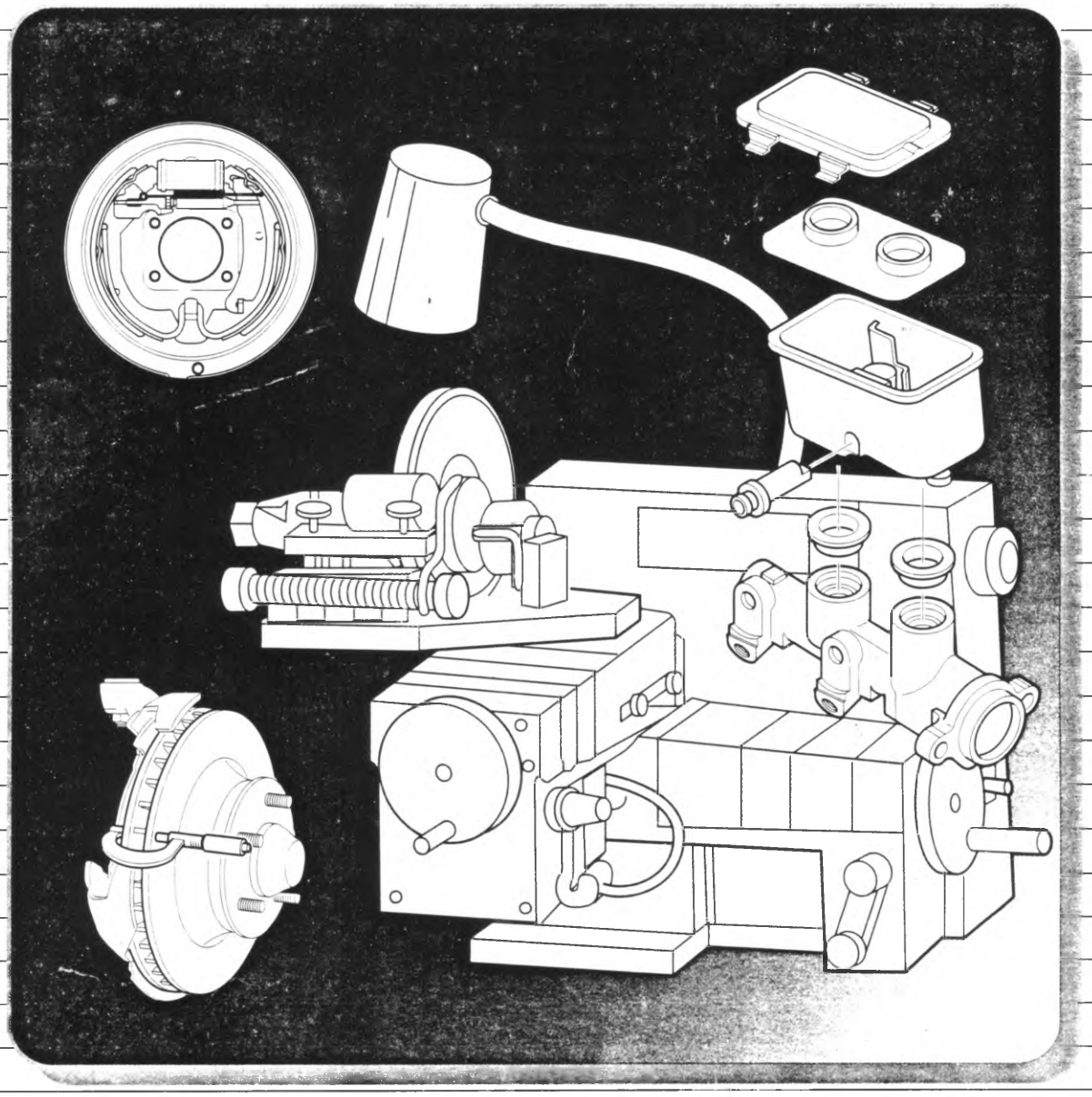
Base Brake Systems



GM STG

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Foreword

This manual contains information about diagnosing and servicing the items related to the Base Brake System. Always refer to the applicable vehicle service manual and appropriate Dealer Technical Service Bulletins for additional information regarding system operation and diagnostic/repair procedures.

When this manual refers to a brand name, a number or a specific tool, you may use an equivalent product in place of the recommended item.

All information, illustrations and specifications in this manual are based on the latest product information available at the time of publication approval. General Motors reserves the right to make changes, at any time, without notice.

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Table of Contents

Notes:

1. Introduction

Objectives

After completing this section, the student will be able to:

- Explain the meaning of special information and abbreviations used in this booklet
- Identify the base brake system from the Regular Production Option (RPO) codes
- Identify and locate base brake components on the vehicle
- Describe brake system operation
- Describe brake system functions
- Describe the variations in the different types of braking systems
- Describe hydraulic theory and how it applies to base brakes
- Identify special tools and their function
- Identify recommended brake fluid types

Introduction

This handout gives you an overview of base brake components. It includes nine main sections:

1. Introduction
2. Apply System
3. Power Brake Boosters
4. Hydralic System
5. Drum Brakes
6. Disc Brakes
7. Balance Control Systems
8. Warning Systems
9. General Brake Diagnosis

Service Manual References

Refer to the appropriate service information for vehicle specific troubleshooting sequences, checklists, system diagrams and service procedures.

- Hydraulic Brakes
- Disc Brakes
- Drum Brakes
- Parking Brake
- Antilock Brake System

Regardless of what service information or manual is used, the following topics can always be found in the table of contents:

- Description/Operation
- Diagnostic Procedures
- Repair Instructions
- Special Tools
- Specifications

Special Information and Abbreviations

Throughout this handout, you will see special information as follows:

- **IMPORTANT**—indicates information that deserves special attention. This information clarifies important points and exceptions
- **NOTICE**—indicates the potential for vehicle or service equipment damage unless specific steps are followed
- **CAUTION**—indicates the potential for personal injury. For your own safety, please read these reminders carefully

Abbreviations used to describe system components and operation include:

- ABS: Antilock Brake System
- ID: Inside Diameter
- in.: inch
- kPa: kilopascals
- mm: millimeters
- mph: miles per hour
- OD: Outside Diameter
- psi: pounds per square inch
- RBWL: Red BRAKE Warning Lamp
- RA: Roughness Analysis
- BTSI: Brake Transmission Shift Interlock
- ISO: International Standards Organization

Base Brake Introduction

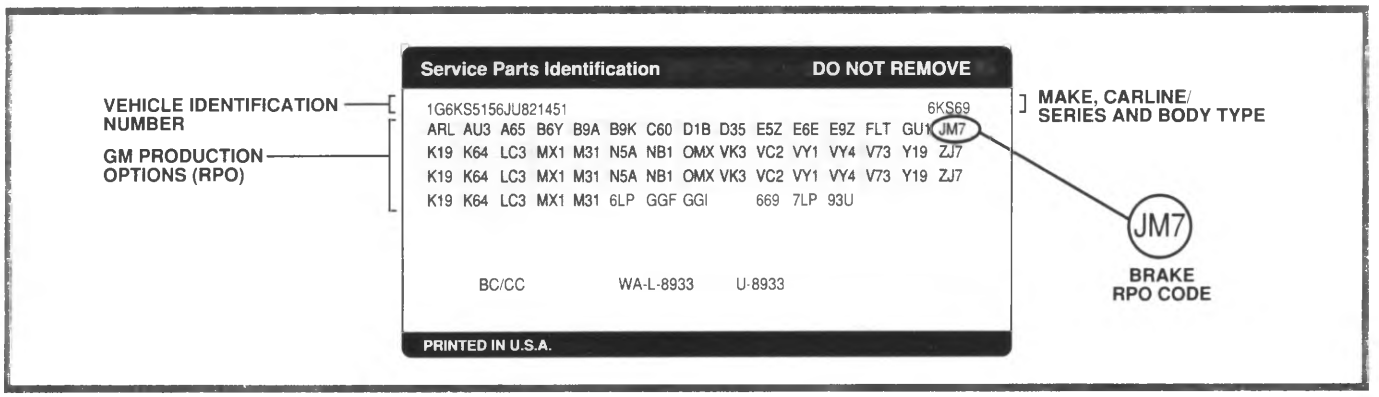


Figure 1-1, **Regular Production Option (RPO) Codes**

Option Codes

The service parts identification label helps dealership personnel identify vehicle options and accessories. Vehicle options are identified on the service parts identification label by the Regular Production Option (RPO) codes (figure 1-1). The option codes are three-digit combinations of letters and numbers. “J” options provide brake types installed during production. The “J” option information may be needed to distinguish the correct parts to use during service.

Base brake components are the parts of the brake system found on all vehicles (figure 1-2). The term "base brakes" does not include antilock brakes or traction control systems.

Base brake components include:

- Brake pedal, pedal linkage, and parking brake
- Power brake boost system
- Master cylinder
- Cables, hoses and pipes
- Brake rotors and pads
- Brake drums and shoes
- Brake balance controls (proportioning valve and metering valve), if equipped
- Red BRAKE Warning Lamp (RBWL) and other warning systems

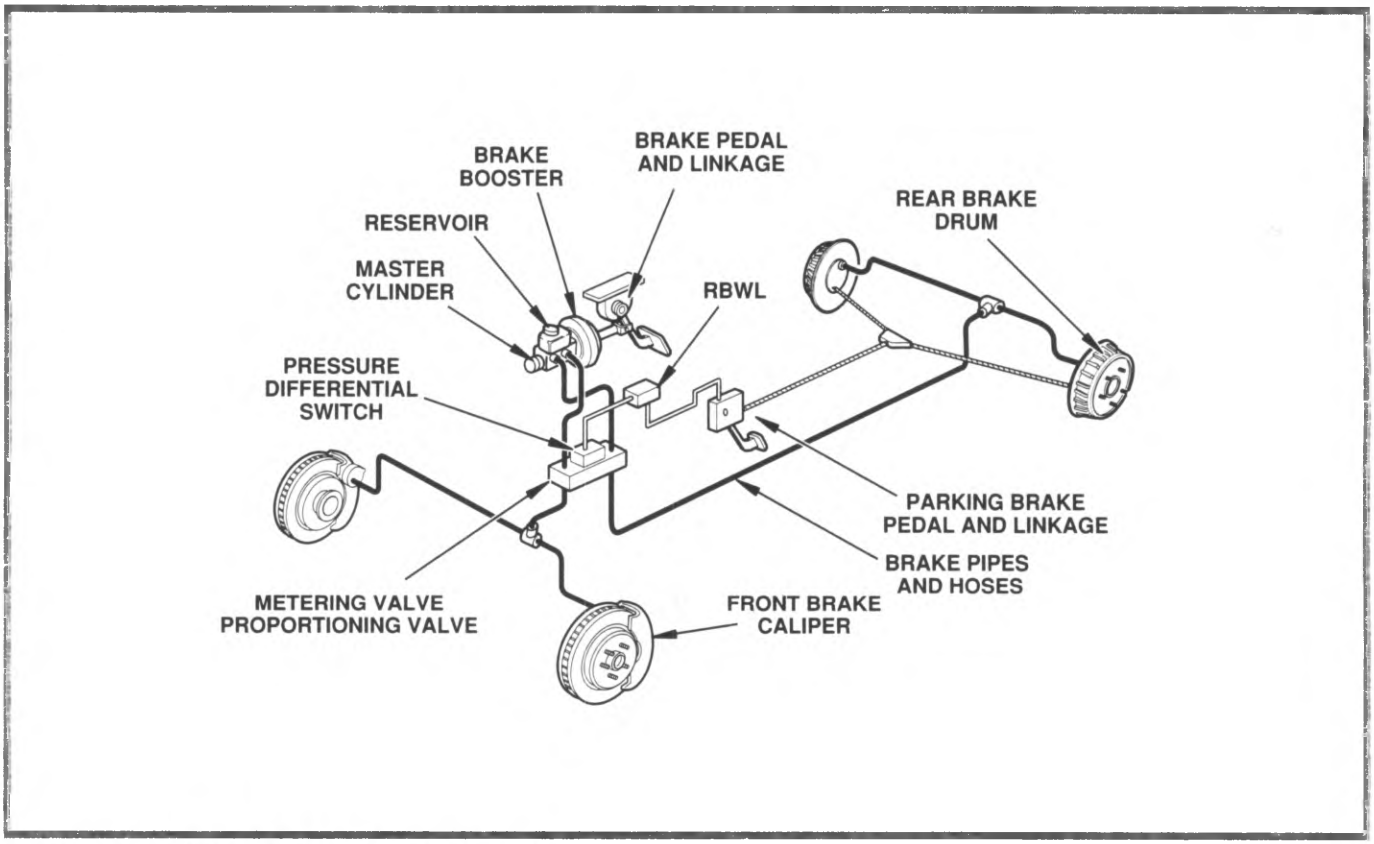


Figure 1-2, **Base Brake Components**

Brake System Operation

Brakes slow and stop a vehicle by transforming kinetic (motion) energy into heat (brake) energy. The brake linings contacting the drum/rotor use friction to convert motion energy to heat energy. The intensity of the heat is proportional to the vehicle speed and the quickness of the stop. Faster speeds and quicker stops equal more heat.

Today's high performance hydraulic brake systems are a result of years of design and component improvements.

Brake System Functions

The brake system includes components in several different sub-systems (figure 1-3):

- Apply system
- Boost system
- Hydraulic system
- Wheel brakes
- Balance control system
- Warning system

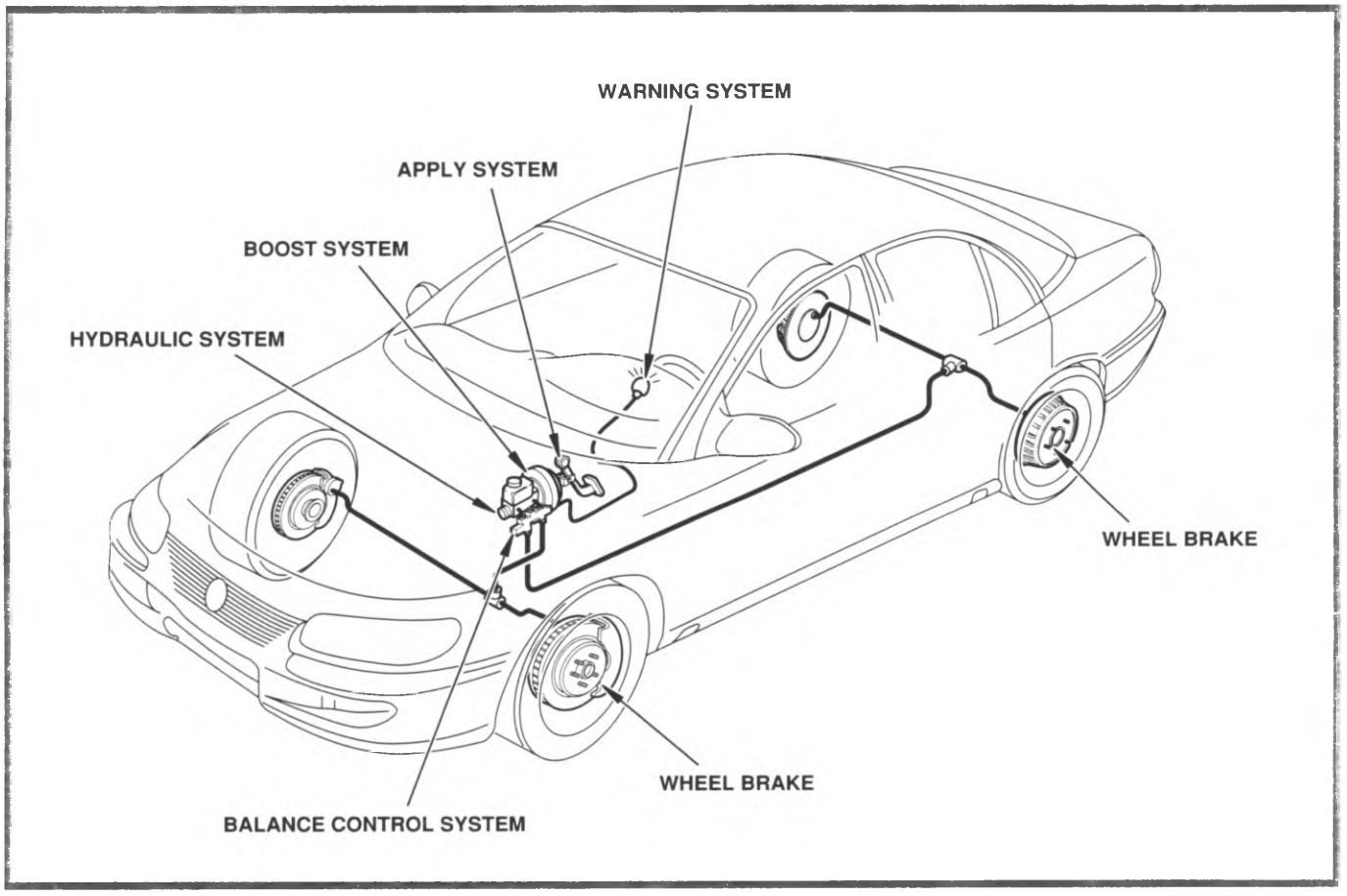


Figure 1-3, **Base Brake Sub-Systems**

1. Introduction

Stopping a vehicle requires that all brake sub-systems act together (see figure 1-3).

1. The driver presses the brake pedal, operating the pedal linkage (apply system).
2. The brake booster (if equipped) increases the brake pedal force (boost system).
3. The pedal force moves the pistons in the master cylinder, forcing out pressurized brake fluid (hydraulic system). The brake fluid is directed through pipes and hoses to the wheel brakes.
4. At the wheel, the pressurized brake fluid moves pistons. The pistons press brake friction material against a spinning rotor or drum, slowing the vehicle (wheel brakes).
5. Hydraulic and mechanical valves ensure that brakes apply quickly, simultaneously and at balanced pressure for safest operation (balance control system).
6. An instrument panel lamp signals the driver of brake system failure (warning system).

Because of innovations in materials and technology, there is a wide variety of components specific to each of these base brake component systems. This handout discusses the theory and operation of the components most common on General Motors vehicles.

Types of Braking Systems

This handout includes theory, diagnosis, and service information about several variations of brake system components:

- Drum brake: leading-trailing, advance leading-trailing and duo-servo types
- Front disc brake: single-piston and dual-piston calipers
- Rear disc brake with integral and non-integral parking brakes
- Power booster: single-diaphragm and dual-diaphragm vacuum booster, hydraulic booster

Front-to-Rear Split Hydraulic System

A typical front-to-rear split hydraulic system is shown in figure 1-4. The master cylinder is connected through the combination valve to the wheel circuits. One master cylinder outlet is connected to the front brakes, the other to the rear brakes. This type of system is typically found on rear wheel drive vehicles.

If either system fails, the other remains unaffected.

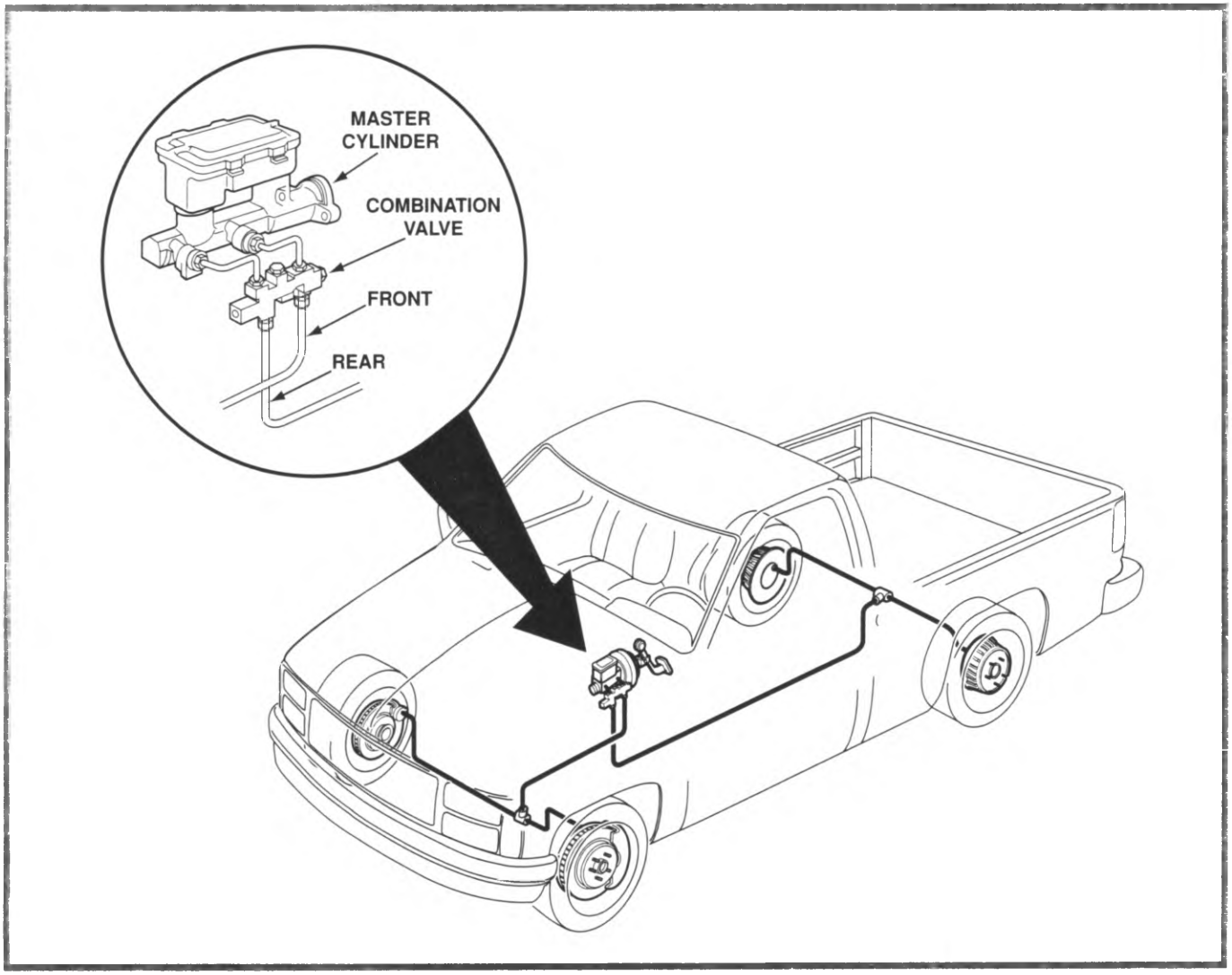


Figure 1-4, **Front-to-Rear Split Hydraulic System**

Diagonal Split Hydraulic System

Due to vehicle weight distribution, most front wheel drive vehicles utilize a diagonally split design. In the diagonal split hydraulic system, diagonally opposite wheels share a hydraulic circuit (figure 1-5).

- Left-front (LF) and right-rear (RR) brakes are connected to one channel of the master cylinder
- Right-front (RF) and left-rear brakes (LR) are connected to the other channel of the master cylinder

Proportioning valves are installed in the master cylinder circuits to the rear brakes to maintain the proper front to rear pressure balance.

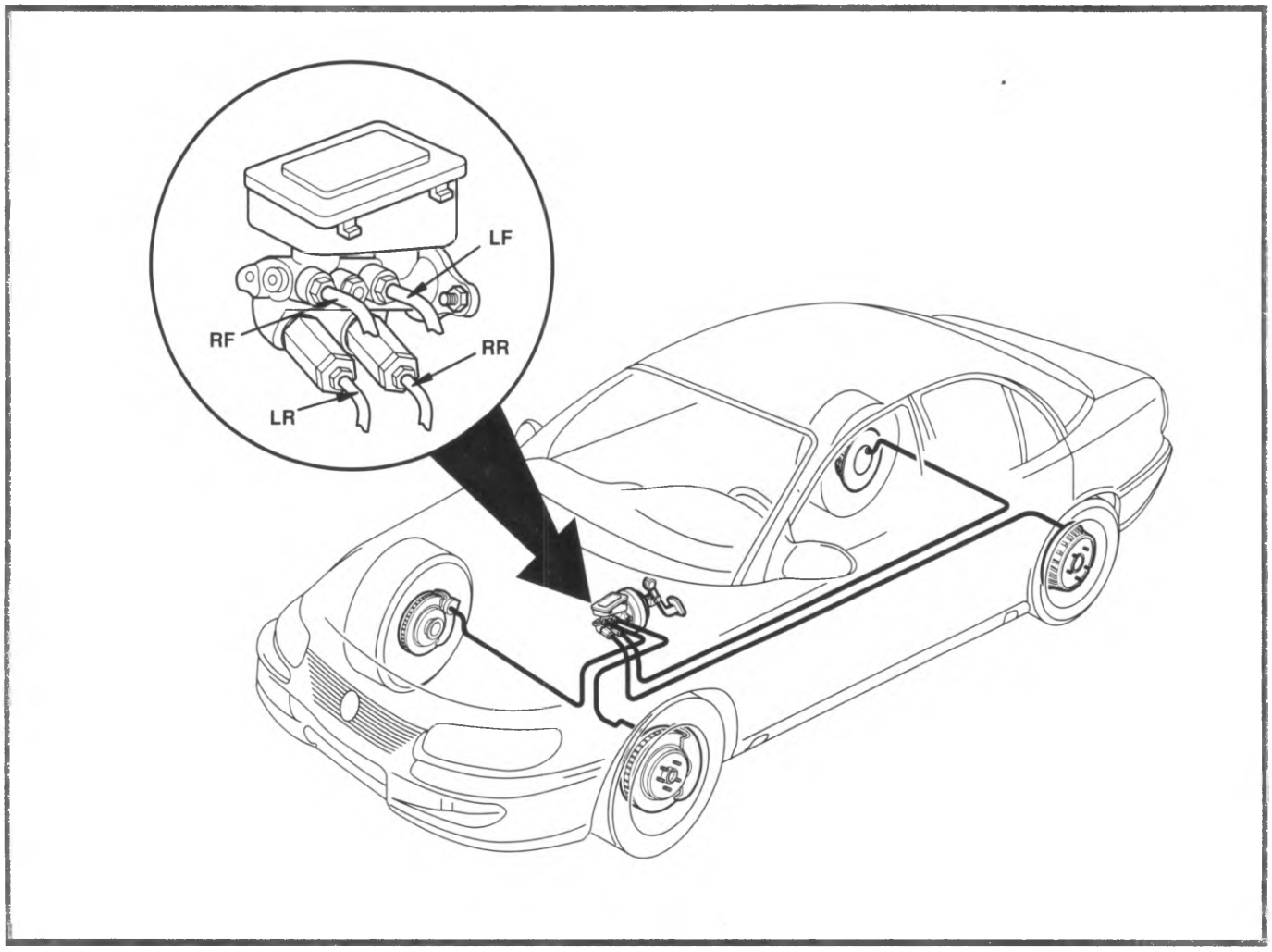


Figure 1-5, **Diagonal Split Hydraulic System**

Brake Operation–Non-Assisted

In non-assisted brake systems, the force the driver applies to the brake pedal in combination with mechanical linkage is converted into hydraulic braking pressure.

Brake Operation–Power Assisted

Brake hydraulic operation is the same as manual brakes. Power brake systems add a vacuum or hydraulic brake power booster to supplement brake pedal pressure. Most vehicles today are equipped with some type of power assist.

Hydraulic Theory

In the brake system, a relationship exists between:

- Force and piston area
- Piston travel and piston area

Force and Piston Area

Hydraulic pressure, created by the master cylinder, is the same in all parts of the system.

For example, if the master cylinder generates 500 psi of its piston area, it also transfers 500 psi to the pistons in each wheel cylinder or caliper.

When pressure from the master cylinder exerts 500 psi on a piston having one square inch surface area, the piston transfers 500 pounds of force (figure 1-6). If hydraulic pressure exerts 500 psi on a piston that has two square inches, the piston transfers 1,000 pounds of force to the brake lining (500 psi x 2 in.^{2} = 1,000 lb.) (figure 1-7).

Piston Area and Piston Travel

The operation of the wheel cylinder is affected by piston size. If the one square inch master cylinder piston moves one inch, a one square inch wheel cylinder piston will also move one inch.

When the one square inch master cylinder moves one inch, a two square inch wheel cylinder piston (twice the size) will move one-half inch (half the distance).

