digital volt ohmmeter.

(**NOTE:** A meter with a 10 megohm or greater impedance must be used to protect delicate electronic curcuitry.)

E. **Flow charts** — Checklists and schematics that give step-by-step procedures for locating a malfunction.

F. **Scan tool** — Electronic tool that connects to the vehicle's ALDL and receives and interprets computer signals.

G. **Trouble codes (sometime called fault codes)** — Numbers generated by the diagnostic (self-test) programs. These code numbers refer to certain flow charts which help to lead the technician to the faulty component.

II. Characteristics unique to ABS

A. In most cases, the pads, shoes, drums, rotors, mounting hardware, and bearings on antilock brake systems will be serviced in the same manner as on conventional brake systems.

B. Many antilock brake system problems are caused by speed sensor air gaps that are out of specification or electrical connections that are loose or corroded.

III. Use extra care when working on or around antilock brake system speed sensors and other electrical components. Listed below are general precautions that must be observed when servicing the ABS. Failure to observe these precautions may result in damage to the antilock brake system and personal injury.

A. If electric are welding equipment is used on the vehicle with antilock brake systems, the battery and ECM should be disconnected.

B. Antilock brake systems operate at very high pressures. The accumulator should always be depressurized before the antilock brake system is serviced.

C. To protect the control module, never disconnect or connect any antilock brake system connector while the ignition switch is on.

D. The antilock brake system operates at very low system voltages; therefore, a conventional 12-volt test light should never be used to probe circuits. A conventional 12-volt test light can damage the antilock components. Therefore, a DVOM is used to probe circuits.

E. Many components of the antilock brake system are not serviceable and must be replaced as an assembly. Do not disasemble any antilock brake system component that is not designed to be serviced.

F. Brake fluid will damage painted surfaces. If brake fluid is spilled on any painted surface, wash it off with water immediately.

G. Some brake parts contain asbestos fibers that can become airborne in the form of dust during brake service. Breathing asbestos fibers can seriously damage one's health.

(CAUTION: Asbestos is a cancer-causing substance. Do not breathe asbestos dust or allow it to escape into the air.)

H. When working with wiring on an antilock braking system, never touch the electrical connections and pins. Also never allow them to contact brake fluid. This kind of contact will damage the ECM.

I. Be sure to follow service manual instructions carefully. Use only the proper service information for the vehicle to be serviced. Following the wrong sequence of service steps, skipping steps, or using the wrong information will lead to unnecessary replacement of parts.

J. Before test driving a vehicle with a brake problem, test the brakes at low speed to be sure that the car will stop normally.

K. There is no one bleeding procedure that applies to all antilock brake systems. Procedures vary greatly from system to system. To bleed a vehicle with an ABS, follow the manufacturer's specific bleeding method for the vehicle being serviced.

IV. To the inexperienced diagnostician, some types of antilock brake system functions may seem to be a sign of a problem when actually they are normal.

A. Some ABS equipped vehicles have "BITE", which stands for "Built In Test Equipment." BITE is activated when the vehicle is started or after it reaches a designated speed.

1. BITE produces a short series of clicking, popping, groaning, or growling sounds. These noises are made by the antilock system as it is tested by the computer.

2. These noises are also produced during antilock stops.

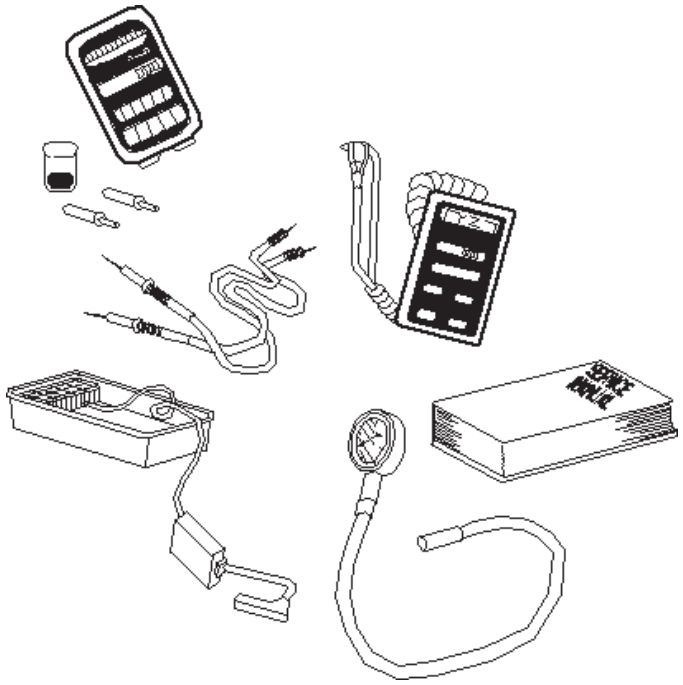
B. Brake pedal pulsation is often a sign of warped rotors or out of round drums. On some antilock systems, however, pedal pulsation is a normal occurrence during antilock braking. In some antilock brake systems,, brake pedal pulsation occurs when the brakes are applied and released very rapidly.