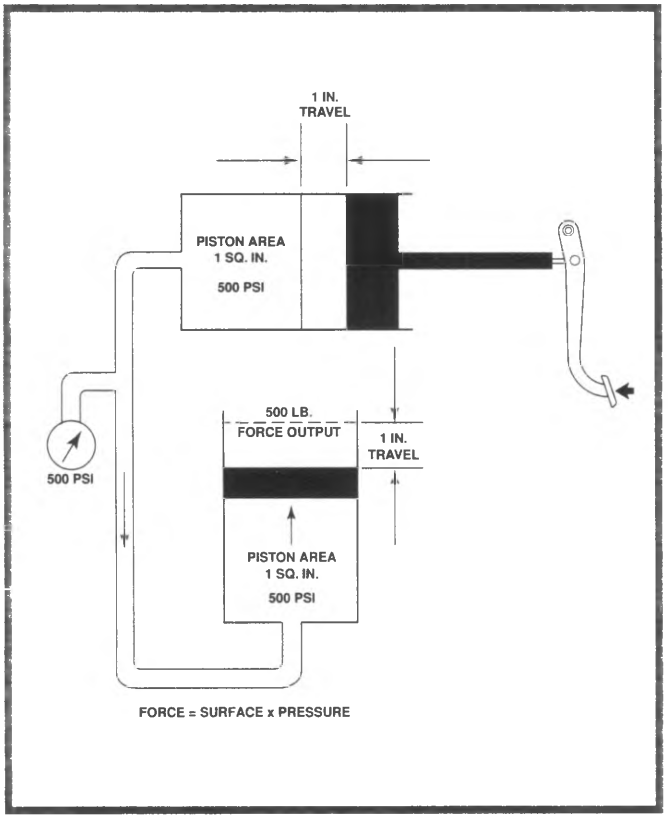


Figure 1-6, **Piston Area and Travel (1 in.)**

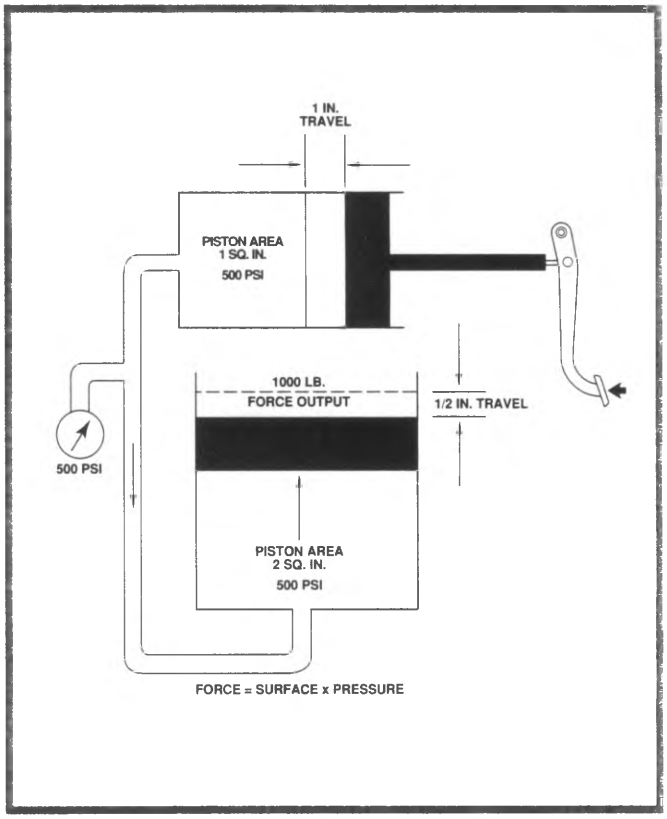


Figure 1-7, **Piston Area and Travel (2 in.)**

Special Tools and Lubricants

The following is a list of special tools needed to perform most base brake service procedures.

- J 8049 spring remover and installer
- J 8057 brake spring pliers
- J 21177-1A drum-to-brake shoe clearance gauge
- J 22348-01 drum brake spring remover and installer
- J 22364-01 drum-to-shoe clearance gauge
- J 23530 brake line flaring tool
- J 25310 universal tubing bender
- J 29117-A wheel bearing cup remover
- J 29532 pressure bleeder
- J 29567 reservoir adapter
- J 29803-A ISO flaring kit
- J 33067 cone grease machine
- J 38400 brake shoe spanner and spring remover
- J 39177 pressure bleed tool
- J 28662 pedal effort gauge
- J 29840 brake spring remover/installer
- J 42450-A hub cleaning kit
- J 37839 pushrod height gauge
- #12345579 silicon lube for caliper slides and bushings
- #1052196 14 oz. lubriplate
- #1052439 12 oz. aerosol can
- #1050109 1-3/4 oz. tube

Notes:

2. Apply System

Objectives:

After completing this section, the student will be able to:

- Perform a brake pedal travel check
- Describe the parking brake systems on current GM vehicles
- Describe the operation of the different types of parking brake systems

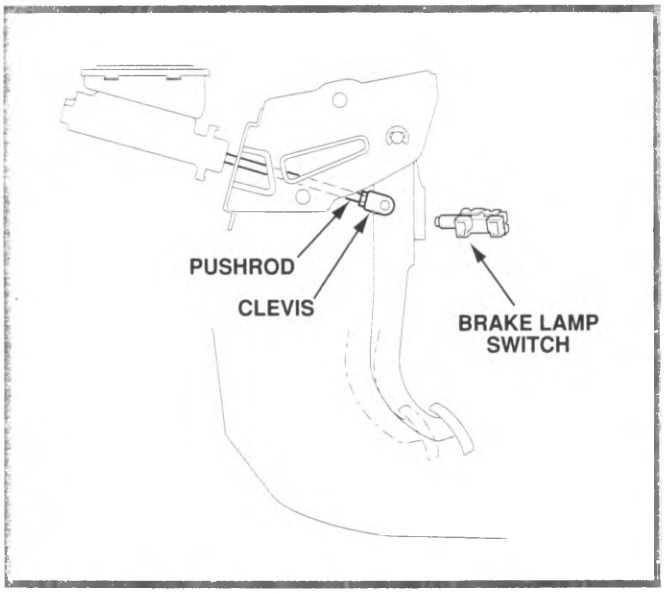


Figure 2-1, **Brake Pedal and Linkage**

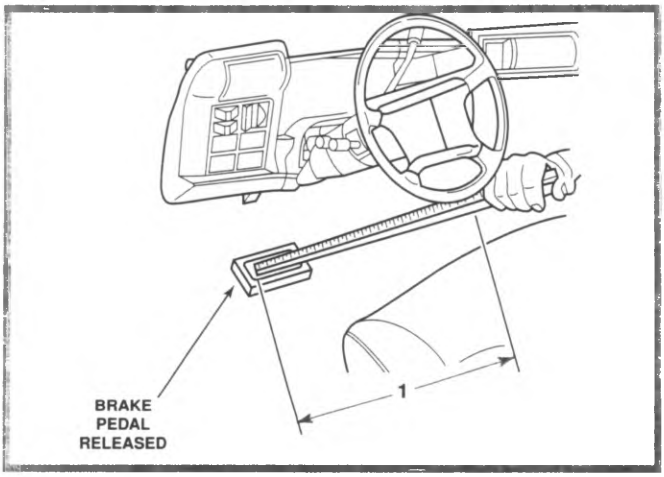


Figure 2-2, **Checking Brake Pedal Travel (Measurement 1)**

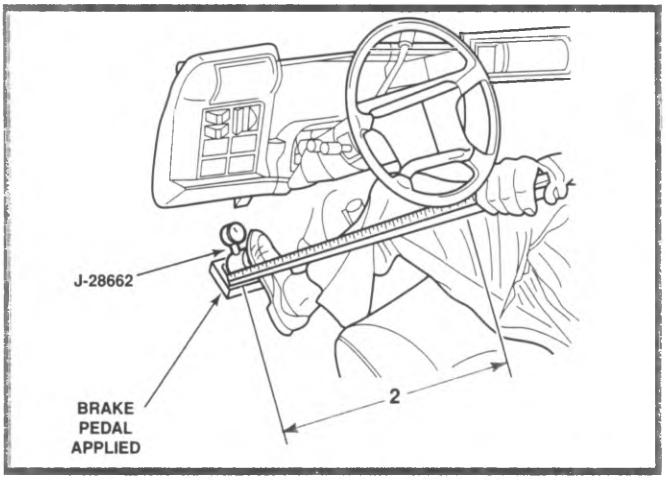


Figure 2-3, **Checking Brake Pedal Travel (Measurement 2)**

Apply System

Brake Pedal and Linkage

The brake pedal, which is connected to the master cylinder, actuates the brake system. The brake lamp switch lights the rear brake lamps when the driver presses the pedal (figure 2-1). The brake pedal also provides a mechanical advantage to assist driver application.

Brake Pedal Travel Check

Example:

Brake pedal travel is the distance the pedal moves toward the floor from a full released position. This check should be made with brakes cold, engine OFF and about 445 N (100 lb.) of force on the pedal using a brake pedal effort gauge, such as J 28662 or equivalent.

Apply the brake pedal at least five times with the engine OFF to remove vacuum from the booster before performing the check.

Measure the distance from the bottom of the steering wheel to the top of the brake pedal.

1. Take the first measurement with the brake pedal released (figure 2-2).
2. Take the second measurement after applying the brake pedal with about 445 N (100 lb.) of force using J 28662 (figure 2-3).
3. Subtract measurement 1 from measurement 2.
4. Compare this measurement with the specification in the service manual.
5. If brake pedal travel is excessive, refer to the brake system diagnostic chart.

   Example: 1st measurement = 20.5 in.

   2nd measurement = 22.75 in.

   Brake Pedal Travel = 2.25 in.

Parking Brake and Cables

The parking brake system uses cables to operate the rear brakes (figure 2-4). Parking brakes are mechanically applied and independent of the hydraulic system.

The driver applies the parking brake with either:

- Foot pedal mounted near the left kick panel
- Hand lever

When the driver operates the parking brake, the Red BRAKE Warning Lamp (RBWL) turns on to indicate that the parking brake is ON.

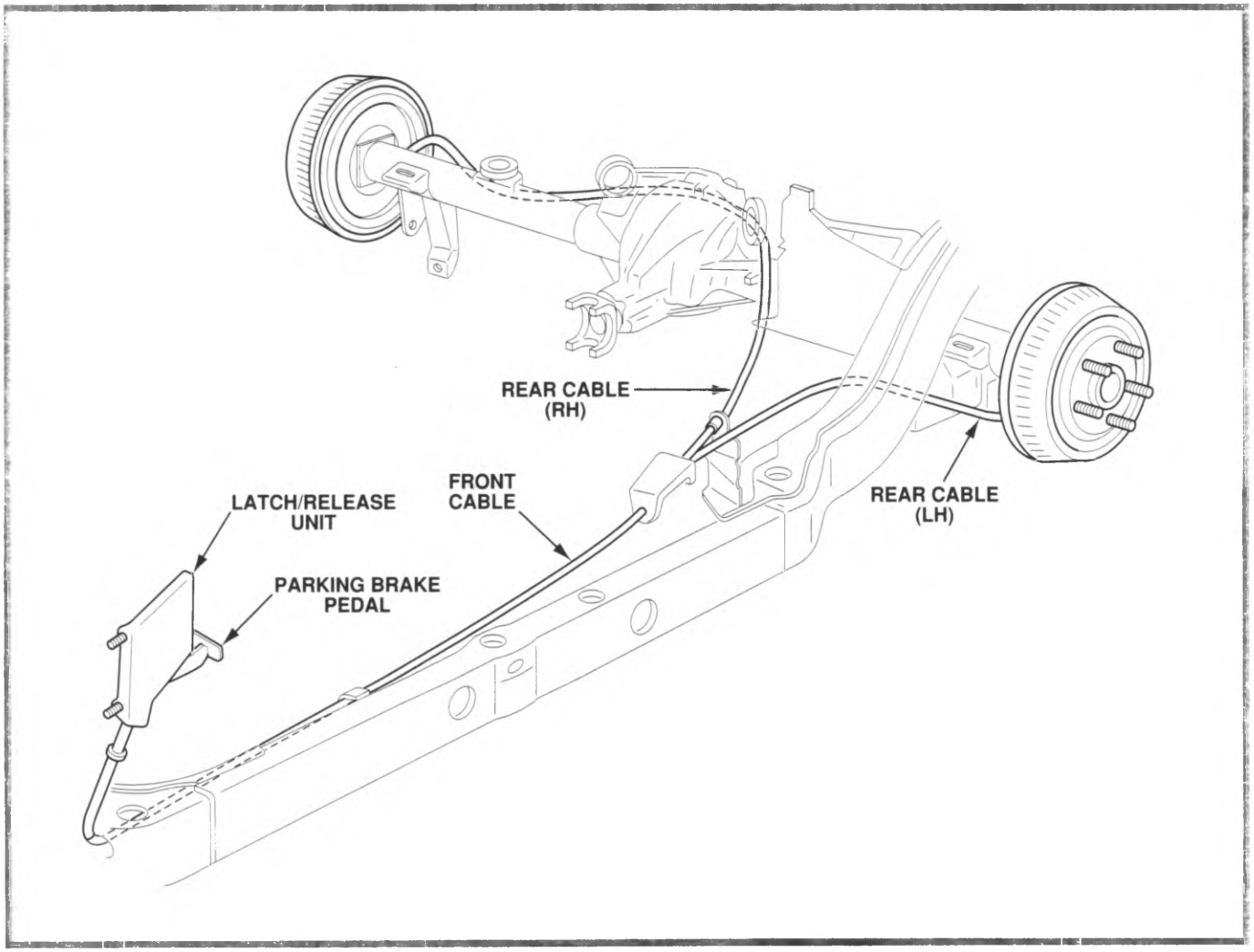


Figure 2-4, **Parking Brake Cable System**

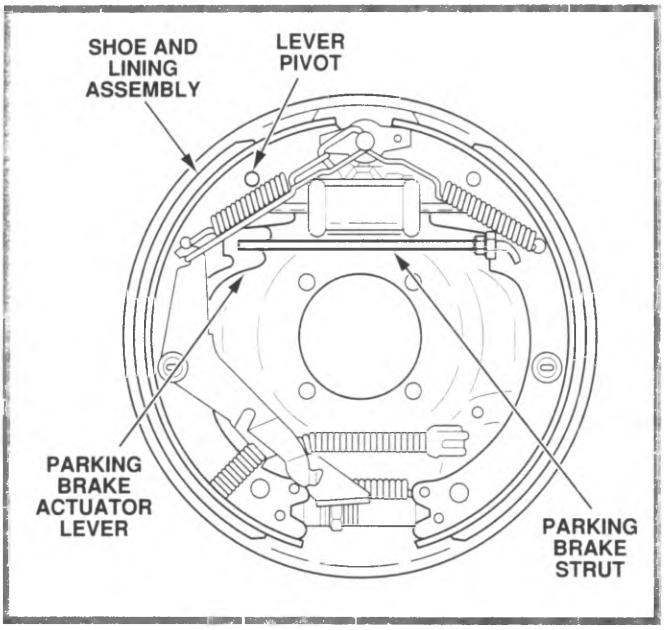


Figure 2-5, **Drum Parking Brake**

Drum Parking Brake (Duo-Servo)

To operate the drum parking brake (figure 2-5):

1. The cable pulls the parking brake actuator lever inside the brake drum.
2. The lever moves one brake shoe outward.
3. The parking brake strut then engages the other shoe and moves it outward. Both brake shoes contact the brake drum.

Disc With Integral Parking Brake

When the driver applies the parking brake (figure 2-6):

1. The cable actuated parking brake lever rotates the actuator screw.
2. The actuator screw unthreads on a nut inside the piston. The nut does not rotate, because it is splined to the cone. When the screw turns, it moves the nut outward by pressing against a cone inside the piston.
3. The piston presses against the inboard brake pad and applies the inboard brake pad against the rotor.
4. The motion of the piston slides the caliper assembly to apply the outboard pad.
5. The actuator screw also acts as a self-adjuster mechanism which moves the piston to compensate for pad wear.

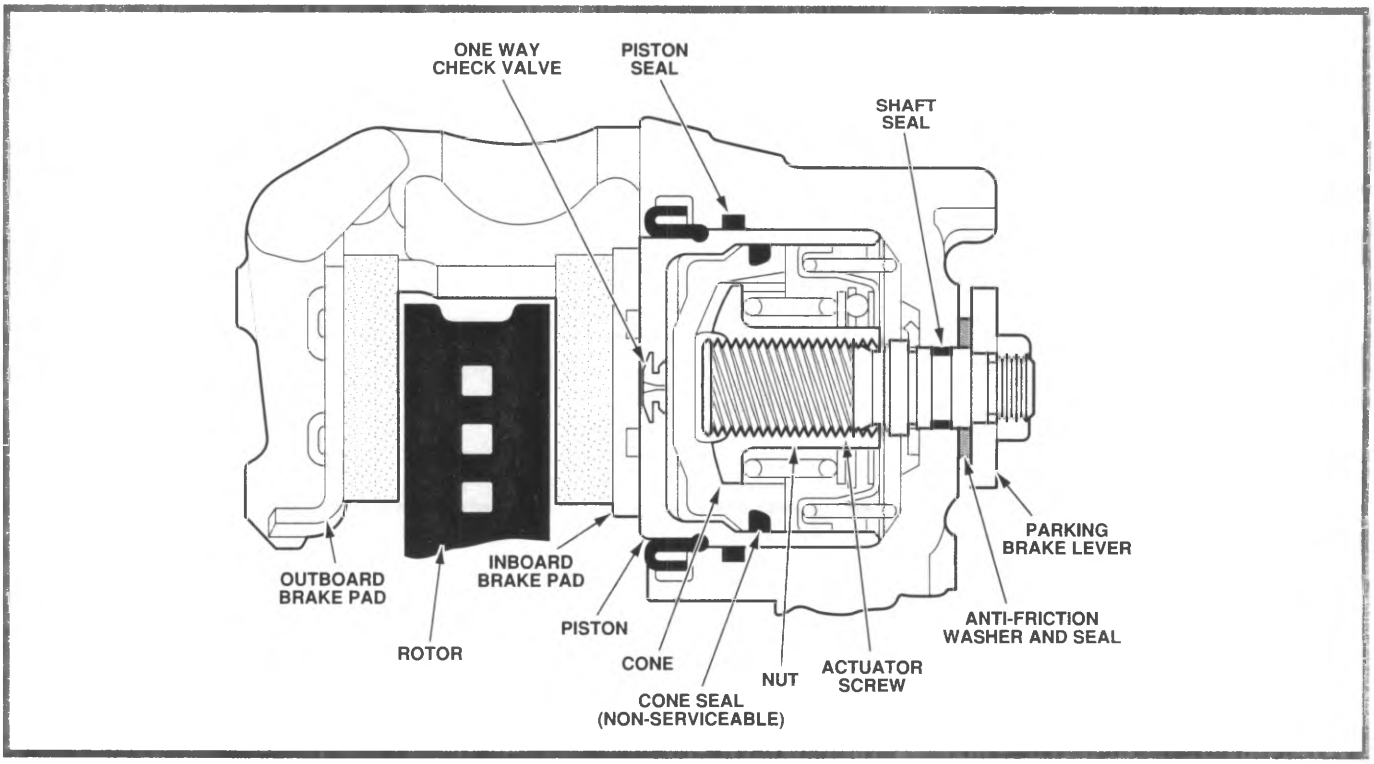


Figure 2-6, **Disc Parking Brake**

Disc With Integral Parking Brake and Actuator Lever

The rear disc brake caliper has a single piston in an aluminum housing which is suspended in the anchor bracket on two guide pins. When the parking brake is applied, the lever on the caliper causes the pushrod, the actuating collar and the clamp rod to be moved outward and the caliper to slide inward, mechanically forcing the pads against the rotor. Parking brake application is completely independent of the hydraulic braking system.

Disc With Drum-In-Hat Parking Brake

The drum-in-hat system consists of a simple drum brake-shoe assembly which applies against a drum machined inside the rotor hat section. With the drum-in-hat park brake (figure 2-7), the rear caliper doesn't have to perform both service and parking brake functions like the integral parking brake system. The system is simpler and provides for better service and parking brake performance.

A special clearance gauge, number J 21177-1A, is used to adjust the parking brake shoe and lining. The procedure is found in the brake section of the service manual.

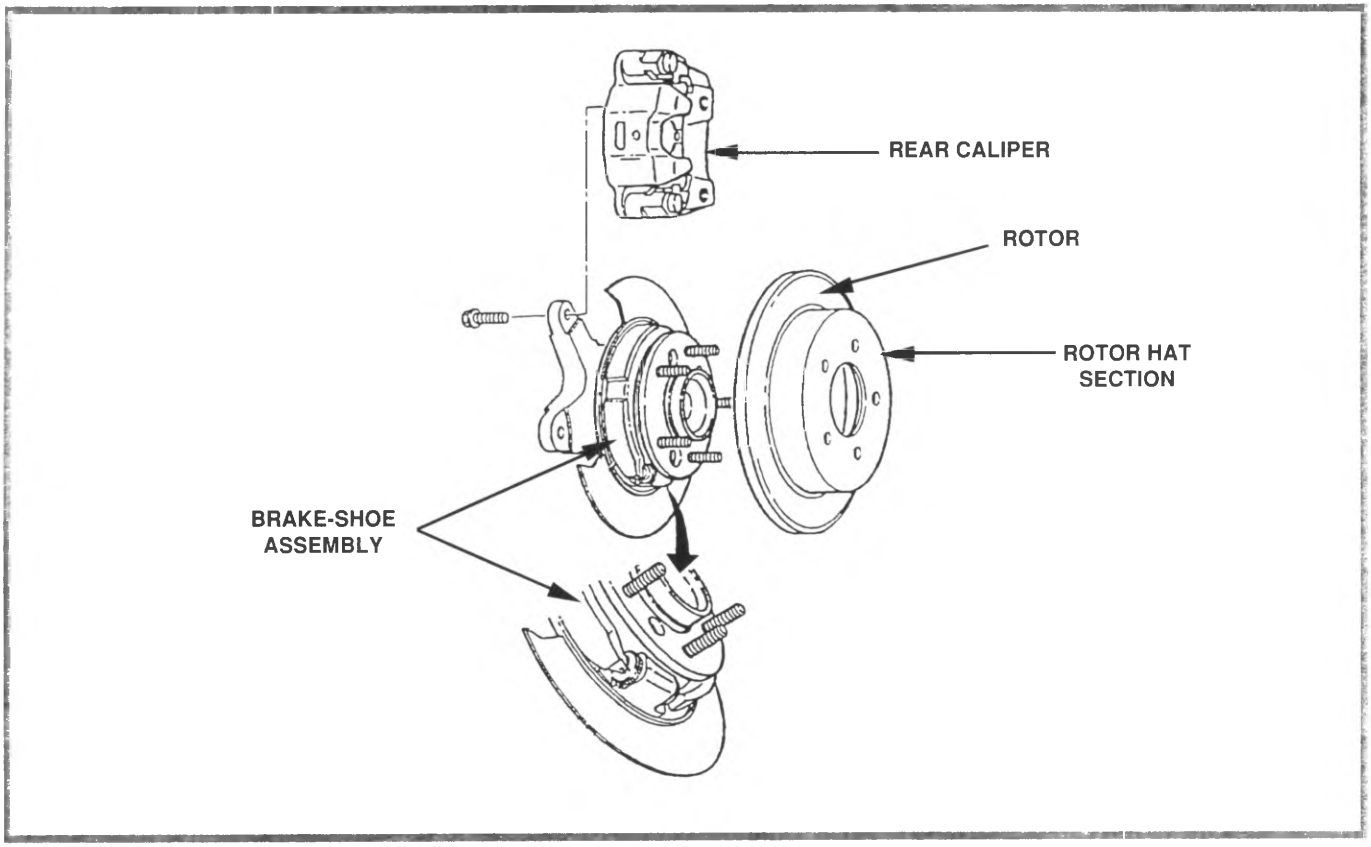


Figure 2-7, **Drum-In-Hat Parking Brake**

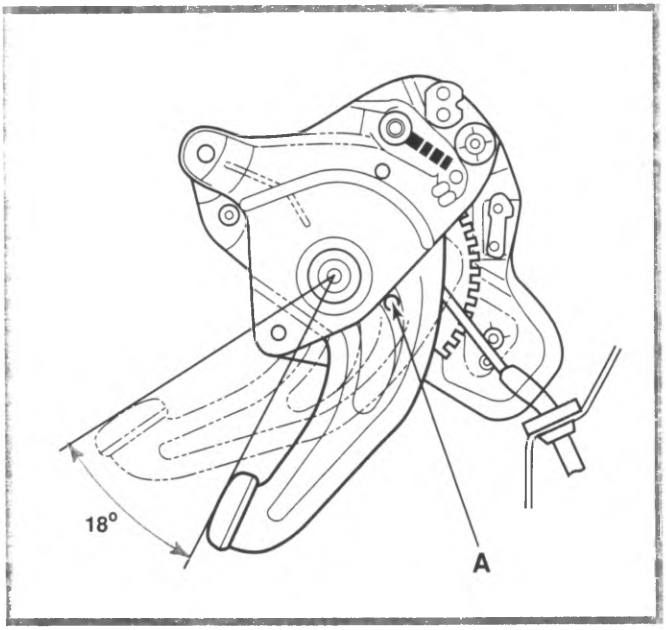


Figure 2-8, **Parking Brake Adjustment Setting**

Parking Brake Adjustment (Rear Drum)

The parking brake must be adjusted any time the parking brake cables are serviced, or the holding ability is not adequate. Before adjusting the parking brake, check the condition of the service brakes. The service brakes must be adjusted properly before adjusting the parking brake. Refer to the appropriate service information.

Example for C/K Truck:

1. Block the front wheels.
2. Raise the rear of the vehicle and support with safety stands.
3. Loosen the adjusting nut at the equalizer.
4. Push the parking brake pedal down 18 degrees to set it (figure 2-8) by:
   - Inserting a 3 mm (0.125 in.) pin into the locating hole in the pedal assembly (A)
   - Pushing the pedal downward until the pin contacts the parking brake outer flange
5. Turn the adjusting nut until the rear wheels rotate forward with moderate drag (figure 2-9).
6. Release the parking brake and rotate the rear wheels. There should be no drag.
7. Lower the vehicle and unblock the front wheels.

— IMPORTANT —

Park brake adjustments vary depending on vehicle application.

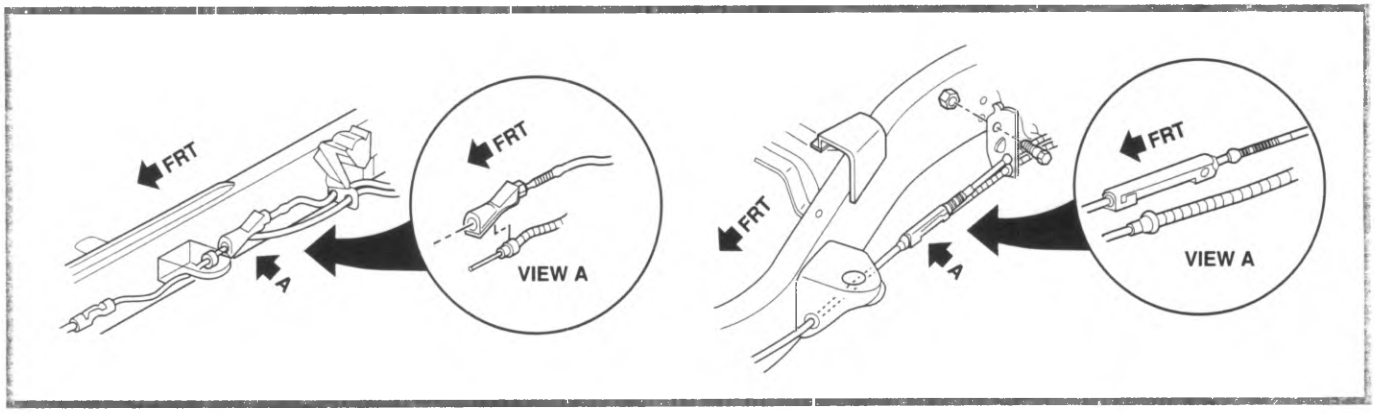


Figure 2-9, **Rear Parking Brake Cable**

Parking Brake Adjustment (Integral Rear Caliper)

Adjust the parking brake to specifications after caliper disassembly or overhaul. Incorrect parking brake adjustment can cause low brake pedal complaints.

— NOTICE —

Use this procedure only on linings with less than 0.15 mm (0.006 in.) taper. Parking brake adjustment is not valid with heavily tapered pads and may cause caliper/parking brake binding.

— IMPORTANT —

- **Inspect old pad and lining assemblies and replace if they are tapered**
- **Parking brake free travel should only be adjusted if the caliper has been taken apart**
- **This adjustment will not correct a condition where the caliper levers will not return to their stops**

Service procedures vary among applications. For example:

1. Apply service brake pedal three times with a pedal force of approximately 778 N (175 lb.).
2. Apply and release parking brake three times.
3. Check parking brake hand lever for full release.
   - Turn ignition on.
   - Red BRAKE Warning Lamp should be off. If Red BRAKE Warning Lamp is still lit, and the hand lever is completely released, pull downward on the front parking brake cable to remove slack from lever assembly.
   - Turn ignition off.
4. Raise car and suitably support.
   - Mark relationship of wheel to axle flange.
5. Remove rear wheels and tires.
   - Reinstall two inverted lug nuts to retain rotor.
6. Pull parking brake hand lever exactly four (4) ratchet clicks.
7. Parking brake levers (2) on both calipers should be against the lever stops on the caliper housings. If levers are not against stops, check for binding in rear cables and/or loosen cables at adjuster until both left and right levers are against their stops.
8. Tighten parking brake cable at adjuster until either the left or right lever begins to move off the stop, then loosen adjustment until lever moves back barely touching stop.
9. Operate parking brake several times to check adjustments. After cable adjustment is performed, parking brake hand lever should travel 14 clicks. Rear wheels should not rotate forward when hand lever is applied 8 to 14 ratchet clicks.
10. Install wheels and tires, aligning previous marks and properly torquing lug nuts.

Parking Brake Adjustment (Integral Rear Caliper with Actuator Lever)

The adjustment process requires a second person to apply a light brake pedal load. Parking brake lever free-travel is set by the position of the adjuster screw. Turning the adjuster screw clockwise increases the free-travel; turning the adjuster screw counterclockwise decreases the free-travel.

— NOTICE —

Pads must be new or parallel to within 0.006 in. (0.15 mm). Parking brake adjustment is not valid with tapered pads and may cause caliper/parking brake binding.

— IMPORTANT —

- **Inspect old pads and replace with new ones if they are tapered**
- **Parking brake free-travel should only be changed if the caliper has been taken apart, or when the pads are replaced**
- **This adjustment will not correct a condition where parking brake actuator levers will not return to their stops**

Example:

1. Disconnect parking brake cable and remove actuator lever return spring.
2. Have an assistant apply light brake pedal load, enough to stop the rotor from turning by hand.
   - This takes up all clearances and ensures that components are correctly aligned
3. Apply light pressure to the parking brake actuator lever. Measure free-travel between parking brake actuator lever and caliper housing.
   - Free-travel must be 0.024 in. to 0.028 in. (0.61 mm to 0.71 mm)
4. If free-travel is incorrect, do the following:
   a. Remove adjuster screw
   b. Clean thread adhesive residue from threads
   c. Coat threads with adhesive
   d. Screw in adjuster screw far enough to obtain 0.024 in. to 0.028 in. (0.61 mm to 0.71 mm) free-travel between parking brake actuator lever and caliper housing
5. Have assistant release brake pedal, then apply brake pedal firmly three times.
6. Recheck free-travel as described in steps 2 and 3 and adjust as necessary.
7. Install actuator lever return spring and parking brake cable.

3. Power Brake Boosters

Objectives:

After completing this section, the student will be able to:

- Discuss power brake booster operation for vacuum and hydraulic assist
- Gauge booster pushrod height
- Perform an accumulator leak-down test
- Identify and diagnose hydraulic booster fluid leaks and determine needed repairs

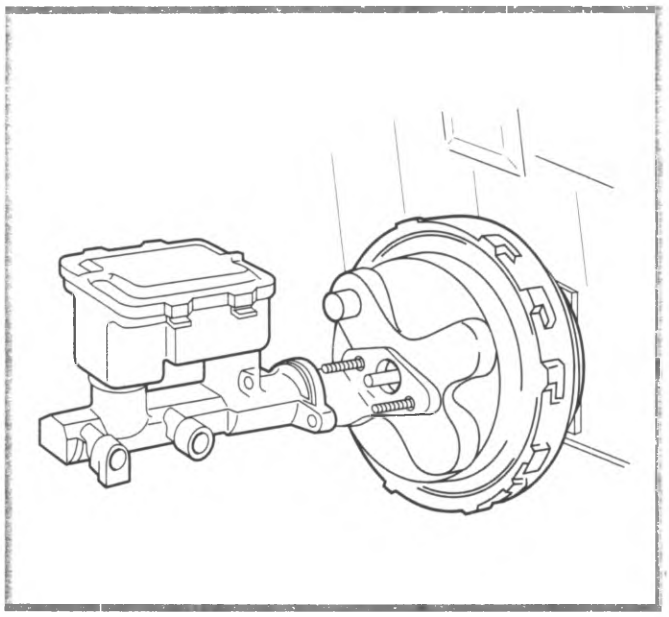


Figure 3-1, **Vacuum Assist Booster**

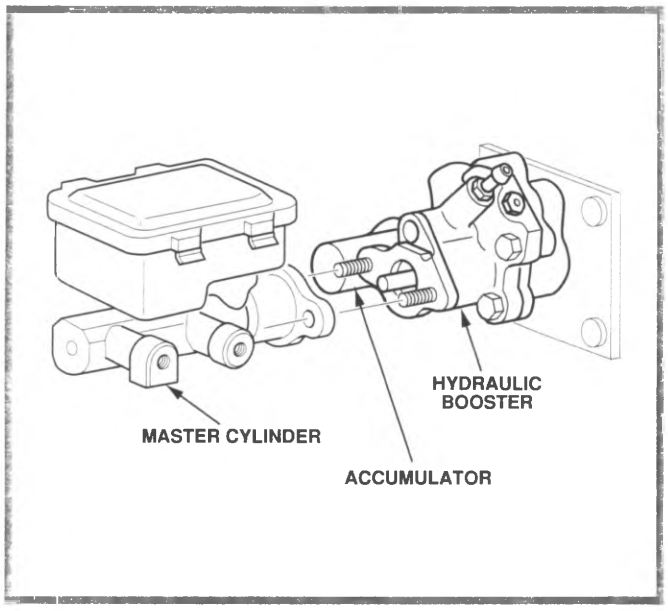


Figure 3-2, **Hydraulic Boost System**

Power Brake Boosters

Power assist increases brake pressure while decreasing driver effort. In power assist systems, driver applied pedal force is supplemented by a power head. This results in easier brake application.

Power assisted brake systems may be:

- Single or tandem vacuum power booster
- Hydraulic booster

Vacuum Assist

Vacuum assist systems use engine vacuum and atmospheric pressure to increase hydraulic pressure in the master cylinder to provide power assist (figure 3-1).

Hydraulic Assist

Hydraulic assist systems utilize power steering pump pressure to increase hydraulic pressure in the master cylinder (figure 3-2).

Vacuum Booster Operation

The vacuum booster includes (see figure 3-3):

- Large diaphragm(s) connected to the power piston assembly
- Air inlet valve controlled by the brake pedal
- Engine manifold vacuum hose located on the front of the power head housing
- Check valve to retain vacuum in the booster

The tandem-diaphragm power head is similar to the single-diaphragm unit except there are two diaphragms that separate the housing into four chambers. This design provides the necessary assist utilizing a smaller unit.

The tandem-diaphragm power piston has two power pistons in tandem to provide additional boost without increasing the diameter of the power head.

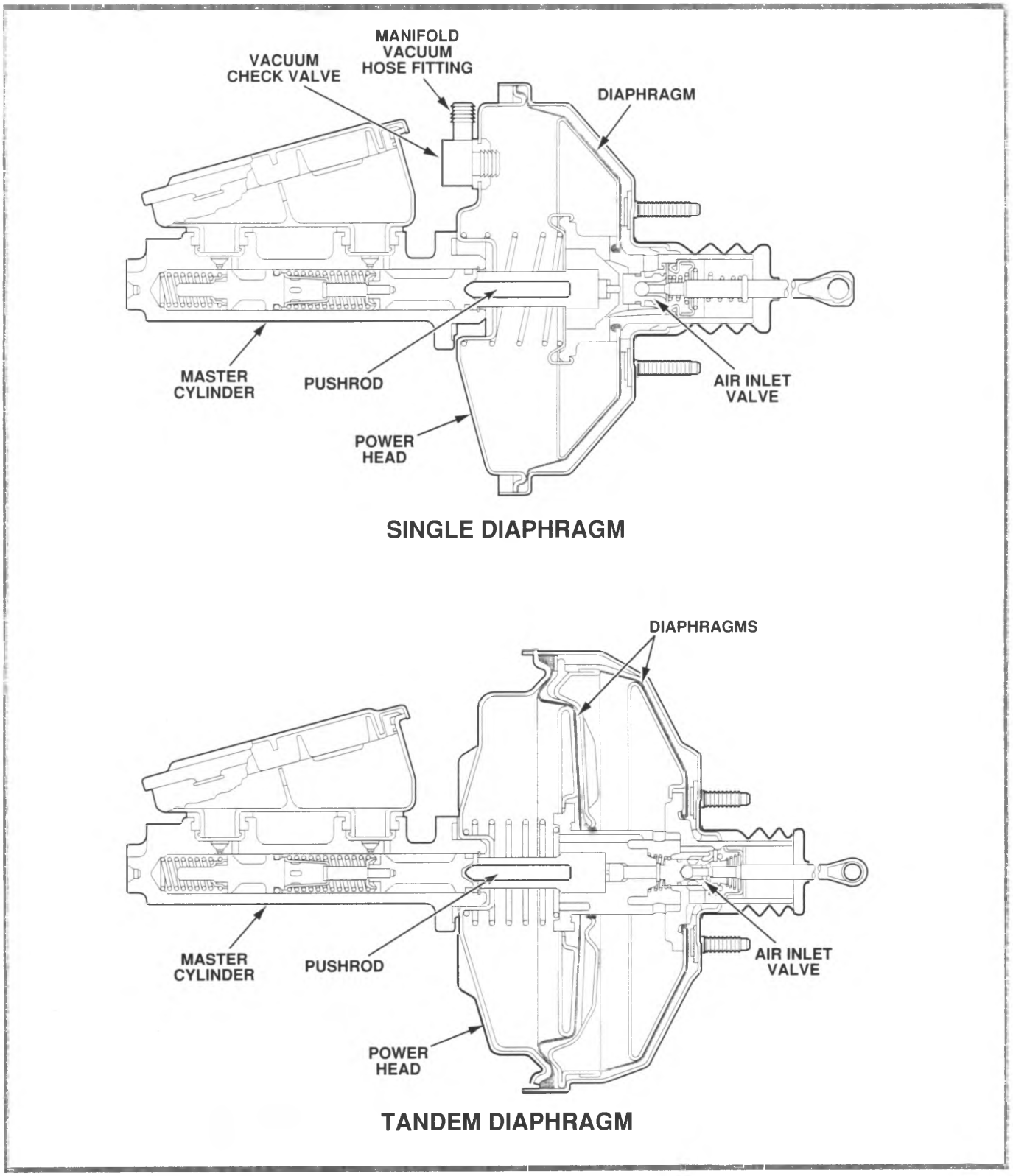


Figure 3-3, **Types of Vacuum Power Booster**

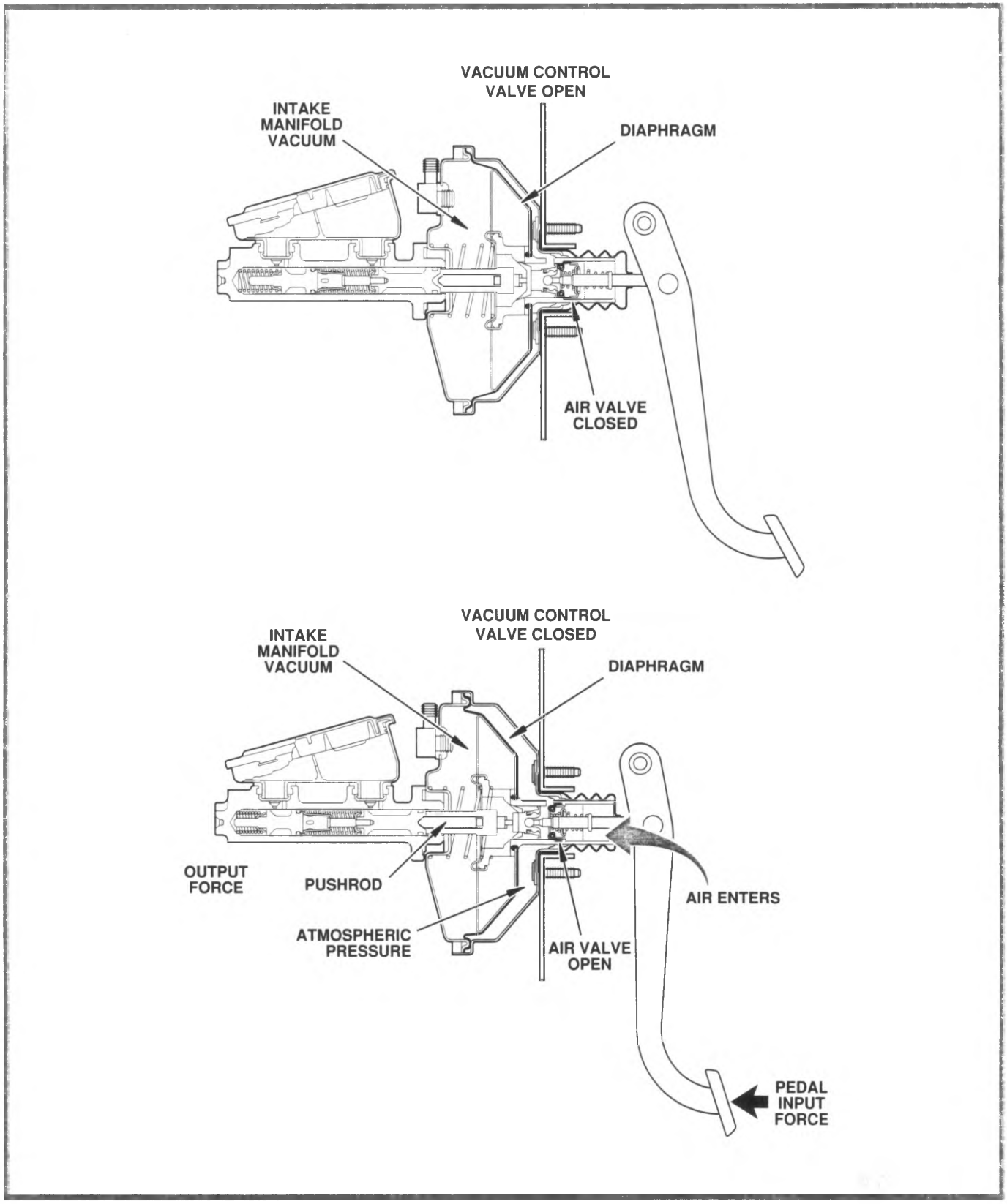


Figure 3-4, **Vacuum Booster Operation**

Power Brakes–At Rest

When the brake pedal is released (figure 3-4, top):

1. Vacuum is applied to both sides of the diaphragm.
2. The return springs hold the diaphragm and the master cylinder pistons in the at rest position.

Power Brakes–Applied

When the driver applies pressure to the brake pedal (figure 3-4, bottom):

1. Brake pedal pressure closes the vacuum source from the engine to the rear chamber of the diaphram.
2. Atmospheric pressure enters the rear chamber of the diaphragm.
3. The pressure differential between the front and rear chambers assists the master cylinder pistons to move and apply the brakes.

Vacuum Booster Operation Example

1. The driver applies 100 pounds of force to the brake pedal (figure 3-5).
2. The brake pedal linkage has a 5:1 ratio mechanical advantage.
3. The brake pedal delivers 5x100 lb. = 500 lb. of force to the booster.
4. Engine vacuum, which is at a lower pressure than atmospheric pressure, is applied to the front of the booster diaphragm (18 in. Hg = 5.8 lb./in.^{2}).
5. Atmospheric pressure is applied to the back of the booster diaphragm. Atmospheric pressure is 0 inches Hg which equals 14.7 psi.
6. The booster diaphragm has an area of 100 square inches (100 in.^{2}) Area equals r^2.
7. Maximum booster output force equals:
   - Pressure Difference x Diaphragm Area + Input Force
   - (14.7 lb. / in.^{2} - 5.8 lb. / in.^{2}) x 100 in.^{2} + 500 lb.
   - 8.9 lb. / in.^{2} x 100 in.^{2} + 500 lb. = 1390 lb. of force
8. The 1 1/8-inch master cylinder bore has a piston area of one square inch (1 in.^{2}).
9. Master cylinder output pressure equals:
   Input Force / Piston Area = 1390 lb. / 1 in.^{2} = 1390 psi

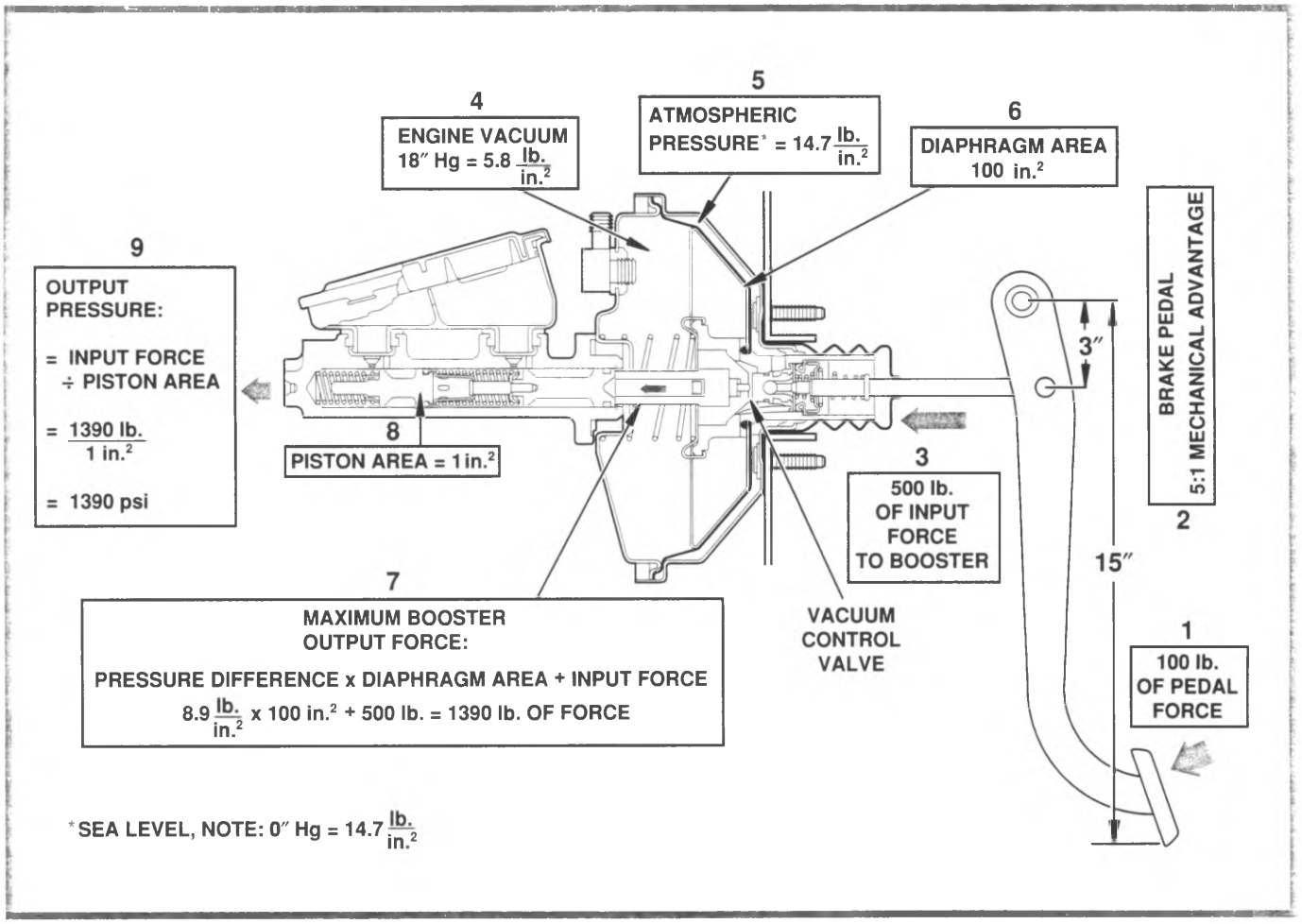


Figure 3-5, **Vacuum Booster Operation Example**

Vacuum Failure

In the event of vacuum source interruption, a check valve in the single-diaphragm or tandem-diaphragm power boosters reserves enough vacuum for approximately three power-assisted stops. The driver can also operate the brakes mechanically, if the vacuum assist system fails.

— NOTICE —

Operation without power assist requires greater pedal force, which could lead to increased stopping distances.

Vacuum Booster Diagnosis

Many internal and external vacuum booster component malfunctions can lead to a misdiagnosed base brake condition. The following can be used to help isolate a potential vacuum booster related malfunction.

Excessive Pedal Effort

- Restricted or leaking vacuum hose
- Restricted or stuck closed vacuum check valve
- Insufficient engine vacuum
- Brake pedal linkage binding
- Restricted vacuum passage in the booster valve
- Leaking internal vacuum diaphragm

Brakes Slow or Fail to Release

- Restricted or stuck open internal vacuum valve
- Brake pedal linkage binding
- Broken internal booster return spring
- Improper stop light switch adjustment
- Improper gauging of power head piston rod
- Blocked passages in power head

Brake Drag

- Booster pushrod height incorrect (too high)
- Binding brake pedal linkage
- Incorrect brake light switch adjustment

Brakes Grabby or Apply Unevenly

- Internal vacuum valve sticking
- Damaged or distorted diaphragm

Gauging Procedure

Tool Required: J 37839 Pushrod Height Gauge

1. Gauge the booster with 85 kPa (25 in. Hg) vacuum or maximum engine vacuum.
2. Check the maximum and minimum rod length using J 37839 (figures 3-6 and 3-7). The pushrod should contact the gauge with the "min" side of the tool and not contact on the "max" side of the tool.
3. If the pushrod is not within limits, obtain a service adjustable piston rod and (if available) adjust the rod to the correct length or replace the booster assembly if a service adjustable piston rod is not available.

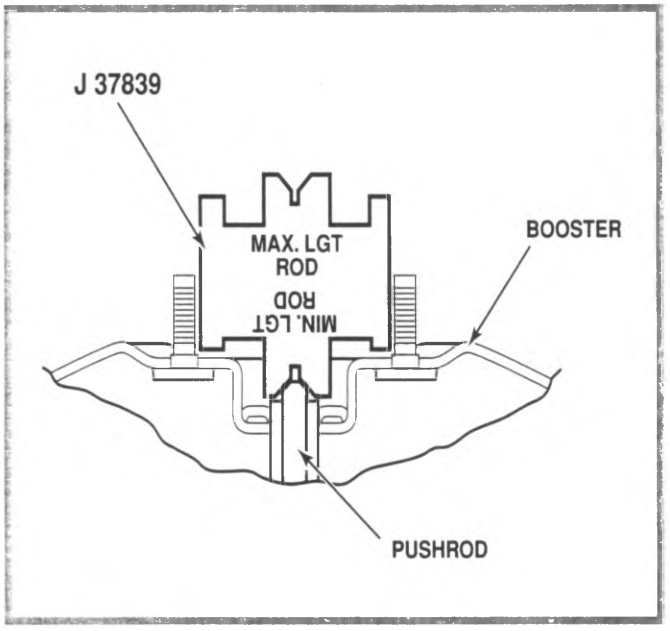


Figure 3-6, **Minimum Pushrod Height**

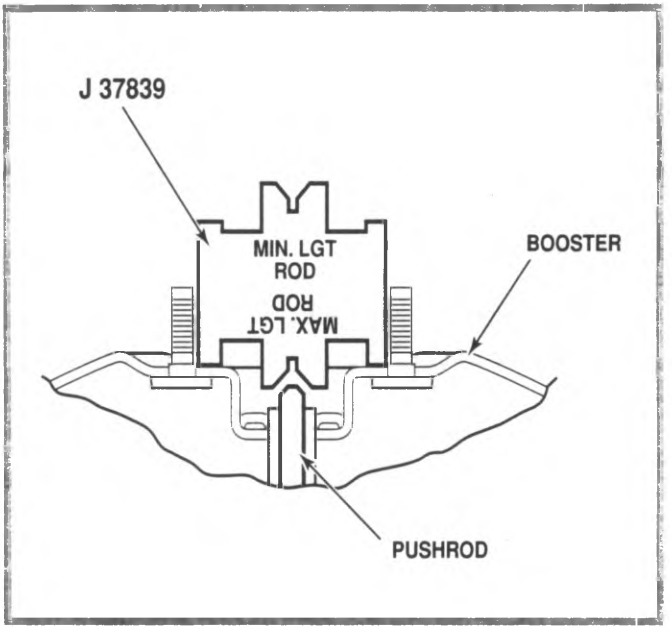


Figure 3-7, **Maximum Pushrod Height**

Hydraulic Brake Boost System

A hydraulic brake boost system, known as hydro-boost, is used on many vehicles. Hydro-boost is utilized on vehicles with underhood space limitation or vehicles that cannot consistently produce sufficient vacuum to operate a vacuum power head:

- Diesel engines
- Turbocharged engines
- Engines that operate at high load (low vacuum) such as truck applications

Hydro-Boost System

Hydro-Boost uses hydraulic pressure from the power steering pump as its primary source of pressure (figures 3-8 and 3-9). The hydraulic accumulator provides reserve pressure. The Hydro-Boost unit consists of:

- Booster
- Accumulator
- Hydraulic hoses

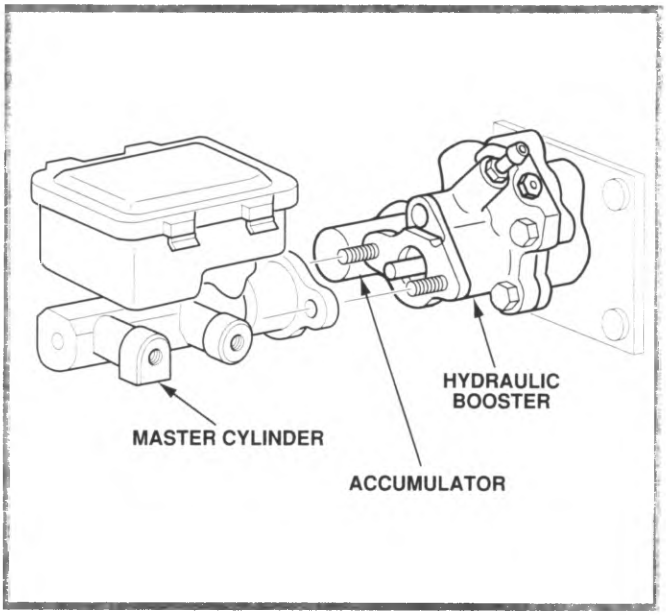


Figure 3-8, **Hydro-Boost Hydraulic Assembly**

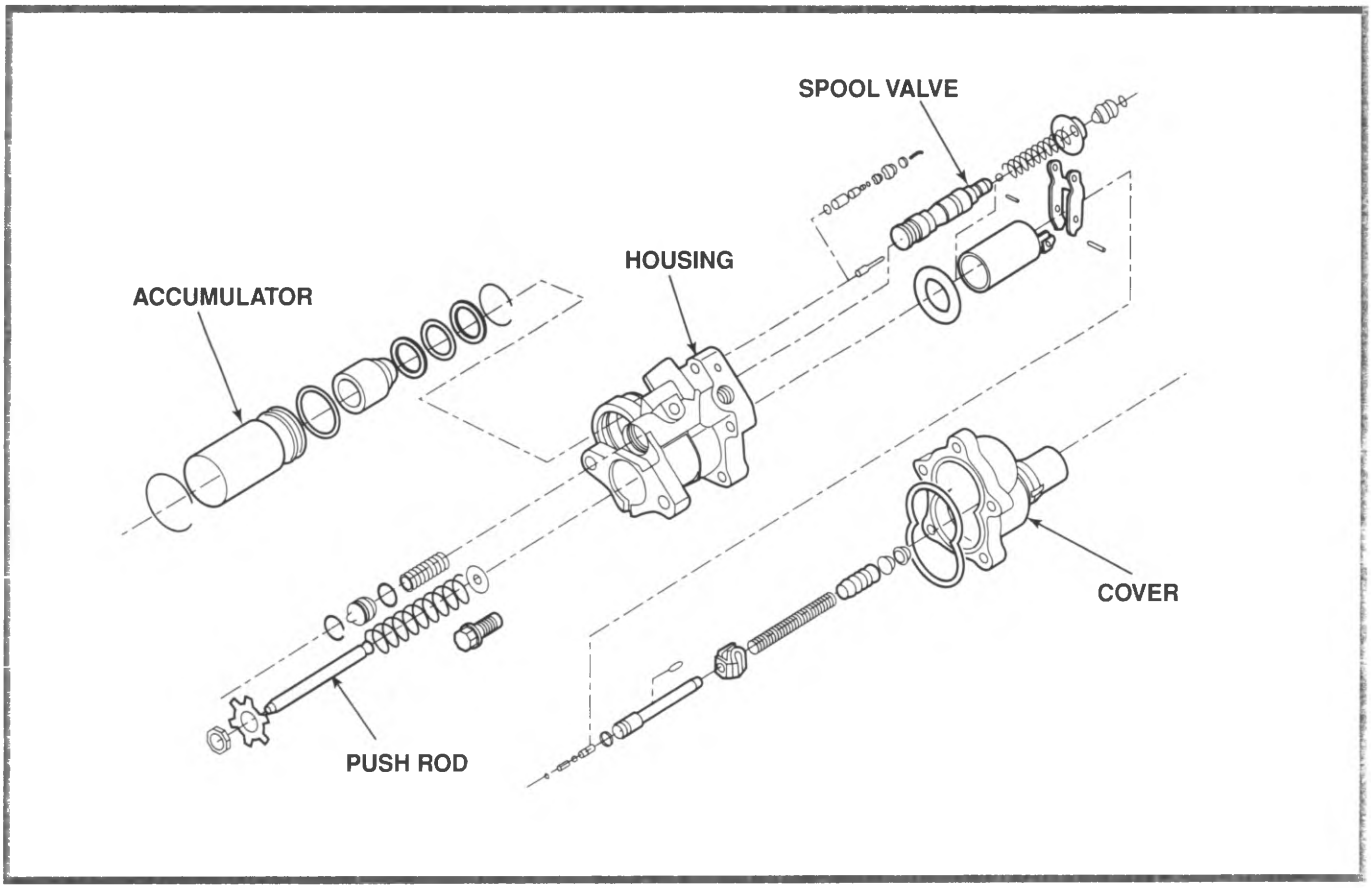


Figure 3-9, **Hydraulic Booster Assembly – Disassembled**

Hydro-Boost Booster

The Hydro-Boost booster uses an open center valve, which requires continuous flow of pressurized fluid. Pressing the brake pedal:

- Opens the pressure inlet valve
- The inlet valve directs up to 1100 psi of pressure from the power steering pump to the Hydro-Boost power piston
- The power piston applies force to the master cylinder primary piston

Accumulator

The accumulator stores pressurized brake fluid, assuring a supply of pressurized brake fluid is available for braking in case the power steering pump malfunctions.