C. In other antilock brake systems, the pedal may drop slightly during antilock braking. This occurs as the accumulator relieves hydraulic pressure by temporarily taking fluid out of the hydraulic system.

V. Diagnosing antilock brake systems

(**NOTE:** Procedures for diagnosing problems in antilock brake systems vary greatly depending on the system in question. Though some antilock brake systems may appear identical, follow only the diagnostic and service procedures recommended by the specific manufacturers of the system.)

(**NOTE:** Service on most antilock brake systems require a high impedance DVOM, a set of pressure gauges, a scan tool with the proper software, and breakout box. Other special tools may be required.)



A. Diagnosis of an antilock brake system should begin with a thorough visual inspection of the entire system.

1. Check the brake fluid level.

2. Check the system fuse(s).

3. Check all the system's electrical connections.

   a. Make sure ground connections are tight and corrosion free and hydraulic lines and connections are in good condition.

   b. Check diodes in the system's wiring harnesses. Refer to the appropriate service manual for diode location and test procedures.

B. If the visual inspection reveals no problems, consult the proper service manual for more detailed procedures.

   1. Some systems may require that a breakout box be used to perform pin-out checks.

   2. Some systems may require that electronic trouble codes stored in the ECM be accessed via a scan tool.

   3. Some systems may require that flash codes be read in the form of flashes from the system warning light.
   4. Most manufacturer's manuals provide flow charts to help precisely identify system problems.

VI. Procedures for diagnosing intermittent antilock brake system problems.

(**NOTE:** Standard diagnostic procedures may not be helpful in determining the cause of intermittent electrical problems in the antilock brake systems. In most cases, the fault must be present to locate the problem using a diagnosis chart. Most intermittent problems are caused by faulty electrical connections or wiring. Listed below are things to look for if an antilock brake system has problems.)

(**NOTE:** The below procedures are general in nature. Always consult the proper service manual and follow all recommended cautions and procedures before conducting any diagnosis.)

A. Make sure connector halves are not poorly mated or that terminals are not fully seated in the connector body.

B. Check for improperly formed or damaged terminals. All connector terminals in a problem circuit should be carefully reformed to increase electrical contact.

C. Make sure there are no poor terminal-to-wire connections. Remove the terminal from the connector body to inspect it.

D. If the visual check does not find the cause of the problem, test drive the vehicle and try to duplicate the condition.

   (CAUTION: Always obtain permission from the instructor before test driving a vehicle, and test for braking before moving the vehicle!)

VII. Servicing of individual antilock brake system components.

A. Servicing speed sensors

1. Visually inspect the speed sensors.

a. Check the toothed wheel for missing or broken teeth. The toothed wheel should show no evidence of contact with the wheel speed sensor. If contact was made, determine the cause and correct it.

b. Check the toothed wheel for excessive run out. Excessive run out can cause erratic wheel speed signals. Replace the assembly if run out exceeds manufacturer's specifications.
(**NOTE:** Not all speed sensor air gaps are adjustable. Most new sensors come with a paper spacer to gauge the air gap. However, when checking or readjusting a speed sensor, use a nonmetallic feeler gauge. Take great care during speed sensor replacement. Proper installation of sensor cables is critical to continued system operation.)

(**NOTE:** If cables are not correctly installed in their retainers, they may contact moving parts and/or become overextended. This may create an open circuit. In addition, if sensor cables are routed incorrectly, false voltage signals may be induced by other conductors positioned too close to sensor cables.)