The accumulator provides reserve power for power assisted stops.

To relieve accumulator pressure, turn ignition off and pump the brake pedal at least 10 times. A noticeable change in pedal feel occurs when the accumulator is discharged. After feeling a definite increase in pedal effort, pump the pedal several more times to make sure all pressure is relieved.

— CAUTION —

THE ACCUMULATOR CONTAINS COMPRESSED GAS. ALWAYS USE THE PROPER TOOLS AND FOLLOW THE RECOMMENDED PROCEDURES OR PERSONAL INJURY MAY RESULT.

DO NOT APPLY HEAT TO ACCUMULATOR.

DO NOT ATTEMPT TO REPAIR AN INOPERATIVE ACCUMULATOR.

ALWAYS REPLACE AN INOPERATIVE ACCUMULATOR WITH A NEW ONE.

DISPOSE OF AN INOPERATIVE ACCUMULATOR BY DRILLING A 1/16 INCH (0.0625 IN.) DIAMETER HOLE THROUGH THE END OF THE ACCUMULATOR CAN, OPPOSITE THE O-RING.

ALWAYS USE EYE PROTECTION.

Hydraulic Hoses

Hydraulic hoses connect the Hydro-Boost to the power steering pump.

Hydraulic Booster Functional Test

With the ignition in the OFF position, apply the brake pedal several times to empty the accumulator.

Hold the brake pedal using 180 N•m (40 lb.) of force. Start the engine. The pedal should fall and then push back against your foot.

Accumulator Leak-down Test

1. Start the engine.
2. Charge the accumulator by pressing the brake pedal or by completely turning the steering wheel in one direction and then in the other.
3. Turn the engine OFF. Let the vehicle sit for one hour.
4. Perform two power assisted applications with the engine off.
5. If the accumulator failed to hold a charge after one hour, but functions normally after charging, the accumulator valves are malfunctioning.

   To repair this condition:

   - Disassemble the power brake booster. (Refer to *Hydraulic Brake Booster Replacement* in the service manual)
   - Replace the accumulator valves. (Refer to the Check Valve section of *Hydraulic Brake Booster Overhaul* in the service manual)

6. If the charging and discharging of the accumulator is audible, but the accumulator still fails to hold a charge, the accumulator valves are malfunctioning.

   To repair this condition:

   - Disassemble the power brake booster. (Refer to *Hydraulic Brake Booster Replacement* in the service manual)
   - Replace the accumulator valves. (Refer to the Check Valve section of *Hydraulic Brake Booster Overhaul* in the service manual)

7. Empty the accumulator by pressing the brake pedal several times.

   - The accumulator can and will rotate or wobble if the accumulator has lost its gas charge. This requires replacement of the accumulator. (Refer to the Accumulator section of *Hydraulic Brake Booster Overhaul* in the service manual)

Potential Hydraulic Booster Leak Points

The following hydraulic booster seal areas (figure 3-10) are sources of potential hydraulic booster leaks. Keep this in mind when performing hydraulic booster service.

Input Rod Seal—A fluid leak from the mounting bracket vent hole indicates a damaged input rod seal.

Power Piston Seal—Damage to the power piston seal causes fluid to leak at the common master cylinder brake booster vent and may cause a reduction in power assist.

Housing Seal—A fluid leak between the two housings indicates a damaged housing seal.

Spool Valve Plug Seal—Damage to the spool valve plug seat causes fluid to leak past the plug.

Accumulator Seal—Damage to the accumulator seal causes fluid to leak past the accumulator cap.

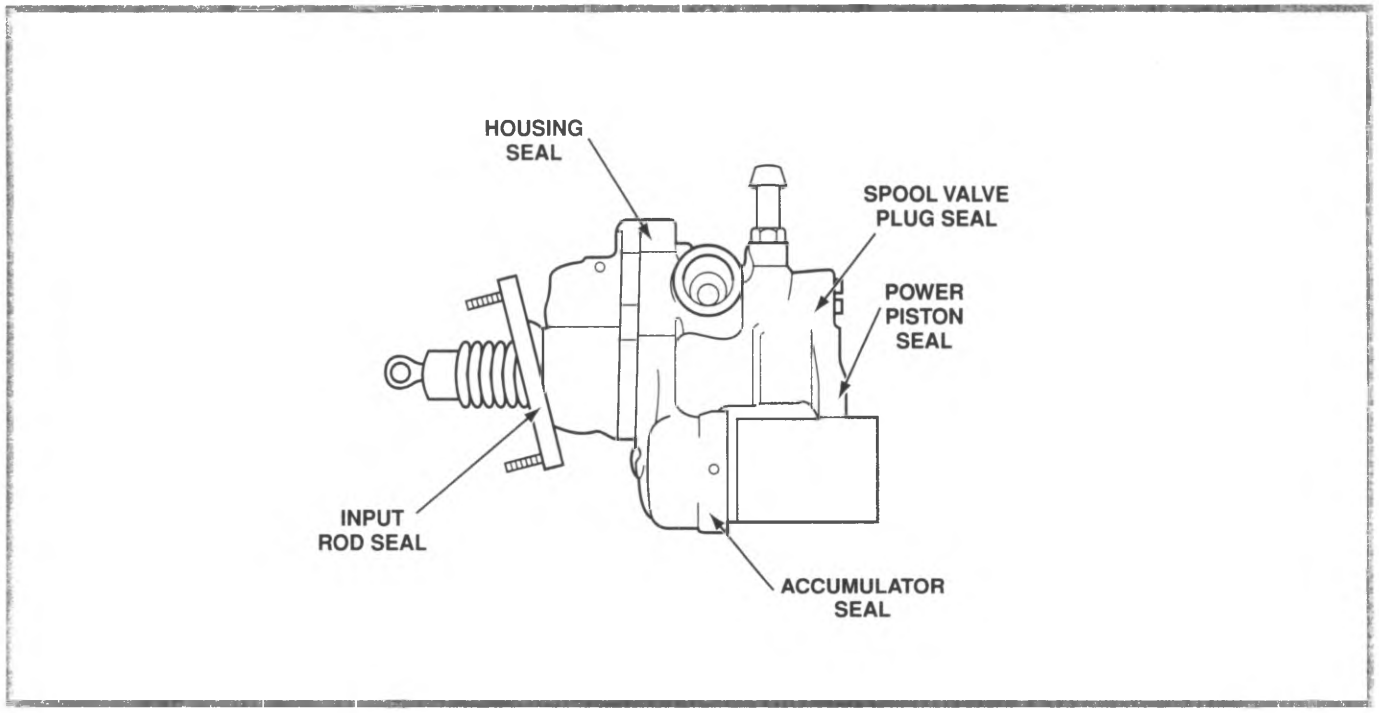


Figure 3-10, **Hydraulic Booster Seals**

4. Hydraulic System

Objectives:

After completing this section, the student will be able to:

- Describe how to prevent brake system contamination during service
- Fabricate brake pipe
- Install brake pipe and hoses
- Overhaul a master cylinder
- Bench bleed a master cylinder
- Manually bleed brakes
- Pressure bleed brakes
- Bleed systems with a combination valve
- Fabricate both ISO and double flare fittings

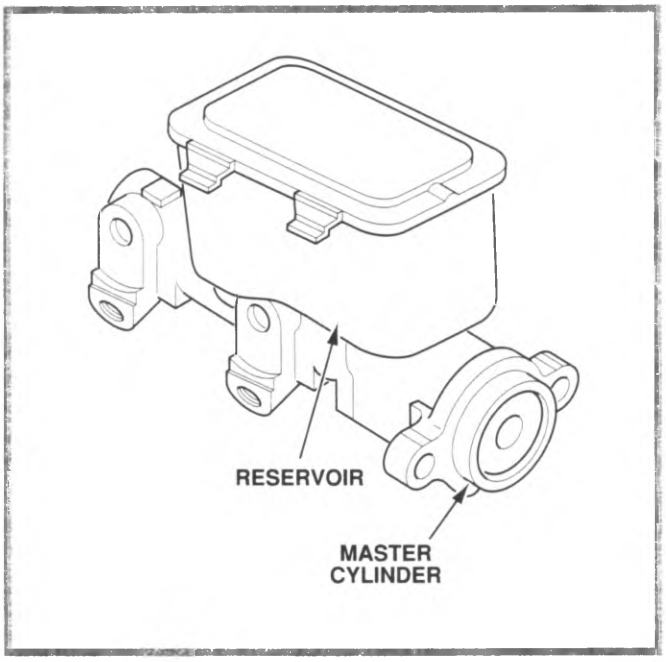


Figure 4-1, **Master Cylinder**

Hydraulic System

The hydraulic system includes:

- Hydraulic master cylinder
- Fluid reservoir
- Brake pipes and hoses
- Calipers and wheel cylinders
- Balance control systems

Master Cylinder

The master cylinder pressurizes and distributes brake fluid to the wheel circuits (figure 4-1). In the braking system:

- A reservoir stores brake fluid for use by the system
- The brake pedal linkage presses against the master cylinder pistons
- The pistons pressurize the brake fluid
- Internal master cylinder passages ensure the brakes apply and release properly
- Metering and proportioning valves control brake pressure distribution
- Brake pipes and hoses distribute the pressurized fluid to the wheel circuits

Dual Master Cylinder

The dual master cylinder contains two separate pressure chambers in a single bore (figure 4-2). Single chamber master cylinders are generally no longer in use.

The master cylinder has two holes between each chamber and the brake fluid reservoir. The holes:

- Provide a supply of fluid during braking
- Allow for normal expansion and contraction of the brake fluid due to temperature change

Each master cylinder chamber supplies pressurized brake fluid to separate wheel brake circuits. The dual system ensures partial braking is available if a failure occurs in one of the circuits. Modern brake systems utilize two split designs:

- Front-to-rear split (normally utilized on rear wheel drive vehicles)
- Diagonal split (normally utilized on front wheel drive vehicles)

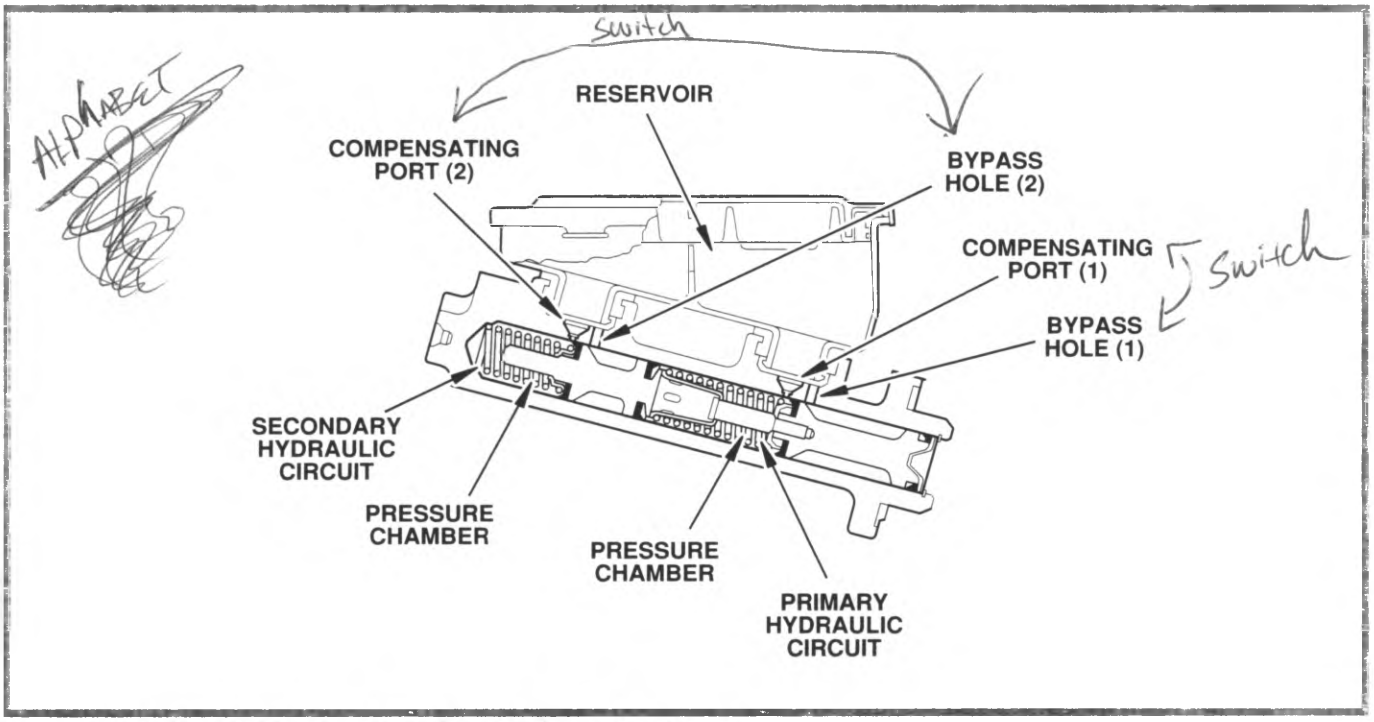


Figure 4-2, **Dual Master Cylinder (Cross-Section)**

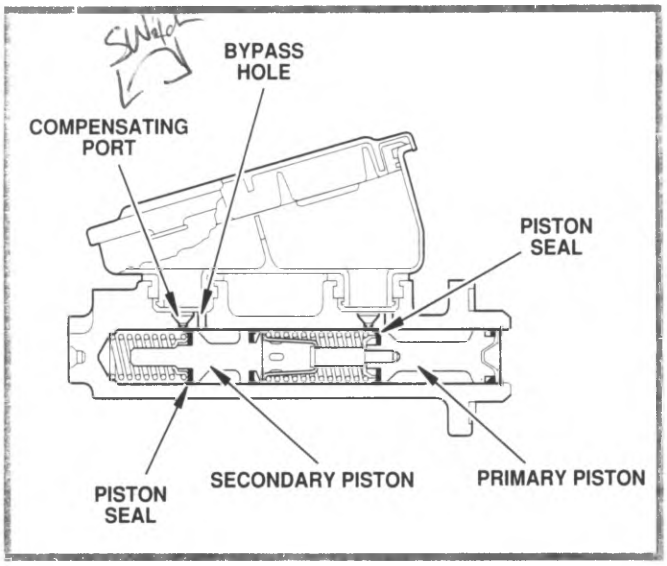


Figure 4-3, **Bypass Hole and Compensating Port**

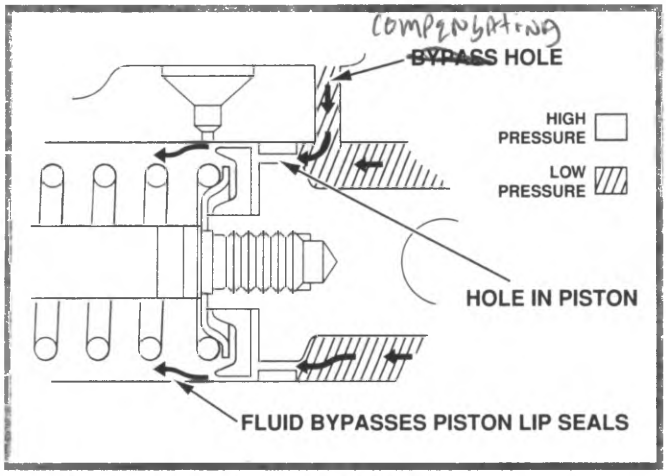


Figure 4-4, **Bypass Operation**

Pistons

The master cylinder contains two pistons, each connected to a hydraulic channel (figure 4-3).

- Primary piston (rear piston, operated by the pedal linkage)
- Secondary piston (front piston, operated by the primary piston)

The pistons pressurize the brake fluid in the hydraulic channels to each wheel brake.

Compensating Port

When the master cylinder pistons are in the at-rest position (no braking), the piston seals uncover the compensating ports and open the passages between the reservoir and the wheel brake channel.

- Allow for normal expansion and contraction of brake fluid due to changes in temperature

During braking, the piston seals close the passage to the reservoir, causing pressure to build in the hydraulic channel.

Bypass Hole

The bypass hole is another passage between the reservoir and the master cylinder chambers. The bypass hole is open to the low pressure side of the pistons.

The bypass hole:

- Allows the master cylinder pistons to return to the at-rest position rapidly

During brake release:

- Strong springs retract the pistons faster than the brake fluid can return through the hydraulic channels. The rapid piston movement could create a vacuum in the master cylinder high pressure and low pressure chambers, delaying brake release
- The bypass holes allow brake fluid from the reservoir to fill the low pressure chambers
- The brake fluid from the low pressure chambers passes through holes in the pistons and bypasses the piston lip seals (figure 4-4)

This action prevents a vacuum in the high pressure chamber which could delay release of the brakes. This could also happen if the seals are installed backwards.

Quick Take-Up Valve

The quick take-up valve is utilized with low-drag disc brake calipers. Low-drag calipers retract the caliper piston slightly after brake release. This reduces brake drag. The quick take-up valve supplies the calipers with a large volume of fluid:

- At low pressure
- With initial brake application

This results in the immediate engagement of all the brakes with relatively little brake pedal travel.

The quick take-up valve is installed in specially designed master cylinders with a large low pressure chamber for the primary piston. On initial brake application:

- The quick take-up valve seals the compensating port passage between the low pressure chamber and the brake reservoir (figure 4-5)
- The movement of the primary piston forces brake fluid to bypass the primary seals. The fluid is directed to the brake calipers. The high volume also forces the secondary piston forward, taking up the brake clearances in the secondary circuit

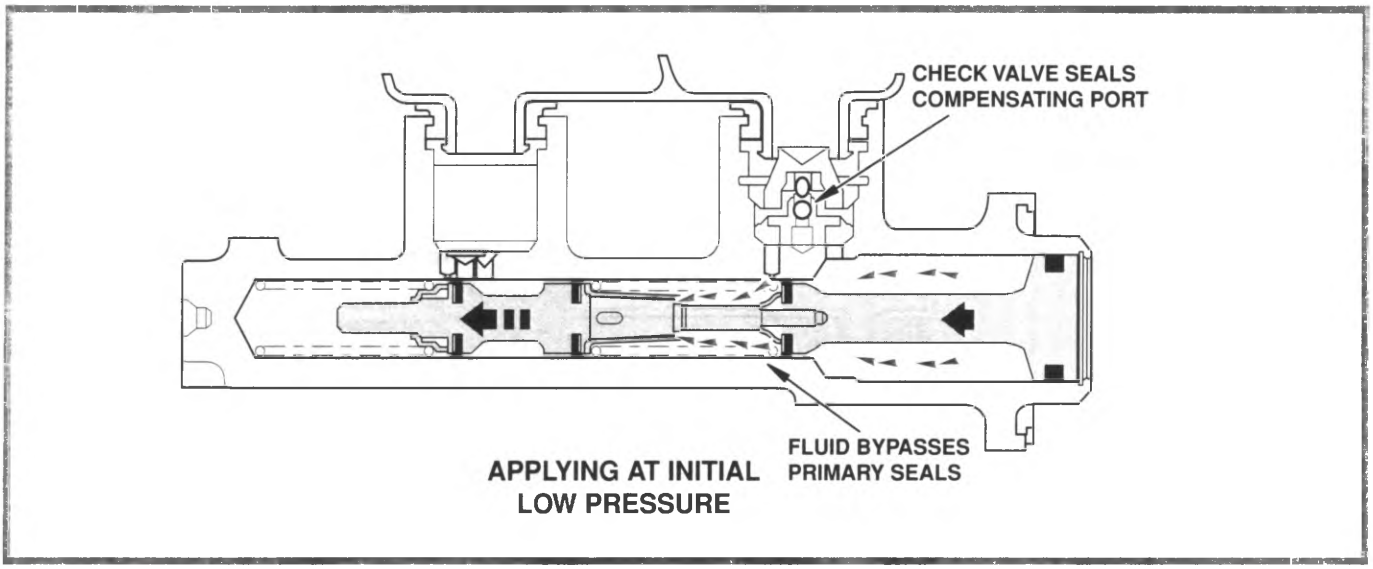


Figure 4-5, **Applying at Initial Low Pressure**

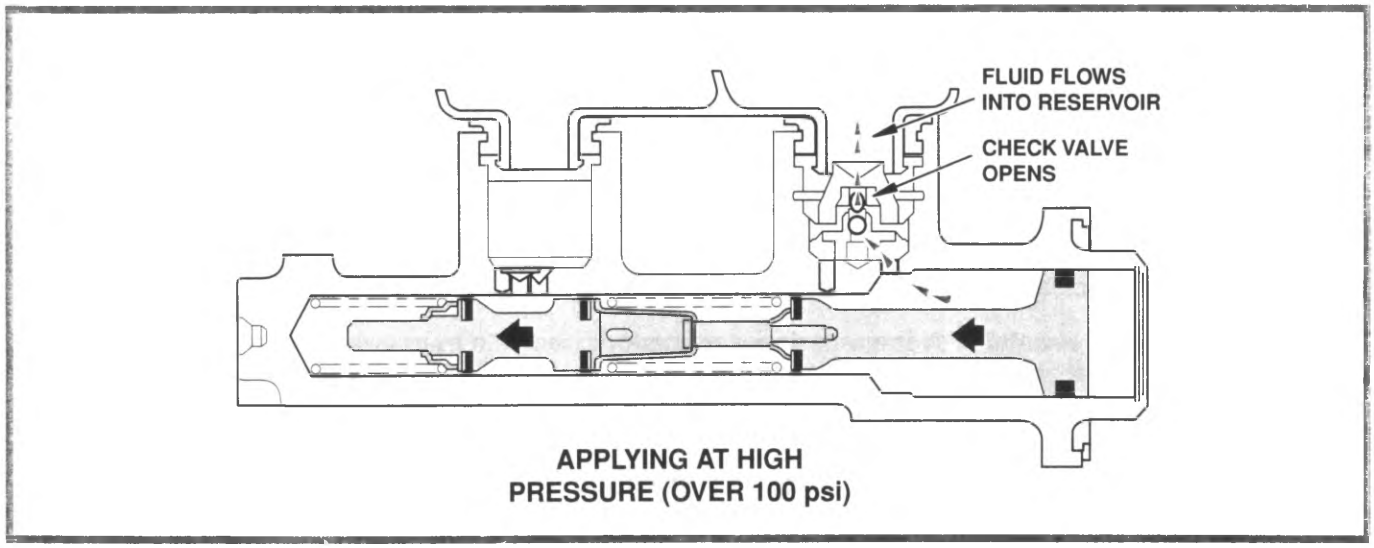


Figure 4-6, **Applying at High Pressure**

- When the low-pressure chamber reaches about 100 psi, the spring-loaded check ball in the quick take-up valve opens, allowing brake fluid into the reservoir (figure 4-6)

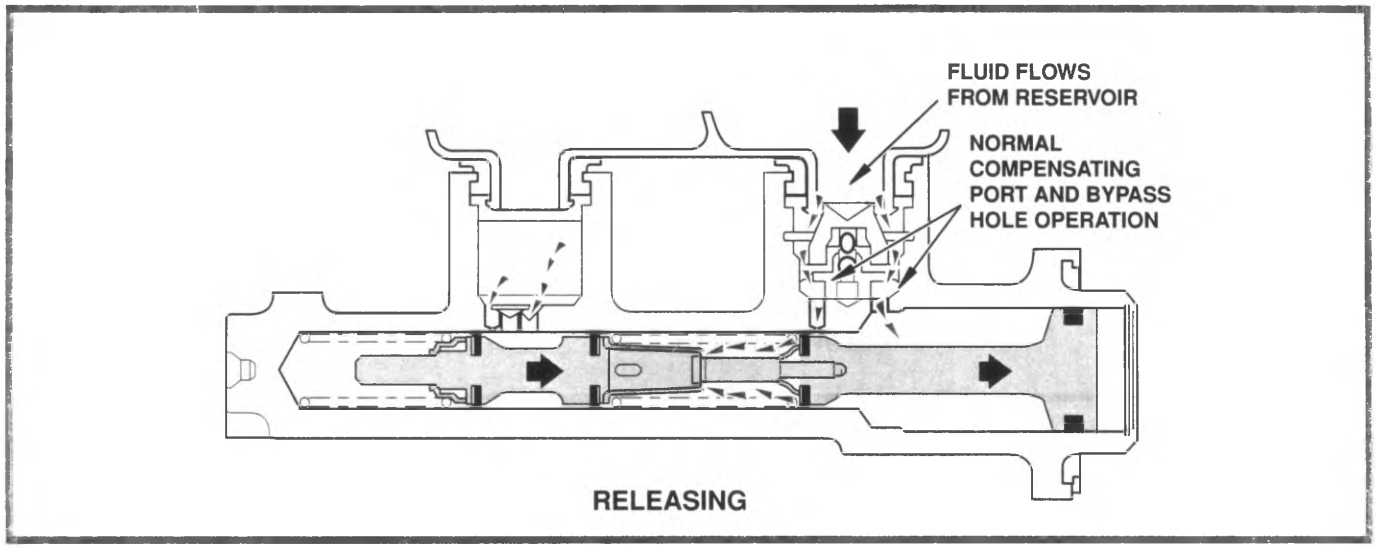


Figure 4-7, **Brake Release**

- On brake release, the quick take-up valve allows the bypass hole and compensating port to operate normally (figure 4-7)

A stuck open check valve inside the quick take-up valve could cause extended brake pedal travel.

Master Cylinder Overhaul

Disassembly Procedure

— NOTICE —

Do not hone the master cylinder bore when the brake master cylinder is overhauled. It is recommended that the cylinder be replaced rather than CLEANED UP by honing the bore. The master cylinder has a hard, highly polished BEARINGIZED surface, which is produced by diamond boring followed by ball or roller burnishing under heavy pressure. Honing will destroy this hard smooth surface and cause rapid wear of the rubber cups.

1. Remove the cover (figure 4-8).
2. Remove the diaphragm.
3. Drain the brake fluid from the reservoir.
4. Remove the reservoir and two grommets from the master cylinder body.
5. Clamp the master cylinder mounting flange in a vise.
6. Remove the snap ring.
7. Remove the primary piston assembly from the master cylinder body (figure 4-9).

— CAUTION —

IF AIR PRESSURE IS USED TO REMOVE THE SECONDARY PISTON, PLACE THE OPEN END OF THE CYLINDER BORE APPROXIMATELY 25 MM (1 IN.) FROM A PADDED WORKBENCH OR OTHER SURFACE TO CATCH THE PISTON WHEN IT COMES OUT OF THE BORE. APPLY LOW AIR PRESSURE VERY CAREFULLY TO EASE THE PISTON OUT OF THE BORE. NEVER POINT THE OPEN END OF THE BORE AT ANYONE WHEN APPLYING AIR PRESSURE. THE PISTON MAY COME OUT OF THE BORE WITH CONSIDERABLE FORCE AND CAUSE PERSONAL INJURY. USE ONLY DRY, NON-LUBRICATED AIR WHEN REMOVING COMPONENTS.

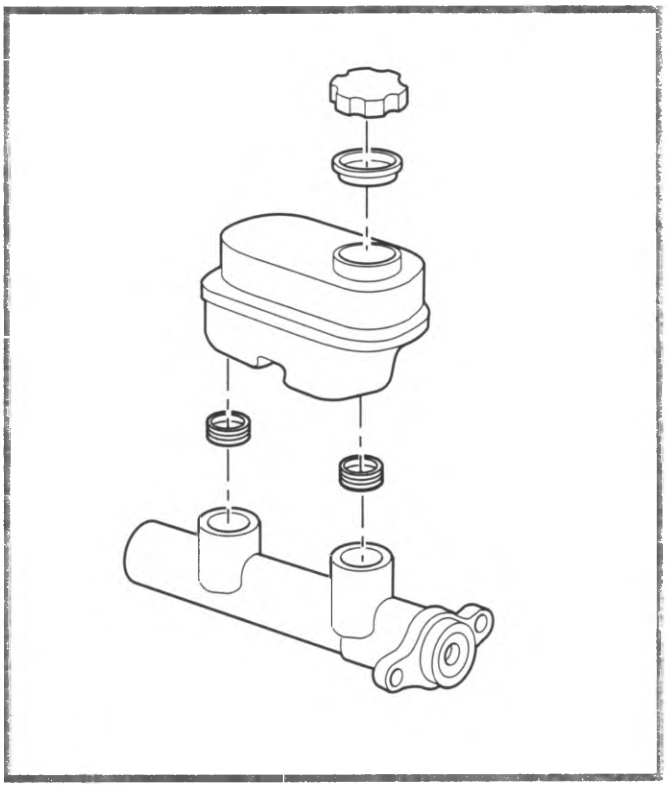


Figure 4-8, **Master Cylinder**

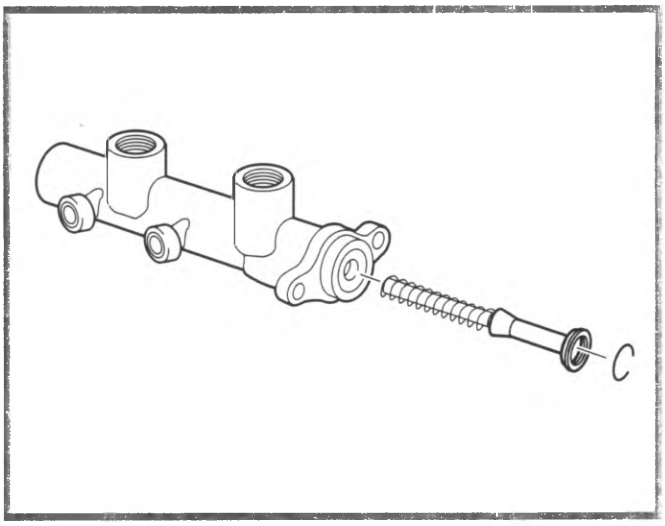


Figure 4-9, **Remove Primary Piston**

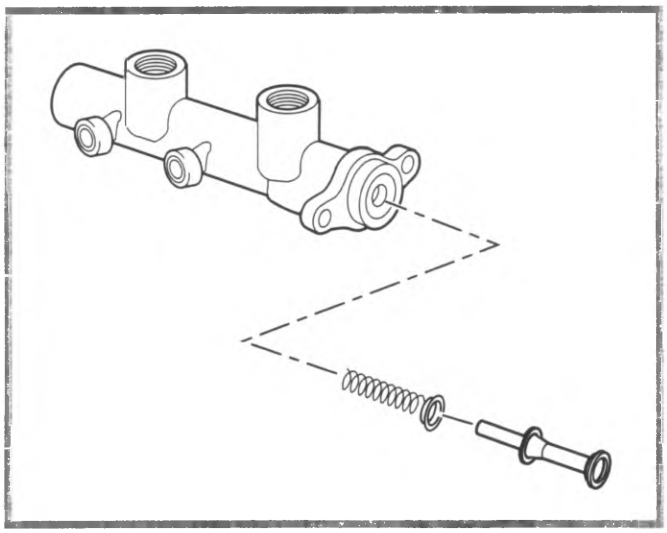


Figure 4-10, **Remove Secondary Piston**

8. Remove the secondary piston from the master cylinder body (figure 4-10). Plug the rear port, and apply a small amount of air pressure to the front port.
9. Remove the seals.
10. Remove the spring retainer and the spring from the master cylinder body.

— NOTICE —

Use approved solvents only when cleaning or flushing the master cylinder and related components. The use of these liquids as cleaning solvent will damage the rubber parts in the system if they have any trace of mineral oil or other contaminants.

11. Clean all the parts using the following procedure:
    - Clean the metal parts in denatured alcohol
    - Clean the rubber parts in clean brake fluid
12. Check the diaphragm for cuts, cracks, or swelling.
13. Inspect the cylinder bore for scoring or corrosion.
    - Replace the master cylinder if corrosion is present
    - Do not attempt to hone the cylinder bore
14. Inspect piston seal and surfaces for damage. Replace pistons as necessary.
15. Check the reservoir for cracks.

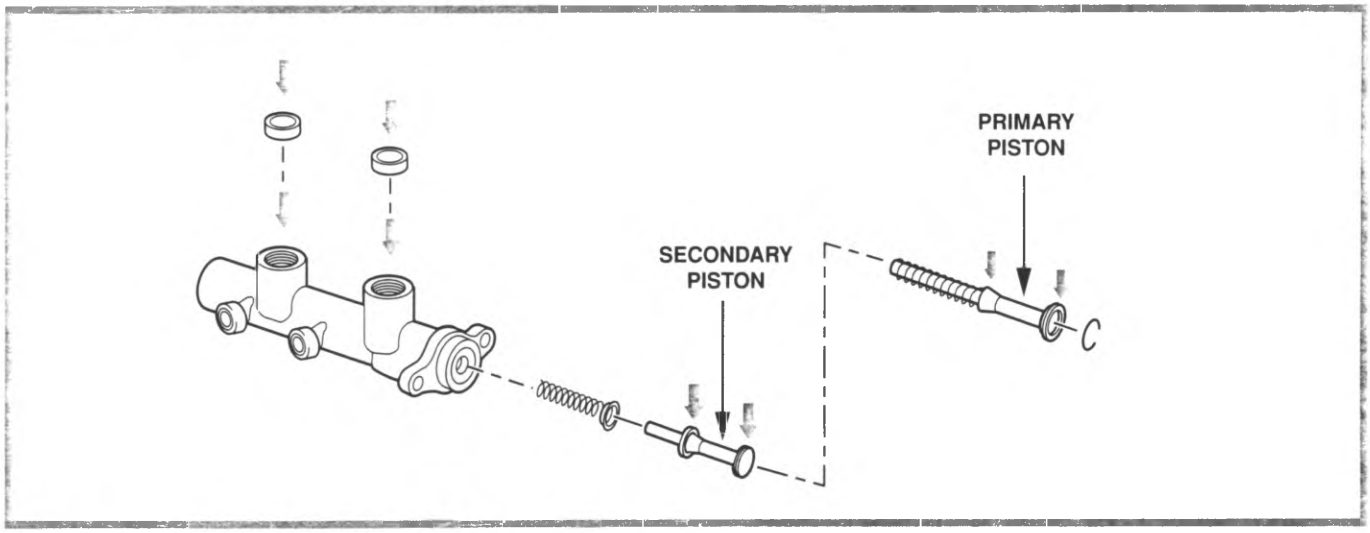


Figure 4-11, **Lubricate Components**

Assembly Procedure

1. Lubricate the grommets, seals and the cylinder bore with clean brake fluid (figure 4-11).
2. Use new seals when assembling the master cylinder.
3. Install the spring.
4. Install the spring retainer.
5. Install the primary seals on the secondary piston (figure 4-12).
6. Install the secondary seal on the secondary piston.
7. Install the secondary piston in the master cylinder body.
8. Install the primary piston assembly in the master cylinder body.
9. Install the snap ring.
10. Compress the primary piston in order to install the snap ring.
11. Install two new grommets to the master cylinder.
12. Install the reservoir on the master cylinder body.
13. Install the diaphragm in the cover.
14. Install the cover on the reservoir.

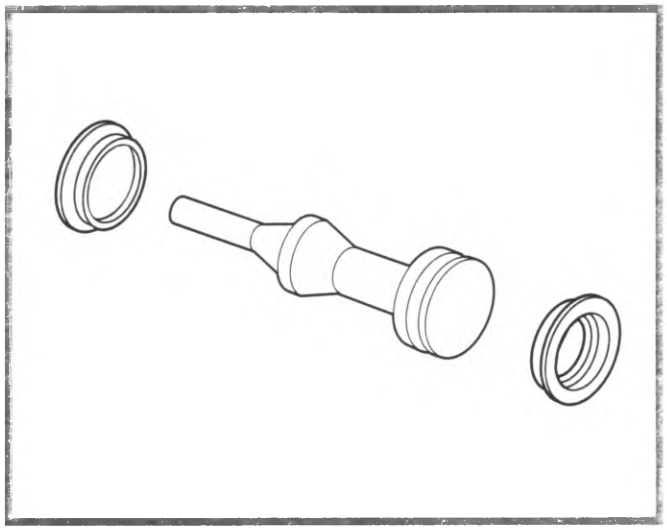


Figure 4-12, **Install Seals**

Master Cylinder Bench Bleeding

Bench bleed the master cylinder before installation on the vehicle. Bench bleeding removes air from the master cylinder. Bench bleeding reduces the time required to bleed the brake hydraulic system after installation.

1. Plug the outlet ports. Mount the master cylinder in a vise with the front end slightly down.
2. Fill the master cylinder reservoir with clean brake fluid.
3. Stroke the primary piston about 25 mm (1 in.) several times using a smooth round-end tool. The primary piston will not travel the full 25 mm (1 in.) stroke as air bleeds from the master cylinder.
4. Reposition the master cylinder in the vise with the front end tilted slightly up.
5. Stroke the primary piston about 25 mm (1 in.) several times again.
6. Reposition the master cylinder in the vise. The master cylinder should be level.
7. Loosen the plugs in the outlet ports one at a time. Then push the piston into the bore in order to force the air from the cylinder.
8. Tighten the plug(s) before allowing the piston to return to its original position. This prevents air from being drawn back into the cylinder.
9. Fill the master cylinder reservoir with clean brake fluid.
10. Follow normal bleeding procedures after installing the master cylinder.

— IMPORTANT —

Do not clamp the bore in a vice. Use the mounting flange ears when clampIng the master cylinder in a vice.

Brake Fluid Reservoir

The brake fluid reservoir houses brake fluid for the master cylinder and includes separate chambers for the primary and secondary pistons (figure 4-13).

For many years, reservoirs were cast as part of the master cylinder. Newer composite plastic reservoirs are press fit onto the master cylinder.

In many applications, brake fluid level sensors are integral with the composite reservoir or part of the reservoir cap.

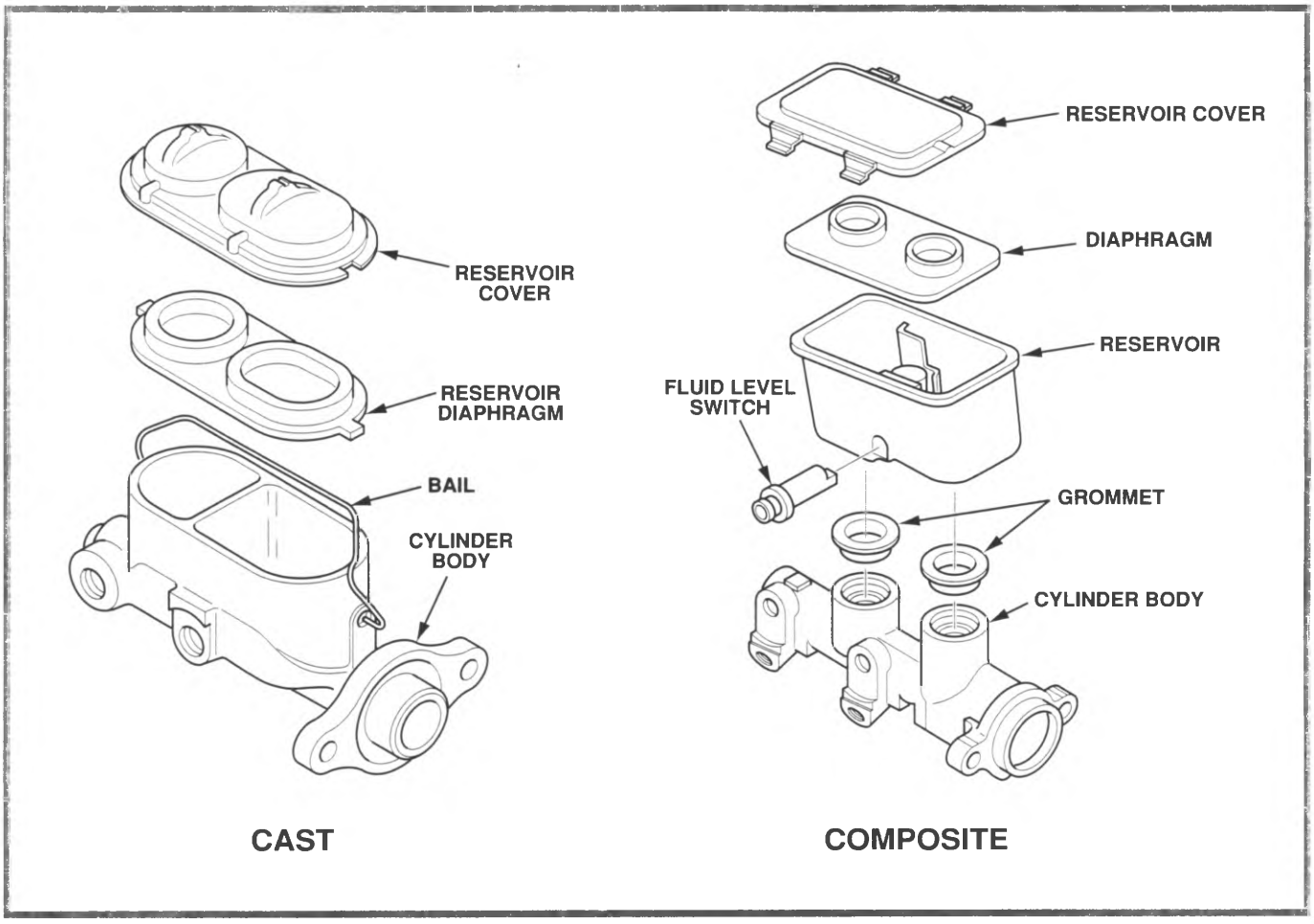


Figure 4-13, **Brake Fluid Reservoirs**

During visual inspection, be sure to take note of the condition of the diaphragm.

— CAUTION —

A SWOLLEN DIAPHRAGM MAY INDICATE CONTAMINATED BRAKE FLUID. REPLACE ALL RUBBER PARTS IN THE SYSTEM, INCLUDING HOSES AND FLUSH THE ENTIRE HYDRAULIC SYSTEM.

If fluid level is low, there may be a system leak or worn out brake pads. For additional information, refer to the Brake Pad Wear Compensation section of this booklet.

Brake Fluid

— CAUTION —

USE ONLY DOT 3 BRAKE FLUID. DO NOT USE DOT 5 (SILICONE) FLUID.

Contamination During Service

Corrosion and particles in the brake hydraulic system quickly destroy the sealing effectiveness of pressure cylinders (master cylinder, wheel cylinder, caliper). Careful work habits during hydraulic service will help prevent contamination of the hydraulic system. Brake fluid can damage painted surfaces. Remember to use care when handling fluids.

- Use only clean DOT 3 brake fluid when assembling hydraulic components
- Never use petroleum-based cleaners for hydraulic components. Use only approved brake cleaning products such as denatured alcohol
- Do not dry components with lubricated shop air
- Service hydraulic components on a clean work bench, away from grinders, sanders and other particle-generating equipment
- Store brake fluid in a sealed container. Brake fluid absorbs moisture. Moisture and water can damage hydraulic components

— CAUTION —

CONTAMINATION OF THE BRAKE HYDRAULIC FLUID WITH PETROLEUM-BASED PRODUCTS CAN RESULT IN SYSTEM FAILURE.

Brake Pipes

All GM vehicles utilize one of two methods of brake line connection flaring (figure 4-14):

- ISO (International Standards Organization)
- Double flare

— CAUTION —

ALWAYS USE DOUBLE WALLED, STEEL BRAKE PIPE WHEN SERVICING BRAKE PIPES. ANY OTHER PIPE IS NOT RECOMMENDED AND MAY CAUSE BRAKE SYSTEM FAILURE. CAREFULLY ROUTE AND RETAIN REPLACEMENT BRAKE PIPES. ALWAYS USE THE CORRECT FASTENERS AND THE ORIGINAL LOCATION FOR REPLACEMENT BRAKE PIPES. FAILURE TO CORRECTLY ROUTE AND RETAIN BRAKE PIPES MAY CAUSE DAMAGE TO THE BRAKE PIPES AND CAUSE BRAKE SYSTEM FAILURE.

— IMPORTANT —

Installing brake lines requires proper routing and torque specifications. If a flare nut is overtightened, the fitting could collapse causing a fluid restriction (figure 4-15). Over-flaring could result in fitting distortion.

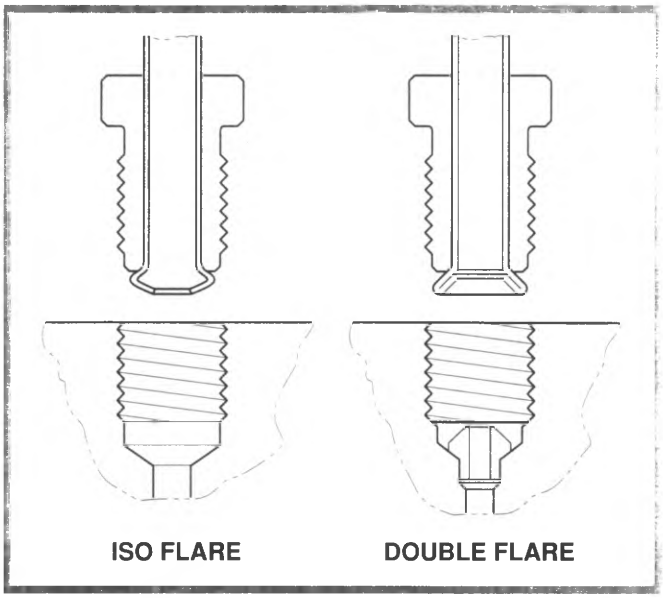


Figure 4-14, **Brake Pipe Flares**

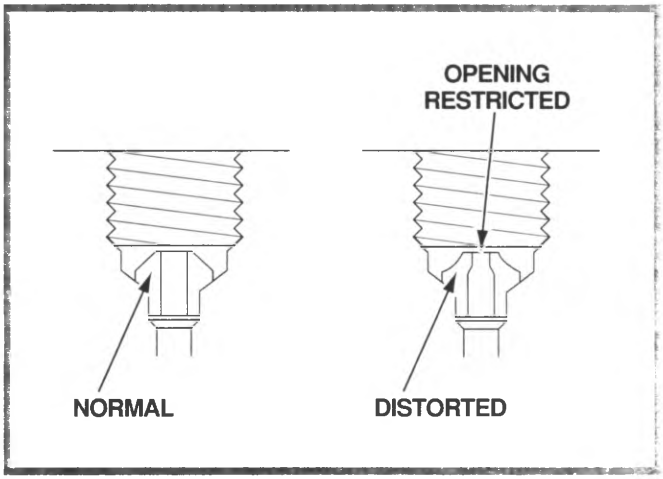


Figure 4-15, **Double Flare Fitting Distorted by Overtightening**

Fabricating and Installing Brake Pipes

All GM vehicles utilize one of two methods of line flaring:

- ISO
- Double flare

ISO Flare

ISO flaring brake pipes requires:

- J 29803-A ISO Flaring Kit
- Hack saw
- Deburring tool
- Vise
- Wrench

— CAUTION —

ALWAYS USE DOUBLE WALLED, STEEL BRAKE PIPE WHEN SERVICING BRAKE PIPES. ANY OTHER PIPE IS NOT RECOMMENDED AND MAY CAUSE BRAKE SYSTEM FAILURE. CAREFULLY ROUTE AND RETAIN REPLACEMENT BRAKE PIPES. ALWAYS USE THE CORRECT FASTENERS AND THE ORIGINAL LOCATION FOR REPLACEMENT BRAKE PIPES. FAILURE TO CORRECTLY ROUTE AND RETAIN BRAKE PIPES MAY CAUSE DAMAGE TO THE BRAKE PIPES AND CAUSE BRAKE SYSTEM FAILURE.

1. Obtain the recommended pipe and fittings of correct size. Use the outside diameter of the pipe to specify size.
2. Cut the pipe square and to length with a hack saw. Correct length is determined by measuring the old pipe using a string and adding 0.125 in. (3.2 mm) for each flare.
3. Install fittings on the pipe before starting the flare.
4. Tubing to be flared must have a square cut end and cleanly deburred inside and outside.
5. Chamfer the inside and outside diameter of the pipe with the deburring tool.

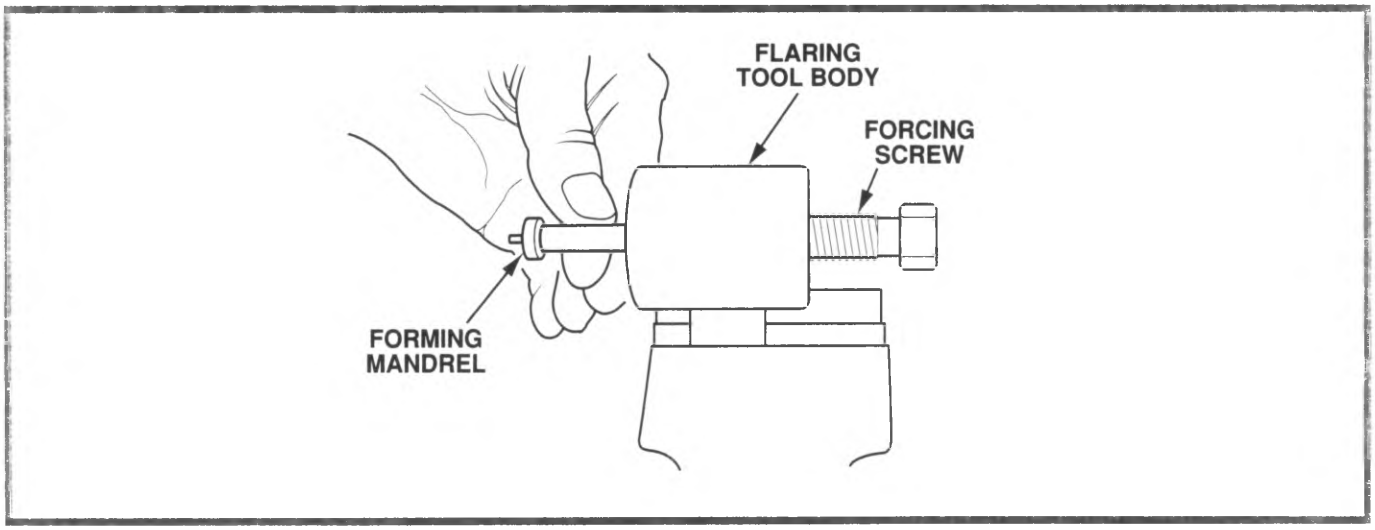


Figure 4-16, **Forming Mandrel and Forcing Screw for ISO Flare**

6. Remove all traces of lubricant from the brake pipe and flaring tool.

— IMPORTANT —

Flush the inside and outside of the brake line with a non-volatile solvent. Remove all contaminants from the cutting and deburring process.

7. Clamp the flaring tool body in a vise.
8. Select the correct size collet and forming mandrel for the pipe size used.
9. Insert the correct forming mandrel into the tool body (refer to figure 4-16). Hold the forming mandrel in place with your finger and thread in the forcing screw until it makes contact and begins to move the forming mandrel. Turn the forcing screw back one complete turn after contact is made.
10. Slide the clamping nut over the brake pipe and insert the prepared brake pipe into the correct collet (figure 4-17). Leave approximately 0.75 in. (19 mm) of tubing extending out the collet. Insert the assembly into the tool body. The brake pipe end must contact the face of the forming mandrel.
11. Tighten the clamping nut into the tool body.

— IMPORTANT —

If the clamping nut is not securely tightened, the pipe may push out and the flare will not correctly form.

12. Wrench tighten the forcing screw until noticeable resistance is felt.

— NOTICE —

Do not over-tighten the forcing screw or the flare may become oversized.

13. Back the clamping nut out of the tool body and disassemble the clamping nut and collet assembly.
14. Measure the flare diameter (figure 4-18). It should fall between 0.272 in. to 0.286 in. (6.92 mm and 7.28 mm).
15. Bend the pipe assembly to match the old pipe. Clearance of 0.75 in. (19 mm) is required for all moving or vibrating parts.