2. For antilock brake systems to function correctly, the vehicle's wheels and tires must all be the proper size and type. Use only the tire size recommended by the manufacturer. Tire size is important because antilock brake systems operate according to wheel speed signals. Inaccurate signals may result from improper wheel and tire size or improper inflation pressures.

B. Electronic control modules

(**NOTE:** Electronic control modules are not serviceable. If defective, they must be replaced. Some service procedures, however, involve the ECM.)

1. Service precautions regarding the ECM.

a. When testing for open or short circuits, never ground or apply voltage to any of the circuits unless the appropriate service information specifically instructs that this be done.

b. Never pierce connectors or wires. Doing so will break the seal, resulting in a poor connection.

c. Never apply or cut off power to a control module while the ignition is in the "on" position.

d. Interchanging ECMs from one vehicle to another may change braking distance, thus making the vehicle unsafe. When replacing, use only components specifically recommended by the manufacturer.

2. Accessing electronic control module memory

a. Antilock brake systems with self-diagnostic capabilities store trouble codes in a nonvolatile memory.

b. The electronic control module cannot recognize all system problems and failures. If memory codes or service codes cannot lead to a diagnosis, other procedures must be taken.

c. In addition, the electronic control module cannot store a service code if the module is receiving no power.

(**NOTE**: When servicing some antilock brake systems, the technician must erase the trouble codes from the ECM memory after making repairs. In other systems, the codes are erased automatically.)

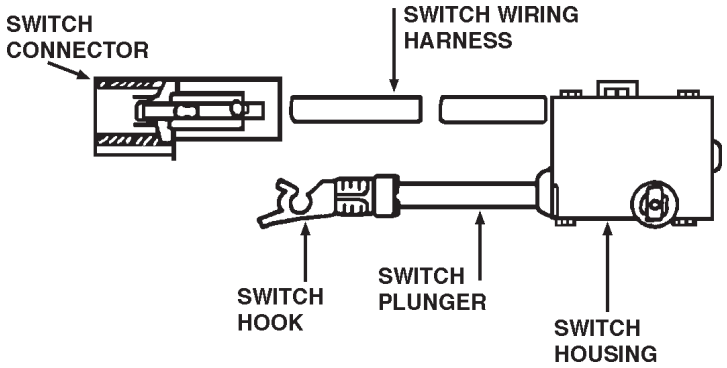
C. The role of antilock brake system warning lamps in brake system service

1. Many antilock brake systems use two lights, one marked BRAKE to signal problems in the normal brake system. The second light signals problems in the antilock system.

2. To trace a problem to specific components, the technician can perform a warning lamp sequence test while observing when the lamps light or count the blinks of the warning lamp.

D. Servicing a brake pedal travel switch

1. The brake pedal travel switch monitors pedal position. The switch relays this information to the electronic control module. If the pedal travel switch is not adjusted properly or is not electrically connected, the pedal will not feel right.

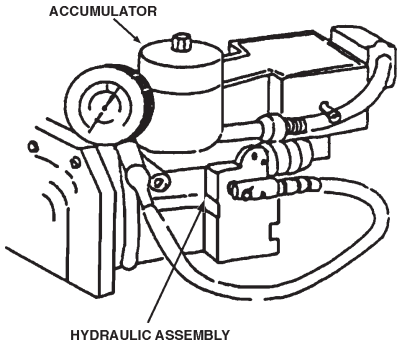


2. Most problems with the switch will cause the pump to run during the entire ABS stop. During this time, the pedal will become very firm, pushing up the driver's foot.

E. Hydraulic assembly

1. The hydraulic unit involves several different components. When a problem develops in one of these components, the parts involved can sometimes be disassembled and repaired or replaced.

   (CAUTION: Some hydraulic assemblies are not serviceable and must be replaced when any of their components fail. Never disassemble any unit or component that has been identified as nonserviceable by the manufacturer.)



2. During many hydraulic assembly tests, brake lines may have to be disconnected in order to connect a pressure testing gauge.

   (CAUTION: The hydraulic accumulator must be depressurized before disconnecting any hydraulic tube or fitting. Failure to depressurize the accumulator may result in personal injury and/or damage to painted surfaces.)