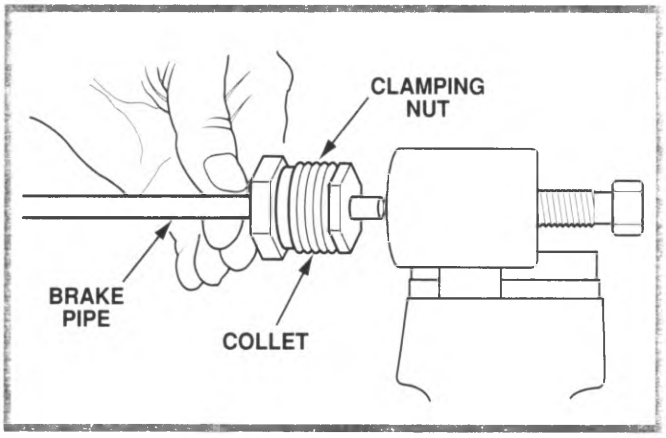


Figure 4-17, **Clamping Nut and Collet**

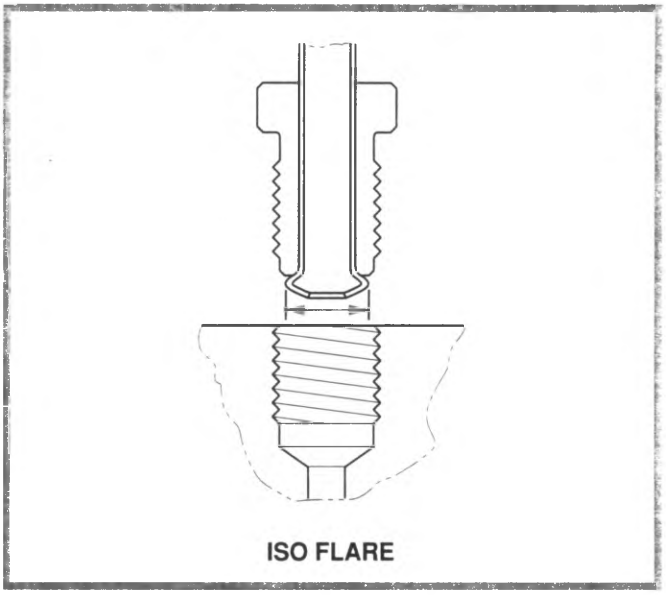


Figure 4-18, **ISO Flare**

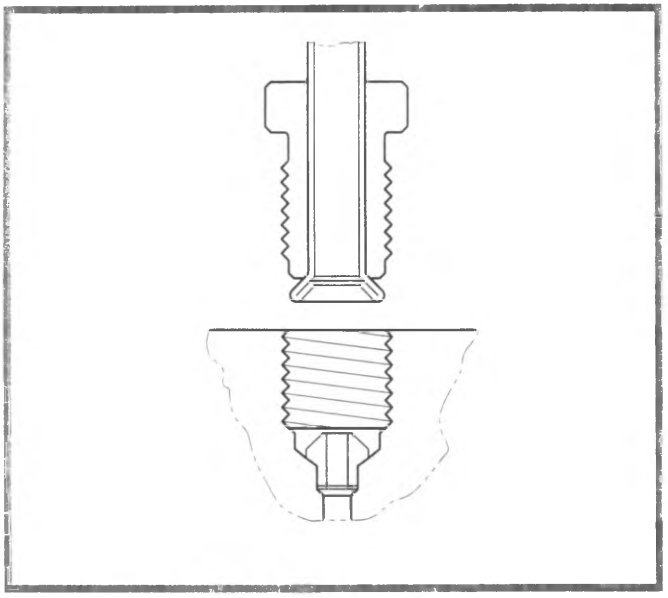


Figure 4-19, **Double Flare**

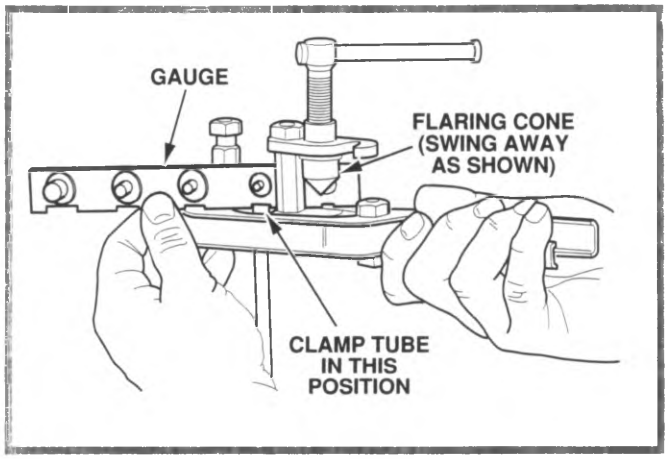


Figure 4-20, **Position Tubing**

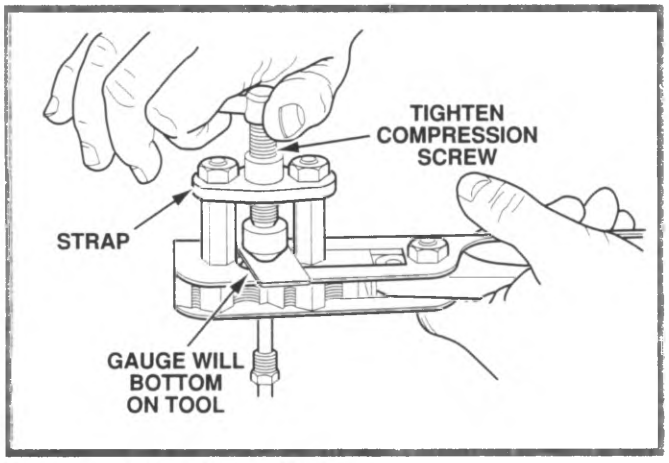


Figure 4-21, **First Flare**

Double Flare

Double flaring brake pipe requires (figure 4-19):

- J 23530 Brake Line Flaring Tool
- Pipe Cutter
- Deburring Tool

1. Obtain the recommended pipe and fittings of correct size. Use the outside diameter of the pipe to specify size.
2. Cut the pipe to length with a pipe cutter. Correct length is determined by measuring the old pipe using a string and adding 0.125 in. (3.2 mm) for each flare.
3. Install fittings on the pipe before starting the flare.
4. Tubing to be flared must have a square cut end and cleanly deburred inside and outside.
5. Raise the flaring cone to its highest position above the tubing clamp blocks. Swing the flaring cone away as shown.
6. Open the lever handle then slide the hexagonal tube lights toward the tool's handle. Rotate the two hexagonal blocks to the desired size.
7. Insert the tube into the opening between the two hexagon clamp blocks. Position the tube so that its end is level with the top of the gauge (figure 4-20). Clamp the tube in position by closing the small lever handle.
8. Insert the proper gauge pin into the tube and swing strap into position. Tighten compression screw until gauge bottoms on tool (figure 4-21).
9. Unscrew the compression screw swing strap to one side and remove gauge.

10. Swing strap back into position, then tighten compression screw to complete the double-lap flare (figure 4-22).
11. Unscrew compression screw and open lever handle.
12. Inspect flared ends for splits, cracks, pits or out of round that could cause leaks.

— IMPORTANT —

Installing brake lines requires proper routing and torque specifications. If a flare nut is overtightened, the fitting could collapse causing a fluid restriction (figure 4-23). Over-flaring could result in fitting distortion.

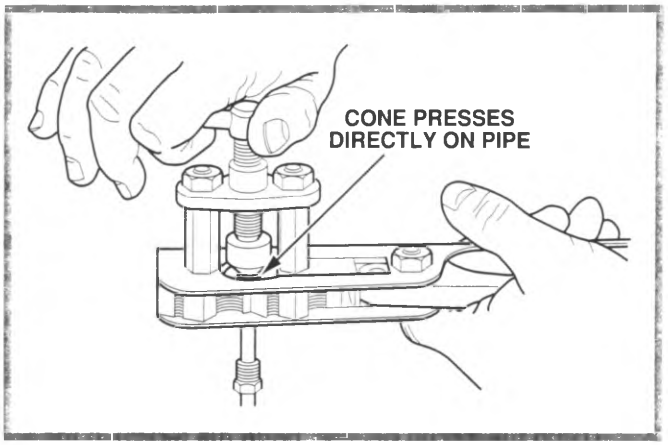


Figure 4-22, **Second Flare**

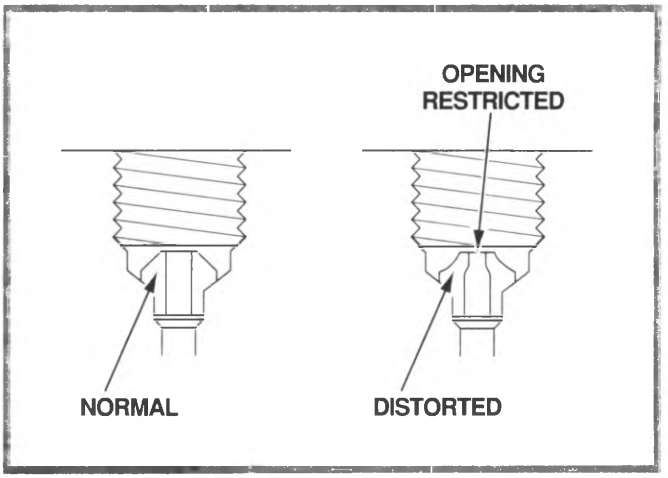


Figure 4-23, **Fitting Distorted by Overtightening**

Brake Pipe Bending

When repairing a brake pipe, a tube may have a multiple number of bends and turns. In order to be able to duplicate the existing brake pipe, bending the new brake pipe is usually necessary.

— IMPORTANT —

Do not kink the pipe as it is being formed or bent.

The preferred method of forming/bending is using a tubing bender of the appropriate size and a piece of stiff wire.

1. Form the stiff wire in the shape of the line to be fabricated on the vehicle, as the existing line may be bent upon removal.
2. Using the tubing bender, bend the tubing in the shape of the stiff wire (figure 4-24).
   Note: Slight bending of the tubing by hand to enhance the fit is acceptable.
3. Move the backplate handle and connecting bar assembly around the forming head until the connecting bar stops on the holding bar. The handles should form a 90 degree angle.
4. Place the straight tubing between the appropriate sized grooves on the forming head and the holding bar.
5. Rotate the backplate and handle until contact is made with the tubing and the calibration marks align at zero (tube bending will start at the "0" calibration point).
6. Move the backplate around the forming head until the desired angle is attained as indicated by the alignment of the calibration marks.
7. When all the bends are in place, flare the ends of the line (install the flare nuts first).
   Note: In some cases, for a very tight radius, the flare must be done on one end of the tubing first, then the flare nut installed and finally, the bending process begins.
8. Install the new brake line, tighten the fittings, bleed the system and check for leaks.

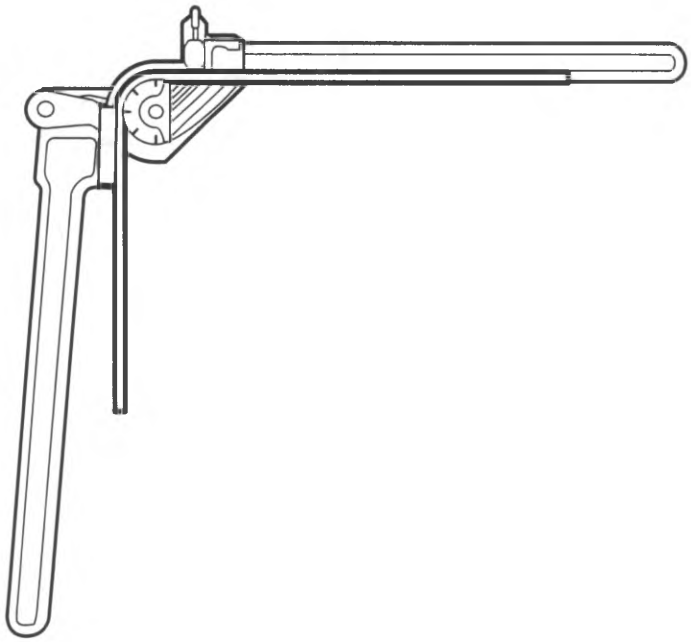


Figure 4-24, **Brake Pipe Tube Bender**

Brake Hoses

Brake hoses distribute brake fluid to the wheel brakes (figure 4-25). The flexible hoses allow movement of the suspension, as well as allow the front wheels to turn as the driver steers the vehicle.

When performing brake service:

- Inspect the hoses for damage, kinks or ballooning
- Inspect hoses for proper routing
- Never hang a brake caliper from the rubber hose

A defective or damaged hose could balloon, acting like an accumulator, causing the vehicle to pull during braking or a low pedal concern.

A blocked, restricted, or kinked brake hose could also cause the vehicle to pull during braking.

- A left front hose that is blocked, restricted, or kinked could cause a pull to the right during braking
- A right front hose that is blocked, restricted, or kinked could cause a pull to the left during braking

When replacing rubber hoses, be sure to also replace the copper sealing washers to the calipers.

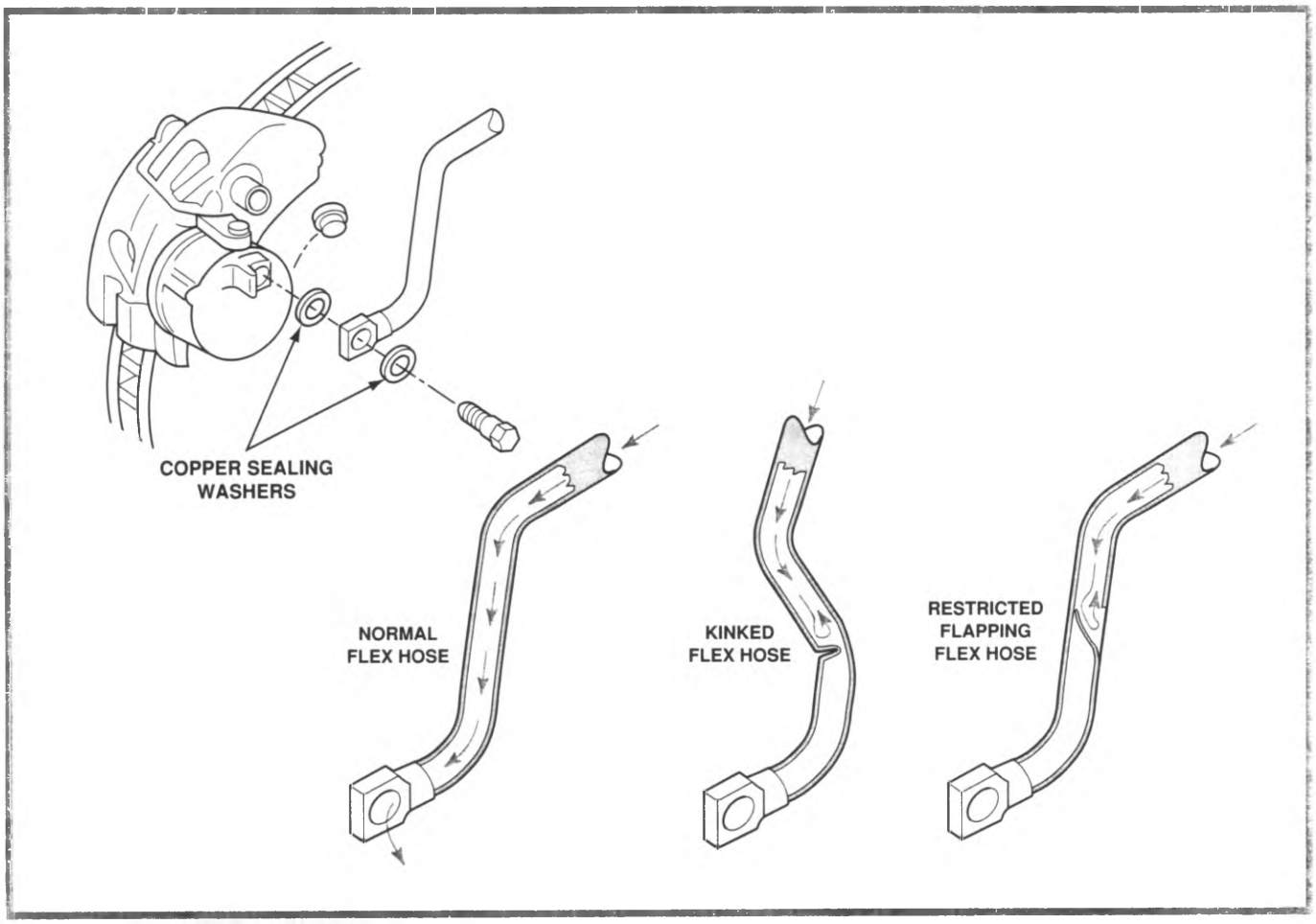


Figure 4-25, **Brake Hose and Failure Modes**

Bleeding Procedures

When the hydraulic system is open to the atmosphere for repairs or due to a leak, bleed the system to remove the air. Unlike liquid, air is compressible which could cause a spongy pedal and inefficient brake application.

See the appropriate service information for wheel circuit bleeding procedures.

This section lists two ways to bleed air from the hydraulic system:

- Manual bleeding
- Pressure bleeding

Manual Brake Bleeding

Manual bleeding requires two people:

- One to operate the brake pedal
- One to bleed the hydraulic system

— NOTICE —

Brake fluid can damage painted surfaces. Prevent brake fluid from contacting painted surfaces.

1. With the engine OFF, pump the brake several times to remove the power assist reserve.
2. Fill the master cylinder reservoir with brake fluid and keep it at least one-half full of fluid during the bleeding operation.
3. If the master cylinder has air in the bore, then it must be bled before any wheel cylinder or caliper.
4. With the proper box-end wrench over the wheel cylinder or caliper bleeder screw, attach a transparent hose to the bleeder connection. Submerge the end of the hose in clean brake fluid in a transparent container.
5. Press the brake pedal slowly and hold. Open the bleeder screw to purge the air from the system.
6. Close the valve, release the brake pedal, and wait 15 seconds.
7. Repeat steps 5 and 6 until all the air has been bled from the system.

Properly torque the bleeder screw, refill master cylinder to level, and replace top. Dispose of the used brake fluid safely.

— IMPORTANT —

Check service information before bleeding the hydraulic system.

Master Cylinder Bleeding

After master cylinder service and master cylinder bench bleeding, it is necessary to bleed the master cylinder again after it is installed on the vehicle.

1. Remove the brake line from the port at the front of the master cylinder.
2. Fill the reservoir until brake fluid runs out of the open port.
3. Reconnect the brake pipe to the master cylinder and tighten.
4. Press the brake pedal one time slowly and hold. Loosen the front brake pipe to purge the air from the cylinder. Wait 15 seconds, then repeat until all the air is purged from the cylinder.
5. Repeat for the rear connections.

Pressure Brake Bleeding

The following procedure refers to the Kent-Moore diaphragm brake bleeder, J 29532, or its equivalent (figure 4-26).

1. Install the correct bleeding adapter to the master cylinder.
2. Ensure that the pressure bleeder tank is at least one-third full of clean DOT 3 brake fluid.
3. Charge the pressure bleeder air tank to 140-175 kPa (20-25 psi).
4. Attach the hose to the master cylinder bleeder adapter and open the pressure tank fluid valve. Inspect for any leaks.
5. With the proper box-end wrench over the bleeder valve, attach a bleeder tube to the valve. The discharge end of the tube must be submerged in brake fluid in a clean transparent container.
6. Open the bleeder valve at least a three-quarter turn and allow the fluid to flow until bubbles stop flowing from the bleeder tube.
7. Close the bleeder valve. Be sure that it is properly sealed.
8. Repeat steps 5, 6 and 7 until all air has been bled from the system. Torque the bleeder screw to specification.
9. Close the pressure tank fluid valve, disconnect the bleeding equipment and adapters.
10. Refill the master cylinder reservoir and replace the top.

Dispose of the used brake fluid safely.

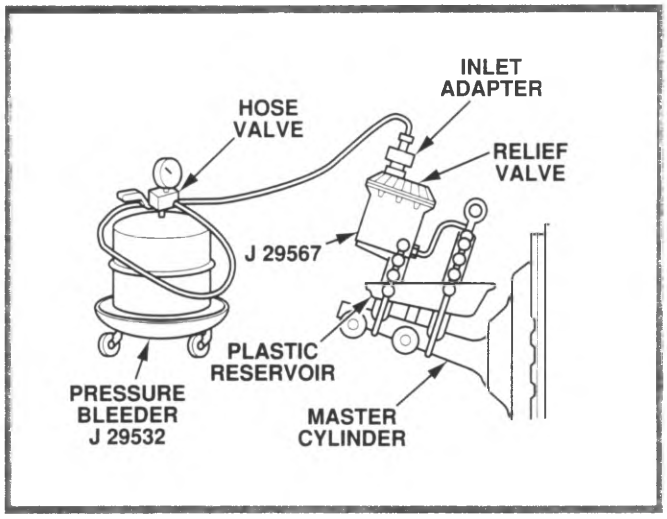


Figure 4-26, **Pressure Bleeding**

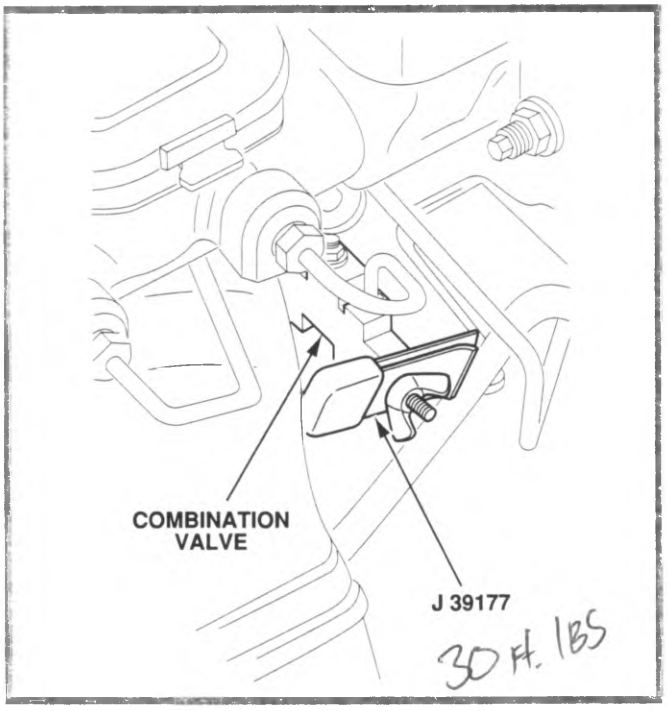


Figure 4-27, **Holding Metering Valve Stem**

Bleeding Brake Systems with a Combination Valve

The hydraulic pressure generated by manual bleeding is sufficient to open the metering valve in the combination valve and allow fluid to flow to the front calipers. This is not true when pressure bleeding. Therefore, it will be necessary to hold the valve stem open manually when pressure bleeding.

To hold the metering valve open, push the valve stem in. Do not use more than 25 pounds pressure to push the stem in. Otherwise the valve may be damaged. Tool number J 39177 (figure 4-27) may be used to hold the valve stem open, since it is specifically designed for this purpose. Do not use a screw clamp, wedges or blocks that may put excessive pressure on the valve stem.

5. Drum Brakes

Objectives

After completing this section, the student will be able to:

- Describe which special tools to use during drum brake service
- Demonstrate how to use the special tools during drum brake service
- Demonstrate how to prevent brake system contamination during service
- Perform brake drum inspection
- Perform brake drum service on duo-servo, leading-trailing, and advance leading-trailing systems
- Demonstrate the proper wheel lug tightening sequence
- Demonstrate how to use a torque limiter
- Explain wheel cylinder operation
- Describe the function of hold-down springs
- Describe self-adjuster operation

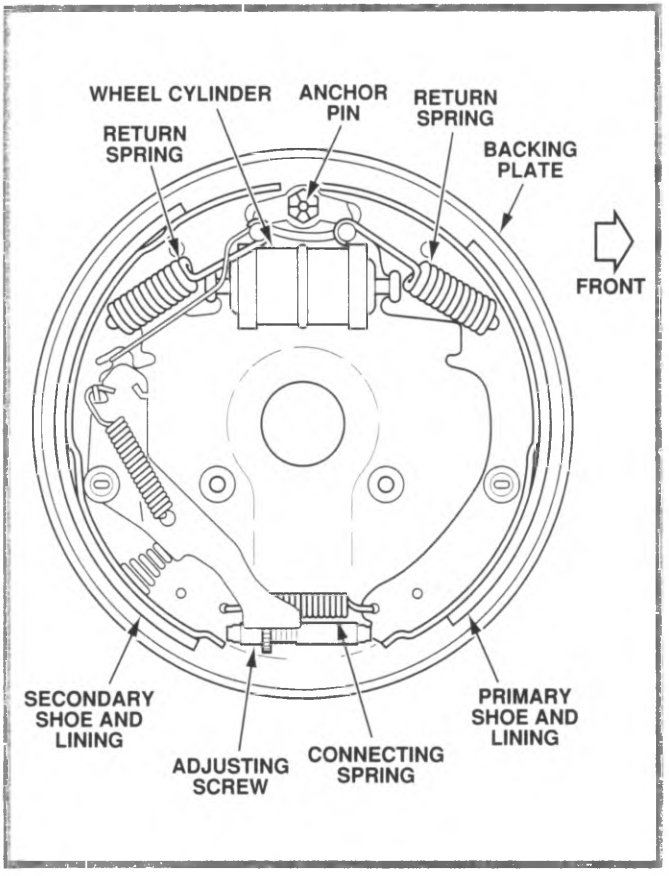


Figure 5-1, **Duo-Servo Drum Brake**

Drum Brakes

Drum brakes include two brake shoes mounted on a stationary backing plate. Return springs hold the shoes retracted.

There are three types of drum brakes used on GM vehicles:

- Duo-servo
- Leading-trailing
- Advanced leading-trailing

Duo-Servo Drum Brake

In the duo-servo unit, braking forces increase (energize) in both forward and reverse motion (refer to figure 5-1).

The energizing force transfers from one shoe to the other when the wheel rotates in either direction. A wheel cylinder actuates both the primary (front) and secondary (rear) brake shoes. Return springs hold the upper end of each shoe against a single anchor. An adjusting screw assembly and spring connect the lower ends of the shoes.

Duo-Servo Operation

The wheel cylinder mounts on the backing plate at the top of the brake. When the driver applies the brakes (figure 5-2):

1. Hydraulic pressure in the wheel cylinder forces both pistons outward to apply the brakes.
2. When the primary (forward) brake shoe contacts the rotating drum, the frictional forces drag the shoe and turn it outward from its pivot points.
3. The shoe is energized when it wedges into the drum with a force greater than the hydraulic pressure applied to the wheel cylinder.
4. The rotational force from the primary shoe transfers through the adjusting screw to the secondary shoe.
5. The shoe wedges against the drum with the same energizing action as the primary shoe.
6. The secondary shoe overcomes the wheel cylinder force and returns the secondary shoe to the anchor pin.

The secondary shoe performs more of the braking. Therefore, the secondary brake lining is usually thicker and has more surface area than the primary brake lining.

Self-Adjuster Operation

The self-adjuster on duo-servo brakes operates only after the vehicle has been driven in reverse and the brake has been applied and then driven in forward and the brake applied. This action causes the adjuster lever to rotate the adjuster wheel.

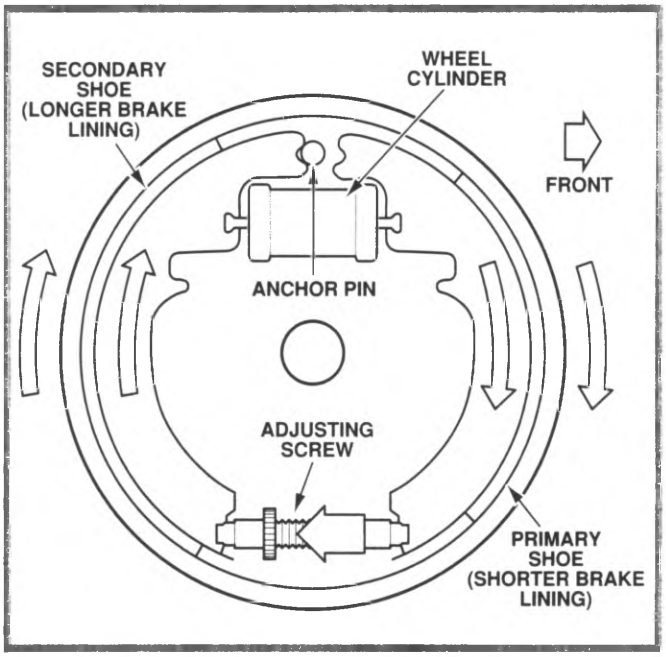


Figure 5-2, **Duo-Servo Operation**

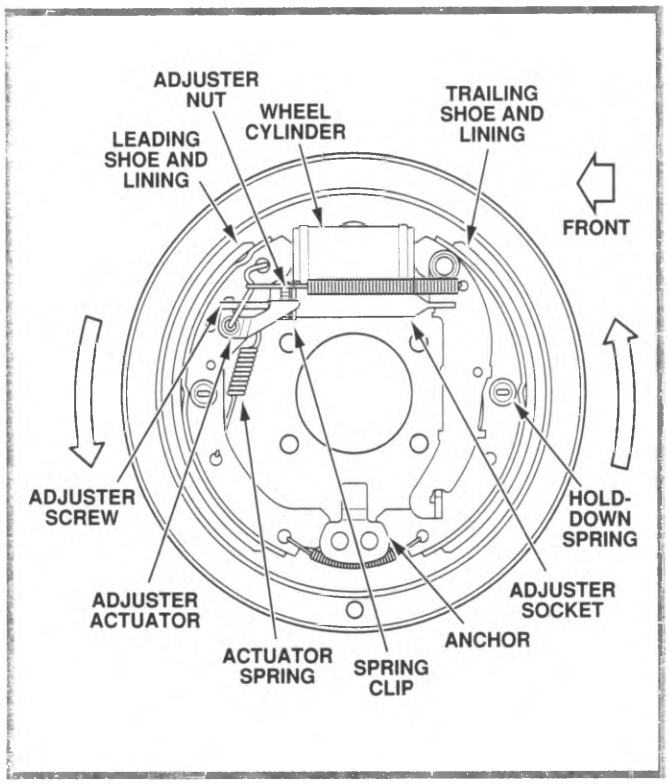


Figure 5-3, **Leading-Trailing Drum Brake**

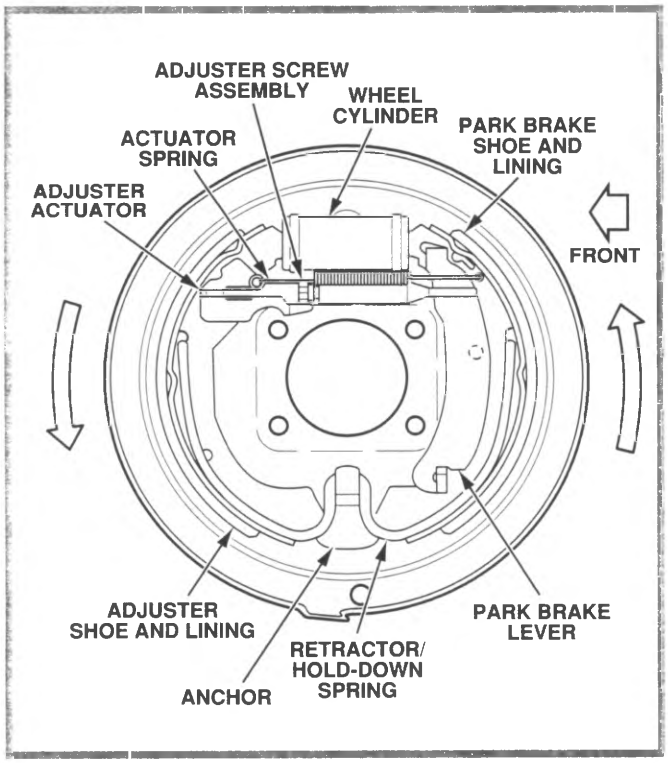


Figure 5-4, **Advanced Leading-Trailing Drum Brake**

Leading-Trailing Drum Brake

In the leading-trailing type of drum brake, the leading shoe performs the greater portion of the braking. Leading-trailing brakes have a fixed anchor at the bottom of the brake backing plate (figure 5-3).

Leading-Trailing Operation

On brake application during forward motion:

1. Wheel cylinder forces the lining of the leading (forward) shoe into contact with the rotating drum.
2. Friction between the drum and lining energizes the leading shoe and places pressure against the anchor pin at the bottom of the shoe. The forward shoe rotates outward until the drum prevents further outward movement.
3. The wheel cylinder also actuates the trailing (rear) shoe. Rotational force does not energize the trailing shoe. The friction force is the same as the input force from the wheel cylinder.

Advance Leading-Trailing Operation

The advanced leading/trailing drum brake (figure 5-4) operation is the same as the leading/trailing design except for the return and hold-down spring. Advance leading-trailing uses one component to work as the return and hold-down spring. This design extends lining life and reduces cost due to fewer components.

Wheel Cylinder

The wheel cylinder transfers hydraulic pressure from the master cylinder to the brake shoes.

The wheel cylinder is mounted on the brake backing plate and contains two pistons and seals (figure 5-5). Hydraulic pressure from the master cylinder moves the pistons outward, moving the brake shoes outward.

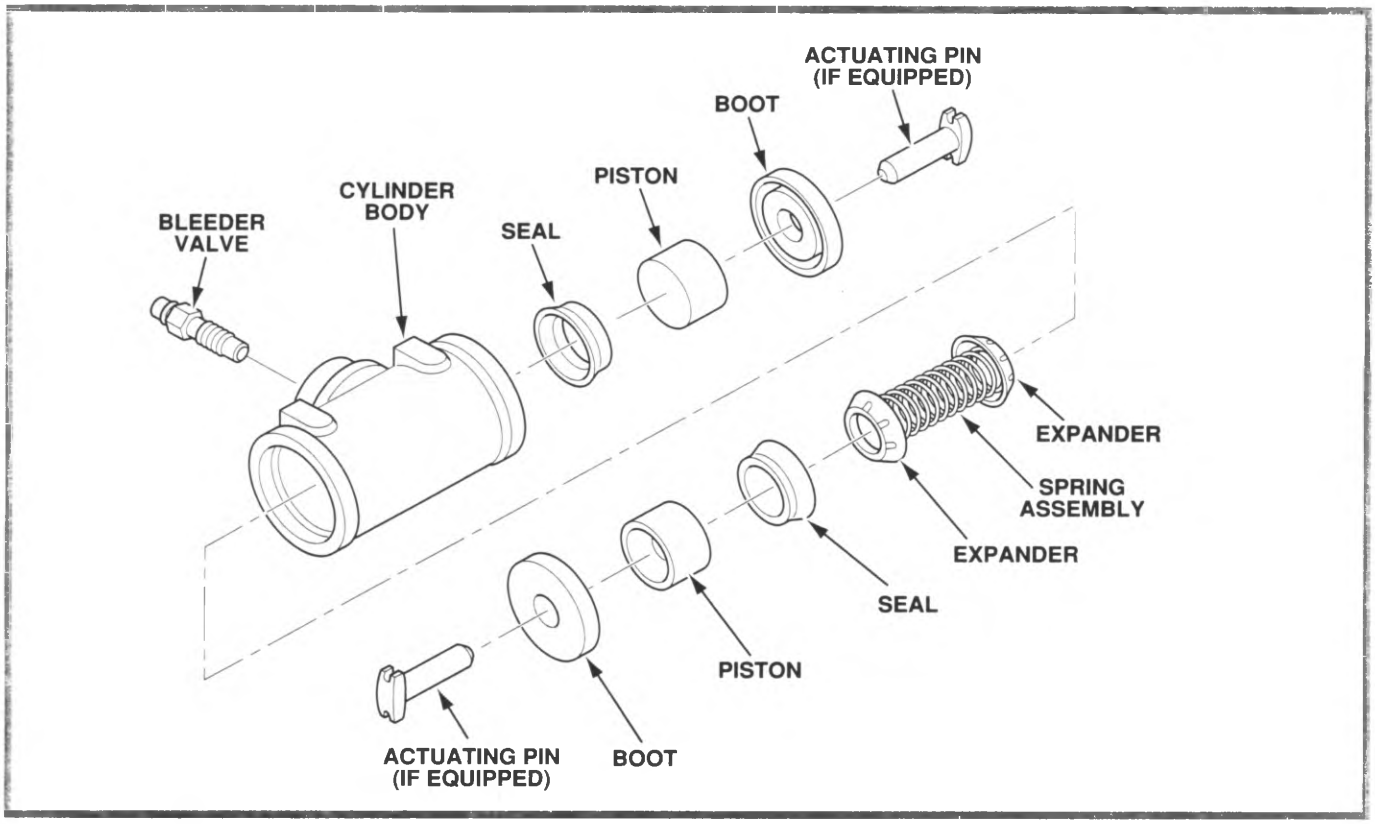


Figure 5-5, **Wheel Cylinder**

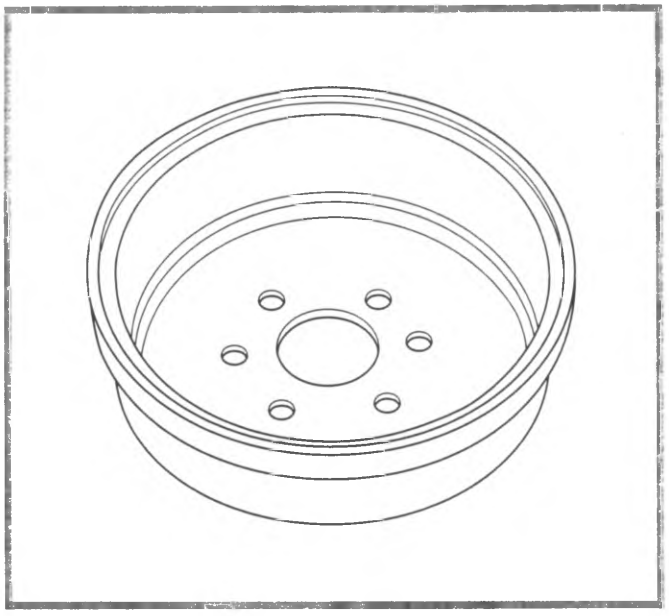


Figure 5-6, **Brake Drum**

Brake Drum

The brake drum provides a friction surface for the brake shoes to contact. It mounts to the axle shaft and physically stops the axle from rotating (figure 5-6).

Brake Drum Inspection

Inspect and measure brake drums when (figure 5-7):

- Replacing brake linings
- The following symptoms occur:
  - Pulsation
  - Chatter
  - Brakes too sensitive
  - Brake fade
  - Wheel drag
  - Springy/spongy pedal

Always be sure to measure brake drums in two or more places to ensure measurement accuracy.

Resurface drums if:

- Taper or out-of-roundness exceeds approximately 0.006 in. (0.15 mm)
- Scoring in excess of approximately 0.060 in. (1.52 mm)

Do not resurface drums due to light scoring or grooves.

Replace drums if:

- The maximum diameter reading equals or exceeds the discard dimension marked on the drum. Discard even if the drums are smooth and true
- The drum is under the discard dimension but refinishing would not leave at least 0.030 in. (0.76 mm) allowance for wear

— IMPORTANT —

The discard dimension marked on the drum is the maximum allowable wear dimension and not the allowable machining dimension. Leave at least 0.030 in. (0.76 mm) for wear after turning a drum.

Setting the Micrometer to the Drum Diameter

1. Loosen the two lock screws and move both the dial and the anvil along the shaft until the "whole" number of the drum diameter is visible at each arrow.

> **— IMPORTANT —**
>
> **The metrically graduated shaft has "even" numbers scribed on one side and "odd" numbers on the other side.**
>
> **The English graduated shaft has identical scales front and back.**

2. Set a fractional drum measurement, if necessary.
   a. English – Tighten the anvil lock screw and slide the dial along the shaft in precise 0.125 in. increments.
   b. Metric – Tighten the dial lock screw and slide the anvil along the shaft in precise 2 mm increments.

Thus, one arrow will point to the whole number of the drum diameter and the other arrow will indicate the desired fraction.

For drum measurements between 15 in. and 16 in. English, or 39 cm to 41 cm Metric, the fractional procedures a. and b. are reversed.

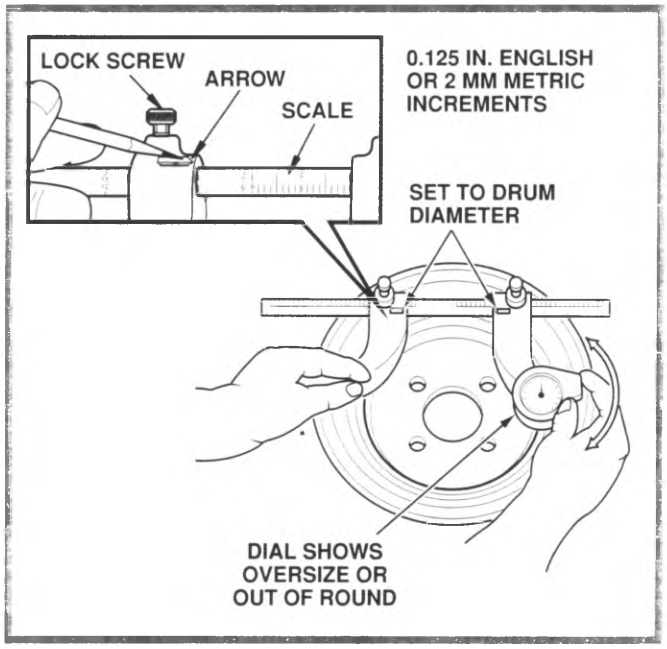


Figure 5-7, **Measuring Brake Drum**

Brake Drum Measuring Procedure

Place the micrometer inside the drum and across the greatest diameter to be measured (refer to figure 5-7). The anvil, or left end of the micrometer, is held steady and the dial, or right end, is moved back and forth slowly to obtain the highest reading.

This 'highest reading' is the amount in thousandths of millimeters that the drum is oversize or undersize.

When measuring brake drum dimensions, it may be necessary to convert measurements from inches to millimeters or vice versa. To do so, use the conversion formulas below:

INCHES X 25.4 = MILLIMETERS

$$\frac{\text{MILLIMETERS STAMPED ON DRUM}}{25.4} = \text{INCHES}$$

0.03937 inches = 1 millimeter

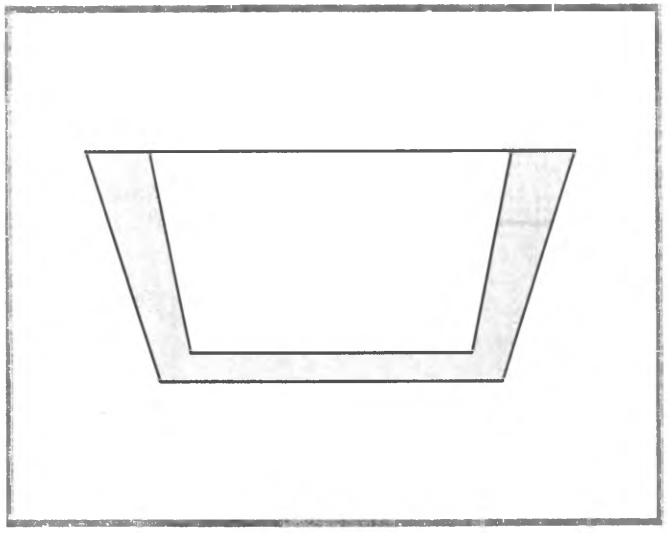


Figure 5-8, **Brake Drum Taper (Bell Mouth)**

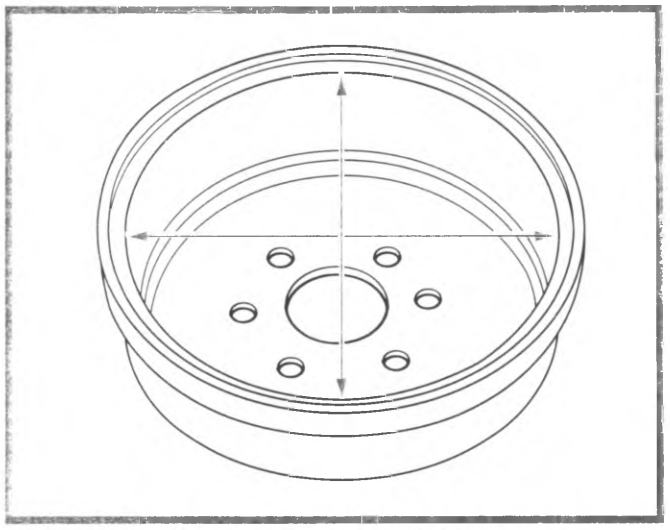


Figure 5-9, **Brake Drum Out of Round**

Brake Drum Taper and Out of Round

Taper and out of round may occur due to normal drum wear or due to damage. Taper is a difference in diameter from the top of the drum to the bottom (figure 5-8). Out of round is a difference in diameter across the face of the drum (figure 5-9).

Hand sand drums with a fine emery cloth only if the drums:

- Are true
- Are lightly scored
- Have only minor surface defects

Replacement drums are normally fully finished and do not require additional machining.

— IMPORTANT —

Turning the drums with a very fine feed obtains best brake performance. Only qualified personnel using reliable equipment should perform drum refinishing. Remove only enough metal to obtain a true, smooth surface. It is important to follow service manual or equipment manufacturers directions during any resurfacing operation.

— NOTICE —

A rustproof coating protects replacement drums. Use a volatile, non-oil base solvent, such as brake cleaner or denatured alcohol, to remove the coating as well as any traces of oil or grease.

Drum Brake Service

Duo-Servo Example

Tools required:

J 8049 Brake spring remover and installer

J 8057 Brake spring pliers

Disassemble

1. Remove wheel and tire. Mark the relationship of the wheel to the axle flange.
2. Mark the relationship of the drum to the axle flange. Remove the brake drum.
   - Make sure the parking brake is released.
   - Back off the parking brake adjustment if necessary.
   - Remove the adjusting hole plug or knockout plate from the backing plate and back off the adjusting screw using a screwdriver and brake adjusting tool (figure 5-10).
   - Tap gently on the outer rim of the drum or around the inner drum diameter by the axle flange. Take care not to deform the drum by excessive use of force.
3. Use the J 8049 tool to remove the return springs (1 and 2) (see figure 5-11).
4. Remove the hold down spring (3) and hold down pin (5) using pliers.
5. Remove the lever pivot (4).
6. Remove the actuator link (6) while lifting up on the actuator lever (7).
7. Remove the actuator lever, (7) pawl (8), if equipped, and lever return spring (9).
8. Remove the shoe guide (10), parking brake strut (11) and strut spring (12).
9. Remove the primary and secondary shoes (13 and 14) from the backing plate and parking brake cable.
10. Remove the adjusting screw assembly (31) and adjusting screw spring (15).
11. Remove the parking brake lever (20) by unhooking lever tab from slot in primary or secondary shoe and lining.

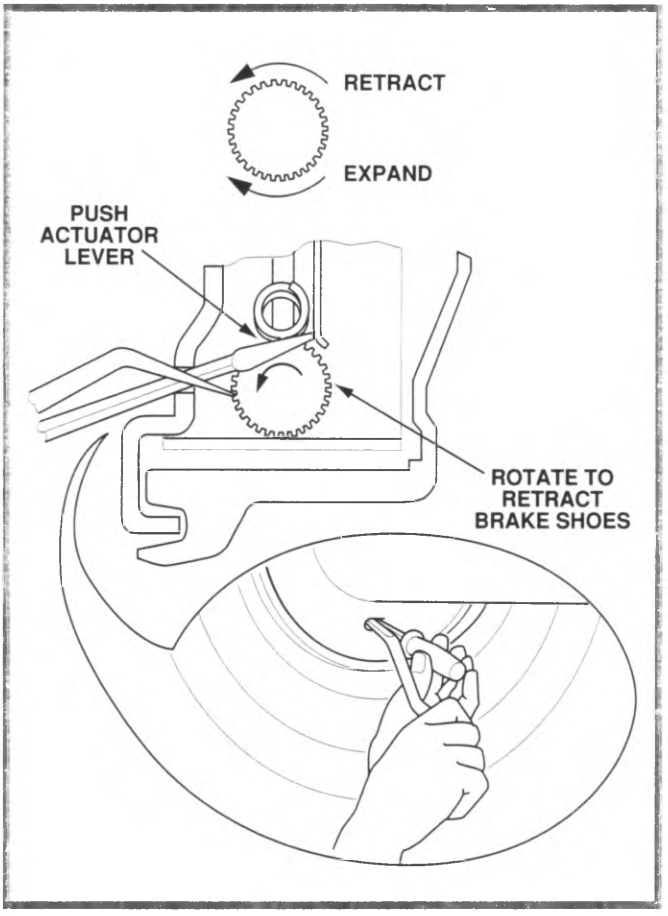


Figure 5-10, **Backing Off Brake Adjustment**

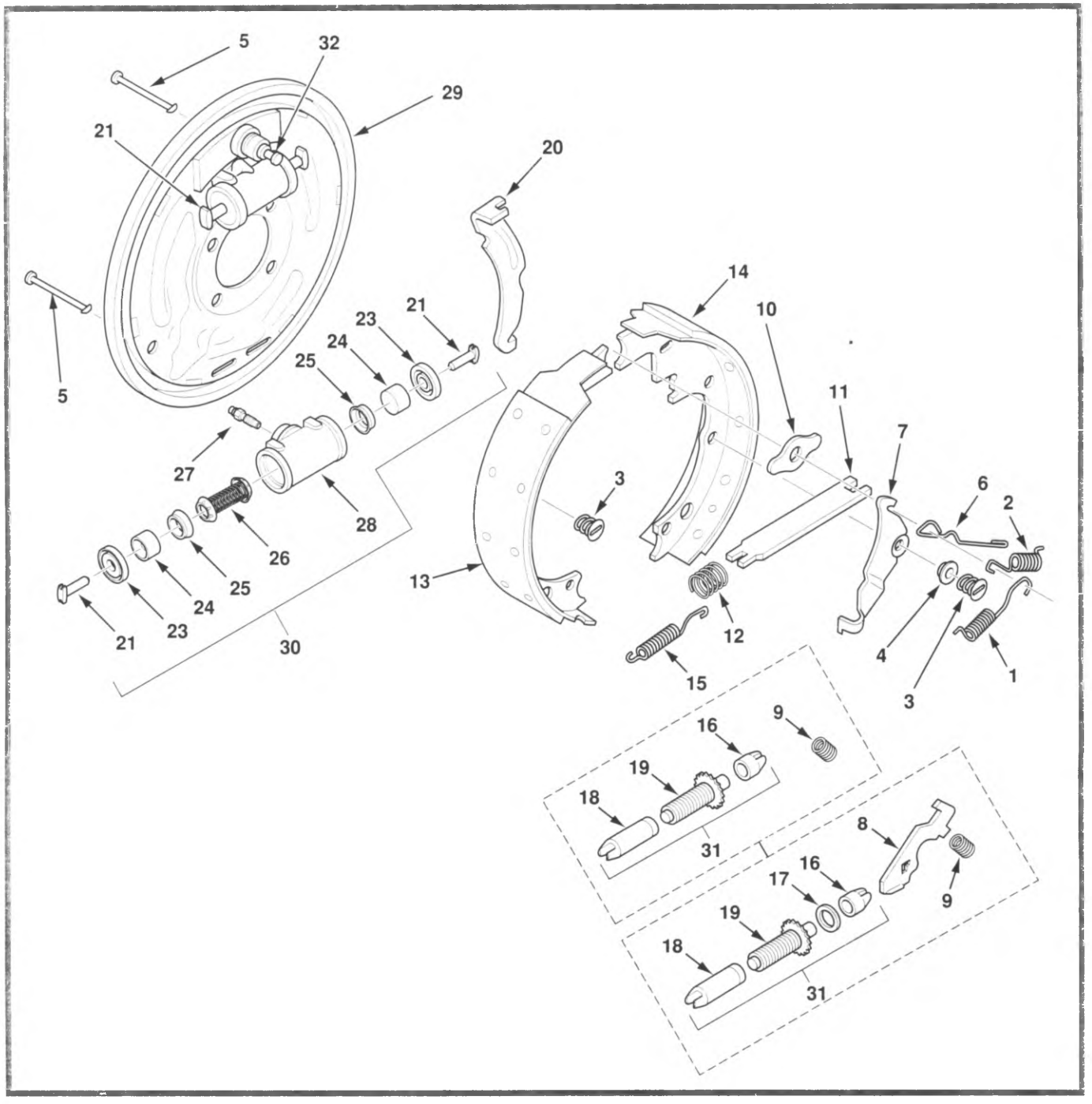


Figure 5-11, **Drum Brake Components**

Clean and Inspect

1. Clean and lubricate adjuster screw assembly (31)
2. Clean backing plate and lubricate contact surfaces with brake lubricant GM part number 5450032 or equivalent on all contact surfaces.
3. Verify the adjusting screw threads rotate smoothly for their full length.
4. Inspect all parts. Replace any parts of doubtful strength or quality due to discoloration from heat, overstress or wear.

Reassembly

1. Install the parking brake lever (20) by hooking lever tab into slot in appropriate shoe and lining.
2. Install adjusting screw assembly (31) and adjusting screw spring (15).
3. Attach primary and secondary shoe and lining (13 and 14) to parking brake cable and backing plate.
4. Install parking brake strut (11) and strut spring (12) by spreading primary and secondary shoes and linings apart. The end without the spring engages the parking brake lever. The end with the spring engages the brake shoe.
5. Install the shoe guide (10), pawl (8), if equipped, actuator lever (7) and lever return spring.
6. Install hold-down pin (5), lever pivot (4) and hold-down spring (3).
7. Install the actuator link (6) on anchor pin. Install the actuator link onto the actuator lever (7) while holding up on the actuator lever.
8. Install return springs (1 and 2) using J 8057.

Preliminary Brake Adjustment

Tool required:

J 21177-1A Drum to brake shoe clearance gauge

1. Set J 21177-1A so it contacts the inside diameter of the brake drum (figure 5-12).
2. Position the J 21177-1A over the primary and secondary shoes and linings (13 and 14) (figure 5-13).
3. Turn the star wheel on the adjusting screw (19) until the primary and secondary shoes and linings contact J 21177-1A.
4. Reinstall brake drums and wheels, realigning marks on the brake drum and wheel.

Final Brake Adjustment

Final brake shoe-to-drum clearance adjustment may vary from vehicle to vehicle. For example:

- Remove the knock-out area of the backing plate.
- Turn the adjusting screws until the wheels can just be turned by hand in both directions. Drag should be equal at both wheels.
- Back off the adjusting screw 24 notches. The brakes should have no drag after about 12 notches.
- Install the adjusting hole cover.
- Check parking brake adjustment.

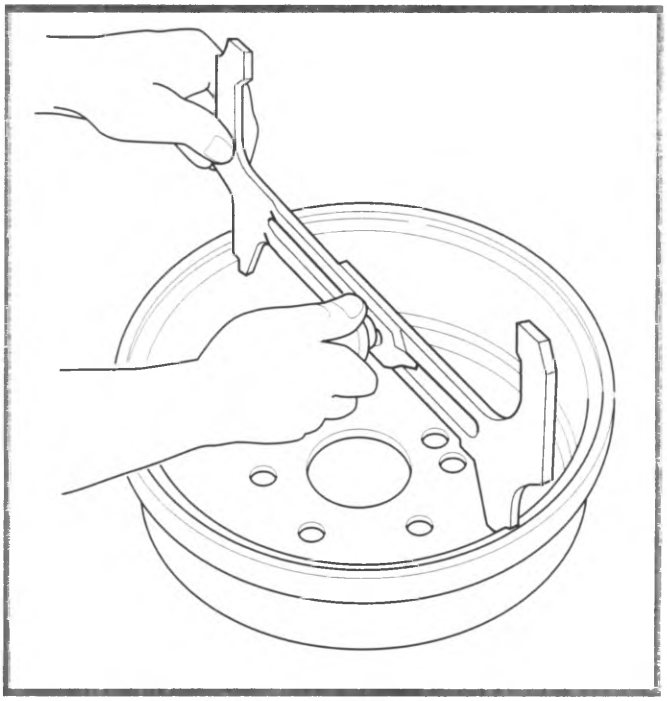


Figure 5-12, **Setting Tool to Drum**

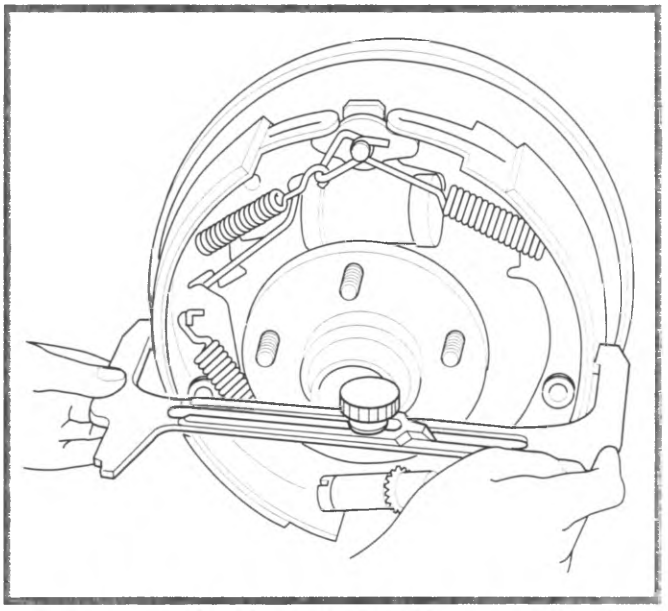


Figure 5-13, **Setting Brake Shoes to Tool**

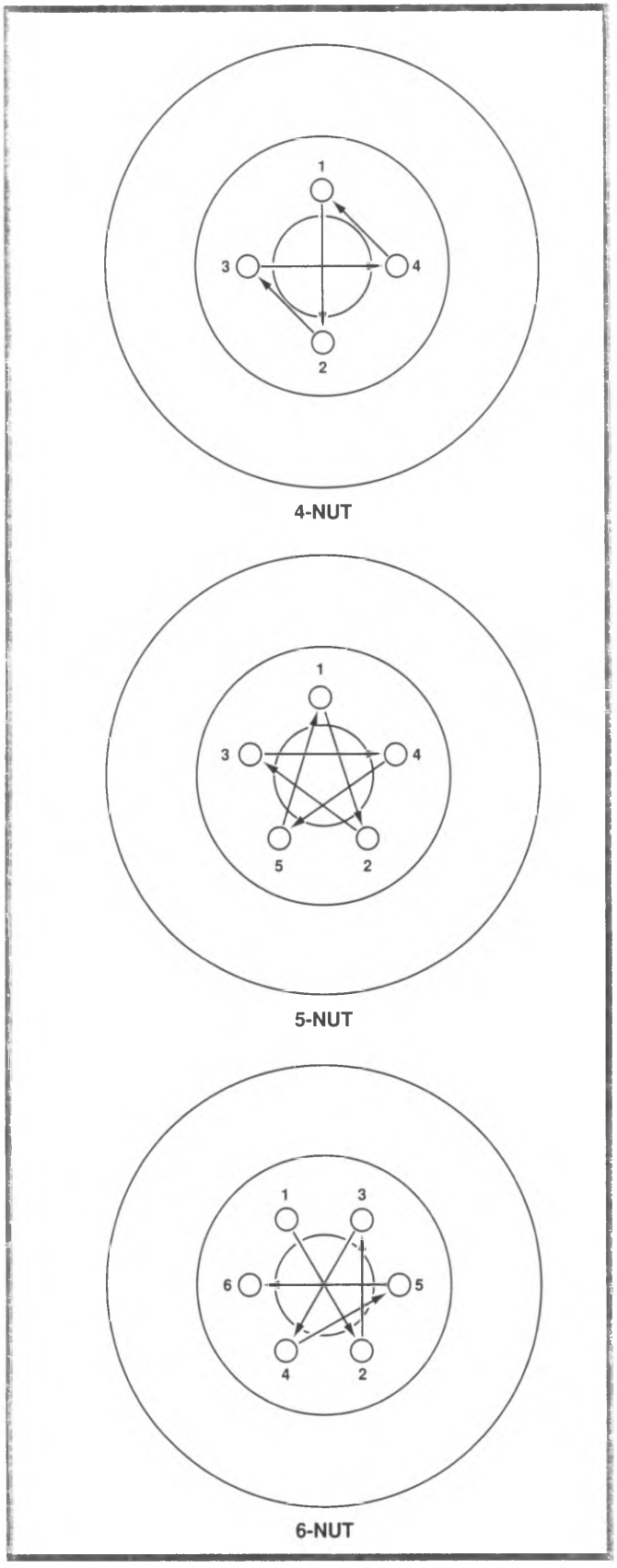


Figure 5-14, **Wheel Nut Tightening Sequence**

Wheel Lug Tightening Sequence

Incorrect wheel lug tightening sequence may distort the drum or rotor which may cause excessive lateral runout. If the customer comments of brake pedal pulsation:

1. Remove wheel lug nuts.
2. Inspect the rotor/wheel contact face and clean off any debris or rust.
3. Use a torque wrench or J 39544 torque limiter with air impact wrench. Follow the manufacturers directions and the appropriate service manual torque specification.
4. Use a star pattern to tighten the wheel nuts in two stages (figure 5-14).
5. Road test the vehicle. If the condition is not corrected, check for thickness variation, lateral runout or wheel bearing looseness.