3. One procedure used on some antilock brake systems to depressurize the brake system requires the ignition switch to be turned off or a battery cable to be disconnected. Then the brake pedal should be pumped a minimum of 40 times. A noticeable change in pedal feel will occur when the accumulator is discharged.

   (**NOTE:** The ABS pump/motor assembly will keep the accumulator charged to a pressure of up to 2600 pounds any time the ignition is in the on position. Care must be taken not to turn the ignition on at any time a brake line is disconnected.)

JS1-L3-UVIII

MODULE: BRAKES

DIAGNOSING THE ANTI-LOCK BRAKE SYSTEM

Equipment:

Common mechanic's hand tools
Special test equipment as required
Safety glasses

Procedure:

1. Wear safety glasses while performing all of the procedures on this job sheet.

2. Mske a general visual inspection of the antilock brake system. Make sure the inspection includes the following checks:

   a. Using a service manual or other information source, locate a procedure for performing a hydraulic assembly test on the antilock brake system as necessary. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, perform hydraulic assembly test as needed. Record observations.

   b. Make sure the vehicle's wheels and tires are all the correct size and type and only the manufacturer's recommended tire size is used.

   c. Check the system's fuse)s). Record observations.

   d. Check all the system's electrical connections. Record observations.

e. Mase sure ground connections are tight and corrosion free and hydraulic lines and connections are in good condition. Record observations.

3. If problems with speed sensors are suspected, make the following checks.

a. Using a service manual or other information source, locate a procedure for inspecting a speed sensor on an antilock brake system as necessary. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, remove and replace the hydraulic power booster.

b. Check the toothed wheel for missing or broken teeth. The toothed wheel should show no evidence of contact with the wheel speed sensor. Record observations and recommend corrective procedures.

c. Check the toothed wheel for excessive run out. Excessive run out can cause erratic wheel speed signal. Record observations and recommend corrective procedures.

(**NOTE:** Not all speed sensor air gaps are adjustable, and most new sensors come with a paper spacer to gauge the air gap. However, when checking or readjusting a speed sensor, a nonmetallic feeler gauge should be used. Care must be taken when replacing speed sensors. Proper installation of sensor cables is critical to continued system operation.

(**NOTE:** Failure to install cables in their retainers may result in contact with moving parts and/or over-extension of the cables, resulting in an open circuit. In addition, incorrect routing of sensor cable can result in false signals due to induced voltages from other conductors positioned too close to sensor cables.)

4. Using a service manual or other information source, locate a procedure for diagnosing a brake pedal travel switch on an antilock brake system as necessary. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, inspect brake pedal travel switch if it is suspected of having problems.

   (**NOTE:** Not all antilock brake systems have a brake pedal travel switch.

5. Using a service manual or other information source, locate a procedure for diagnosing the antilock brake system beyond routine visual inspections. This will likely include accesing touble codes via a scan tool. Make sure the procedure includes all cautions and safety considerations regarding trouble code access. Also include any other advanced diagnostic procedures unique to the system being serviced. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   a. Following the procedure, access and interpret antilock brake system trouble shooting codes or perform other advances diagnostic procedures. List codes and their interpretations below. List any other appropriate diagnostic information. Also state the system problem as clearly as possible. (List information on the back of this job sheet or on an extra sheet of paper as necessary).

JS2-L3-UVIII

MODULE: BRAKES

REPAIRING OR REPLACING THE ANTI-LOCK BRAKE SYSTEM

Equipment:

Common mechanic's hand tools
Special test equipment as required
Safety glasses

Procedure:

1. Wear safety glasses while performing all the procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for repairing or correcting any antilock brake system problems diagnosed in JS1-L3-UVIII. Make sure the procedure includes all cautions, and the necessary tools and equipment needed to deal with the specific problem(s) diagnosed. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor check the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ Instructor Approved

   Following the procedure, repair or correct these problems.

   (CAUTION: Repairing anti-lock brakes is a very complex task. The information below consists primarily of considerations to be taken when making such repairs. Always consult the proper service manuals for the precise repair procedures. Improper repair of an anti-lock system could result in brake failure. Repair anti-lock brakes only after receiving the instructor's approval.)

   (CAUTION: Always obtain the instructor's approval before test driving the vehicle.)

   (**NOTE**: Consult with the instructor when determining whether to repair or replace the anti-lock brake system.)