Torque Limiter Operation

1. Remove any rust or dirt from studs, nuts, wheels and hub with wire brush and repair or replace any damaged components prior to installing wheels.

— CAUTION —

SAFETY GLASSES MUST BE WORN WHEN USING THESE ADAPTERS.

— NOTICE —

Adapters are for use with a 1/2-inch drive pneumatic wrench only! Use of a breaker bar or ratchet may damage adapters. Maximum air wrench setting is 250 psi.

— IMPORTANT —

Do not hold adapter while torquing. Torque will be affected.

2. Select correct torque limiter and fit it to the air wrench.
3. Torque wheel nuts using the appropriate tightening sequence.
4. Check nuts for tightness after torquing and a short test drive.

6. Disc Brakes

Objectives

After completing this section, the student will be able to:

- Perform disc brake service
- Describe which special tools to use during disc brake service
- Demonstrate how to use the special tools during disc brake service
- Prevent brake system contamination during service
- Replace brake pads
- Overhaul a front caliper
- Demonstrate how to make caliper and mounting bracket wear adjustments
- Perform rear caliper service
- Replace rear brake pads
- Adjust parking brake free travel
- Replace hubless rotors
- Replace hubbed rotors
- Perform bearing and bearing race replacement
- Demonstrate how to measure rotor thickness and thickness variation
- Measure rotor lateral runout
- Perform rotor refinishing
- Identify rotor refinishing guidelines
- Demonstrate how to qualify a brake lathe
- Mount hubbed rotors onto a bench lathe
- Mount hubless rotors onto a bench lathe
- Demonstrate how to use a bench brake lathe
- Demonstrate how to use an on-car brake lathe

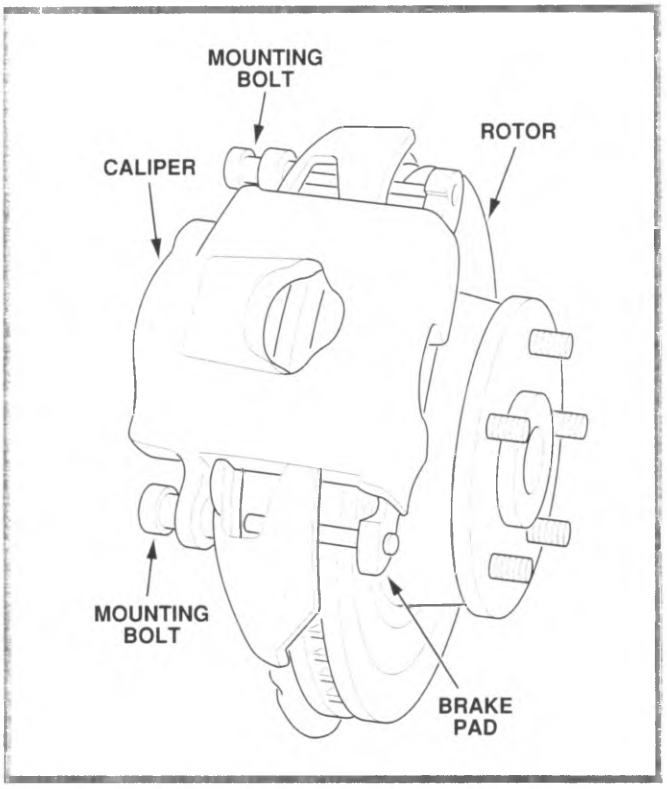


Figure 6-1, **Single Piston Disc Brake Assembly**

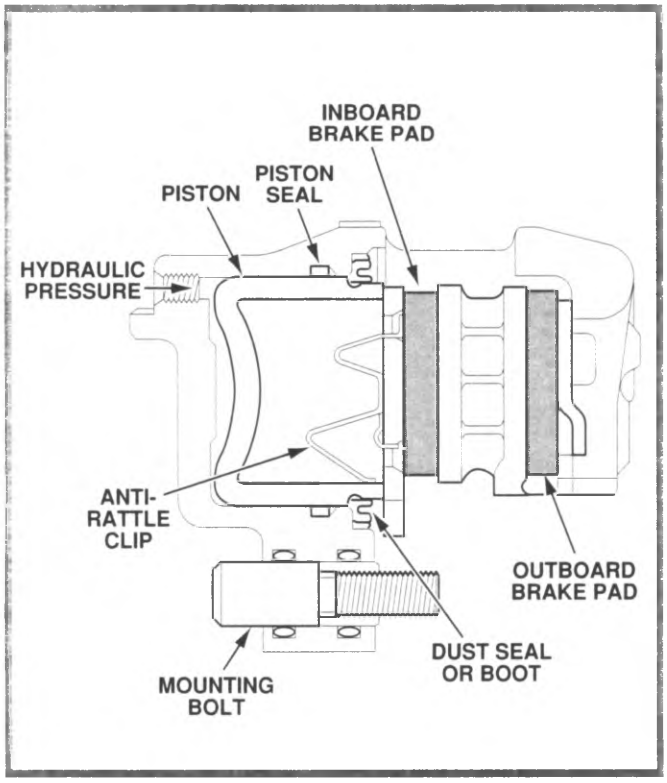


Figure 6-2, **Caliper Components**

Disc Brakes

Disc brakes have a caliper that clamps two brake pads against a rotor (figure 6-1). Some rotors have cooling fins between the two braking surfaces that circulate air between the braking surfaces, making them less sensitive to heat buildup and more resistant to brake fade (temporary reduction of brake effectiveness resulting from heat).

The various types of disc brake caliper (figure 6-2) used by GM vehicles include:

- Single-piston and dual-piston floating or sliding calipers
- Rear calipers
- Rear calipers with integral parking brake

Brake Pads

GM brake linings are designed and tested for specific vehicle applications. The brake friction coefficient of the pad material is vehicle matched to optimize brake operation and wear characteristics.

Stamped on the side of GM brake pads is an alpha numeric stamping which indicates the friction coefficient of the pad as well as other information.

— IMPORTANT —

Using brake pads other than those intended for the vehicle may affect brake operation and/or increase stopping distances.

Single-Piston and Dual-Piston Calipers

Single and dual piston calipers operate the same (figure 6-3). In the dual piston design, two pistons provide more piston surface area in a smaller package. Both single and dual piston calipers use a floating design.

In the floating caliper, the piston is on the inboard side of the caliper. When the brakes are applied, the caliper moves along either:

- Mounting bolts, or
- Machined guides on the caliper and mounting bracket (see figure 6-4)

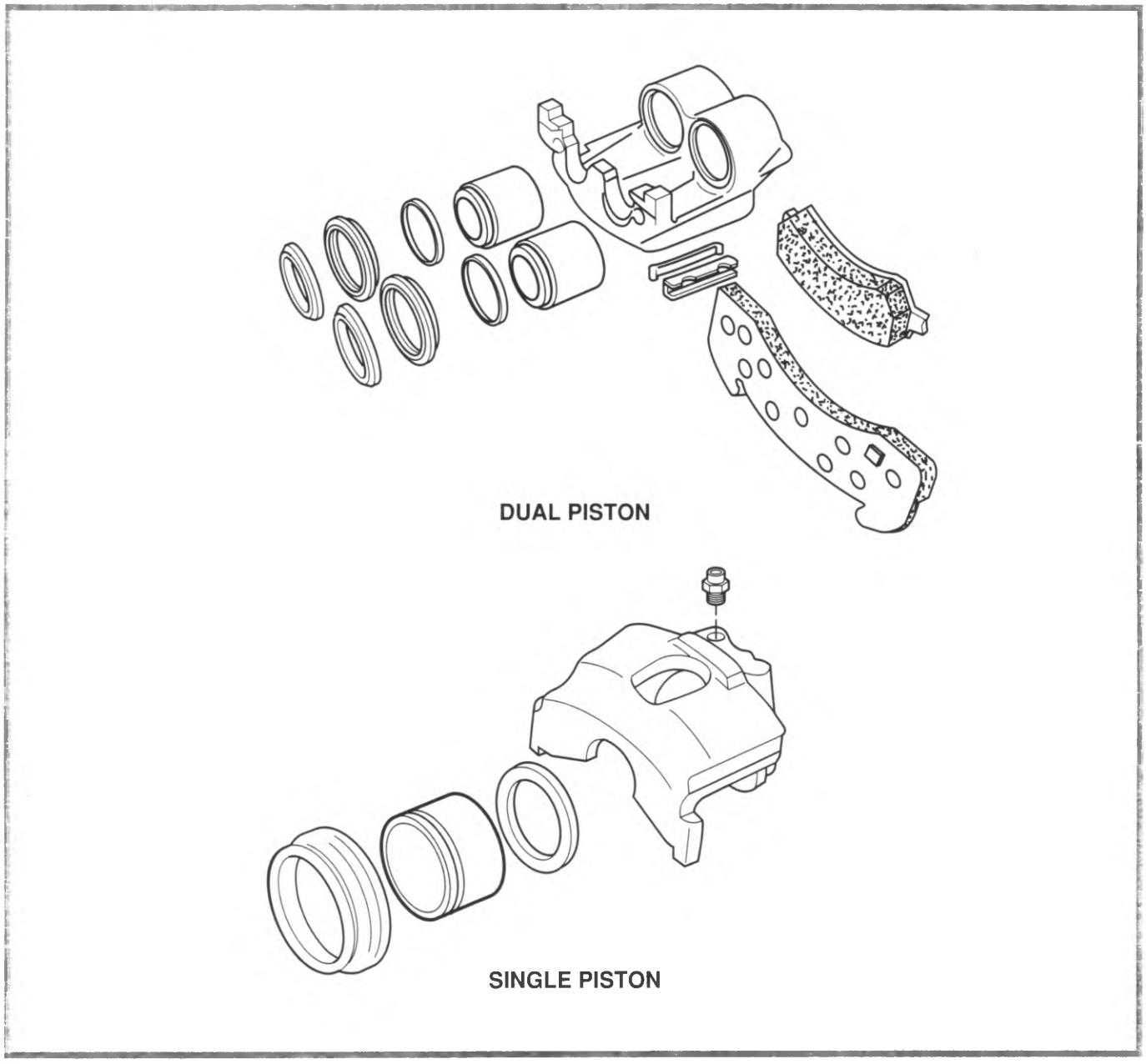


Figure 6-3, **Single- and Dual-Piston Calipers**

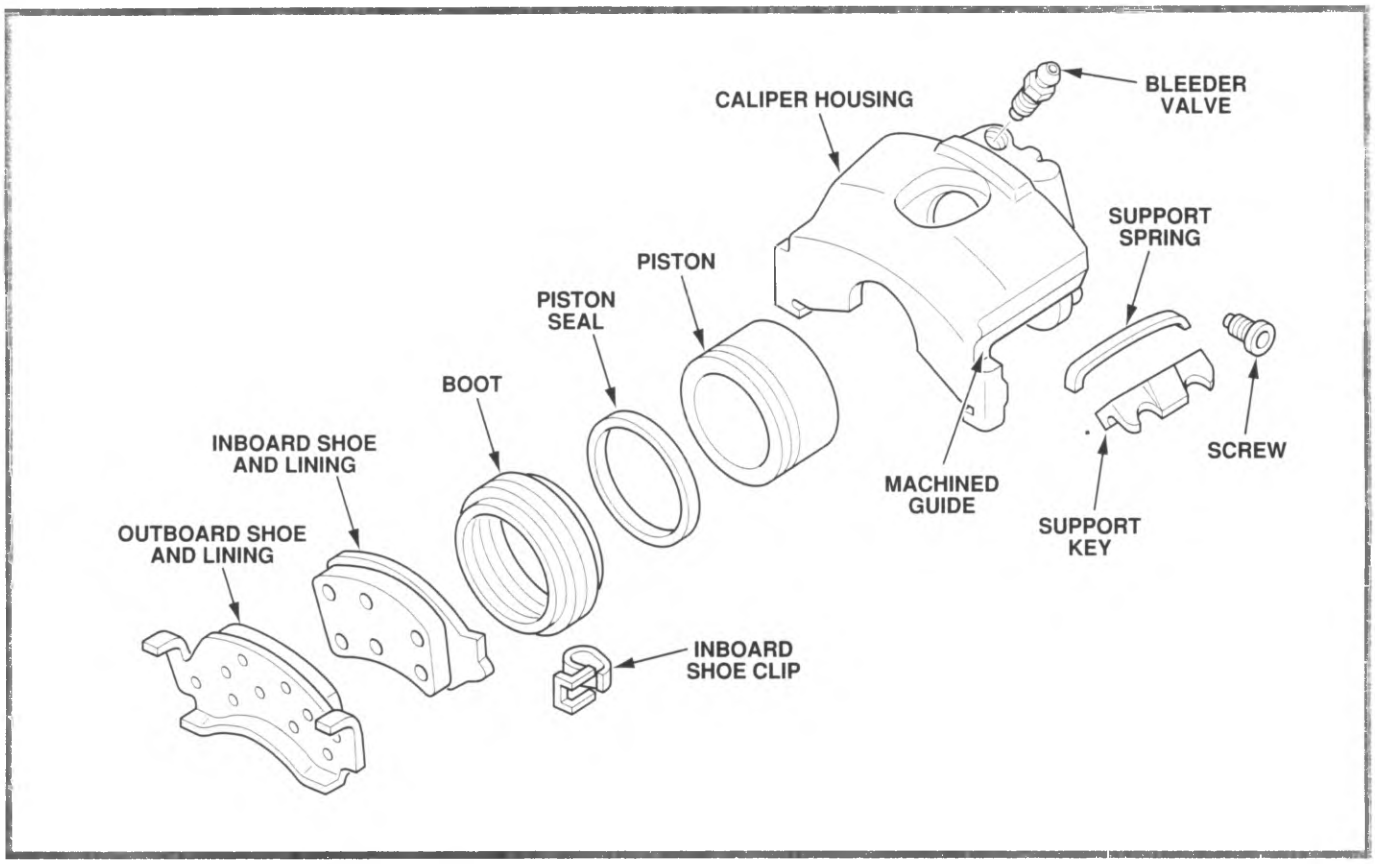


Figure 6-4, **Machined Guide Sliding Caliper**

Floating Caliper Operation

When the driver applies the brakes:

1. Fluid pressure behind the piston presses against the caliper piston and the piston bore (figure 6-5).
2. The piston pressure forces the pad against the inboard rotor surface. Pressure applied to the piston bore forces the caliper to move on its slides.
3. Caliper movement applies pressure against the outboard brake pad, forcing the pad against the rotor surface.
4. Both brake pads press against the rotor surfaces, bringing the vehicle to a stop.

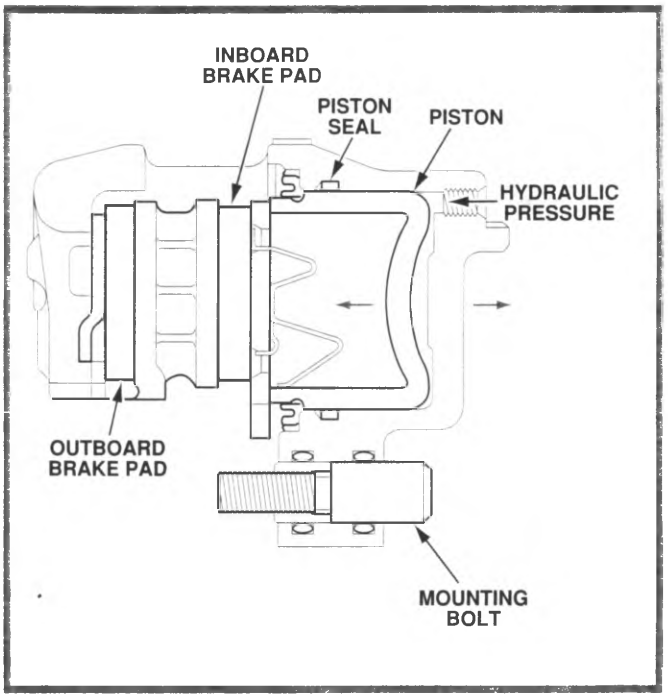


Figure 6-5, **Caliper Operation**

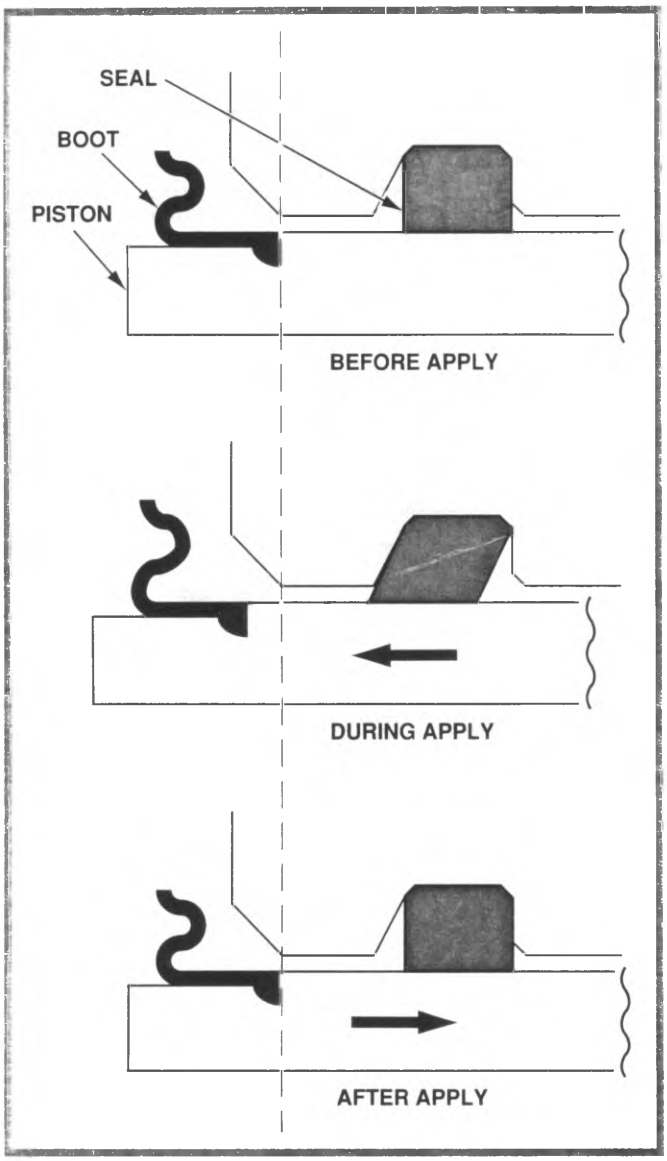


Figure 6-6, **Seal Function**

5. When hydraulic pressure is released, the square cut seal retracts the piston (figure 6-6). This allows the system to reduce brake pad drag improving brake release and fuel economy.

Brake Pad Wear Compensation

As the brake pads wear, the caliper piston moves out further in its bore to compensate for brake material wear (figure 6-7). The brake fluid fills the area behind the piston, allowing the caliper to keep the pads in the proper relationship to the rotor.

The wear compensation results in a lower brake fluid level in the reservoir. Therefore, do not refill the reservoir before depressing the pistons during brake pad replacement. If the reservoir is near full, remove fluid before depressing the pistons.

- A Floating Caliper which binds on its mounting bolt can cause uneven brake pad wear
  - A caliper mount which fails to release can cause the outboard pad to wear prematurely
  - A seized caliper mount, where the caliper does not float or move on the bushings, can cause the inboard pad to wear prematurely
  - A piston which binds and does not fully release will cause premature wear of both brake pads
- A seized piston will prevent the brakes from applying and will cause premature wear of the opposite side brake pads. Typically, this will cause a pull when the brakes are applied. For example, a seized right caliper piston will cause the vehicle to pull left and vise versa

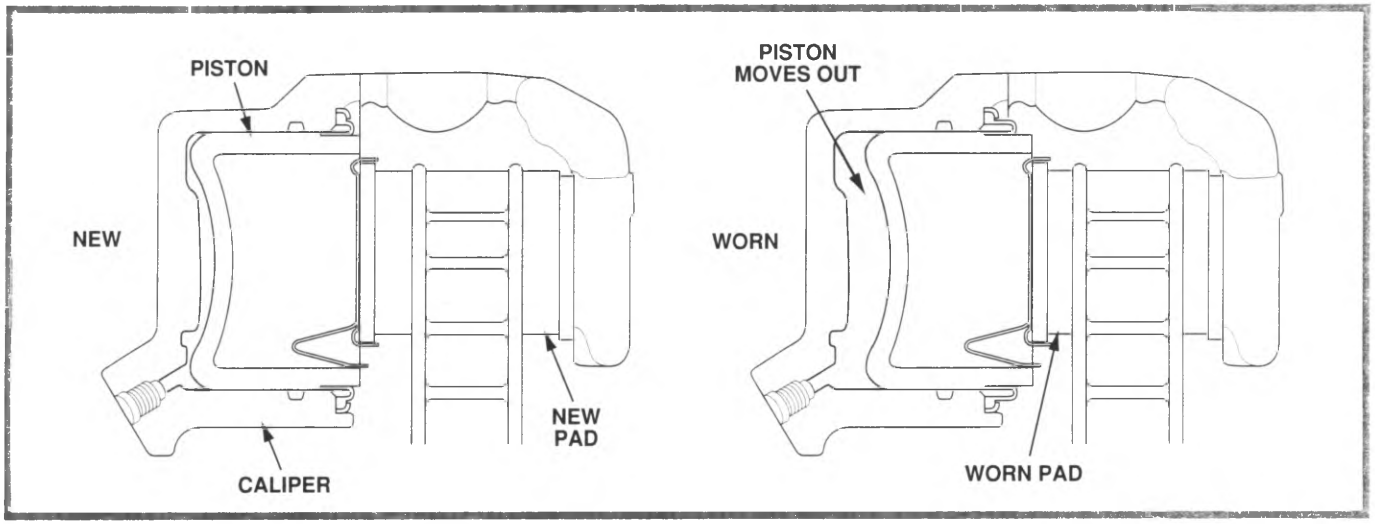


Figure 6-7, **Disc Brake Pad Wear Compensation**

Rear Caliper with Parking Brake

Rear caliper brake (hydraulic) operation is nearly the same as front calipers: The piston assembly applies the inboard brake pad. The caliper housing moves on the caliper slides and applies the outboard pad (figure 6-8). Since the rear brakes are used for the parking brake, some rear calipers are designed with an integral parking brake mechanism.

Rear caliper parking brake operation is mechanical.

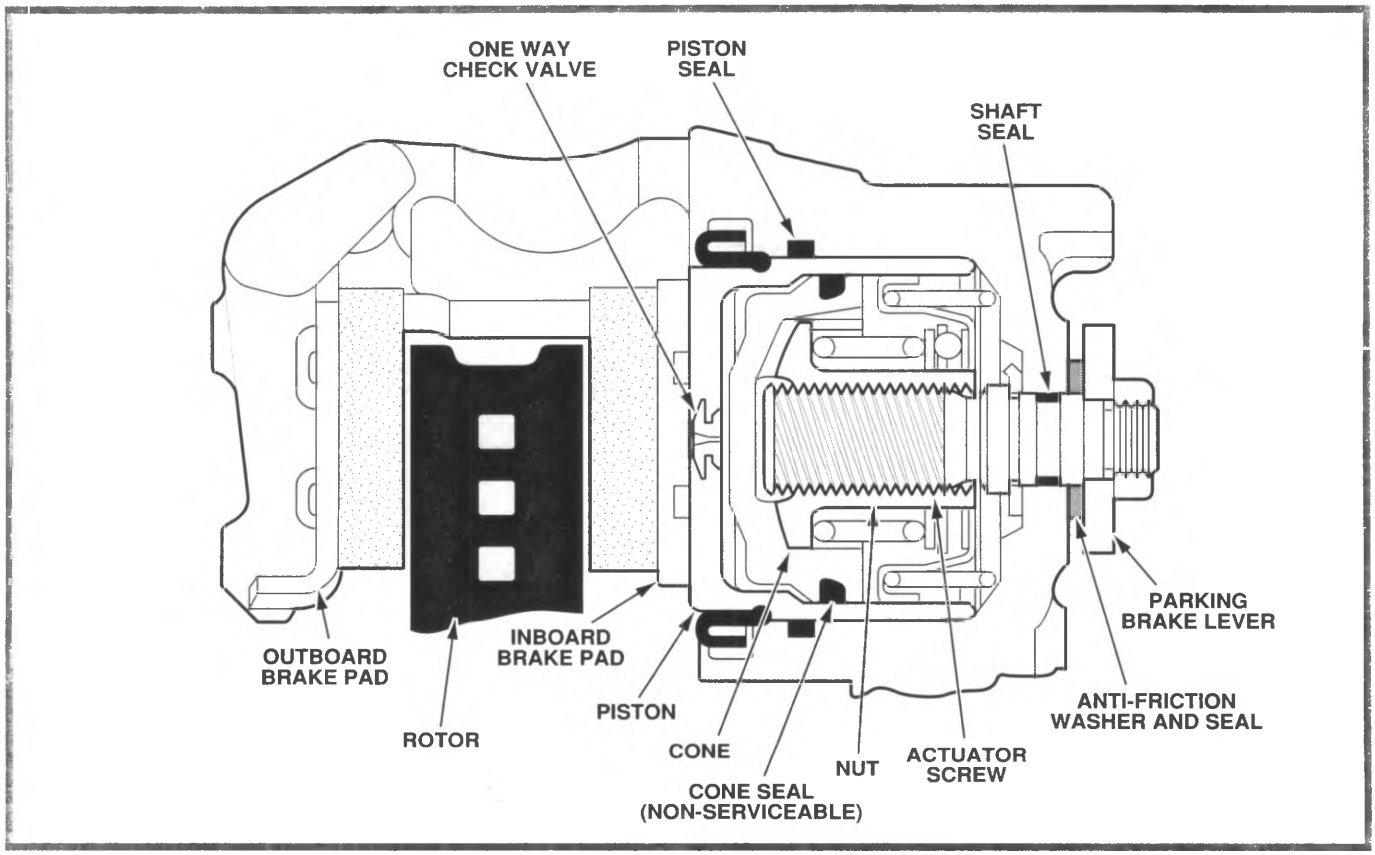


Figure 6-8, **Rear Disc Brake Caliper with Integral Parking Brake**

Drum-in-hat style caliper operation is the same as front caliper operation.

Brake Pad Replacement

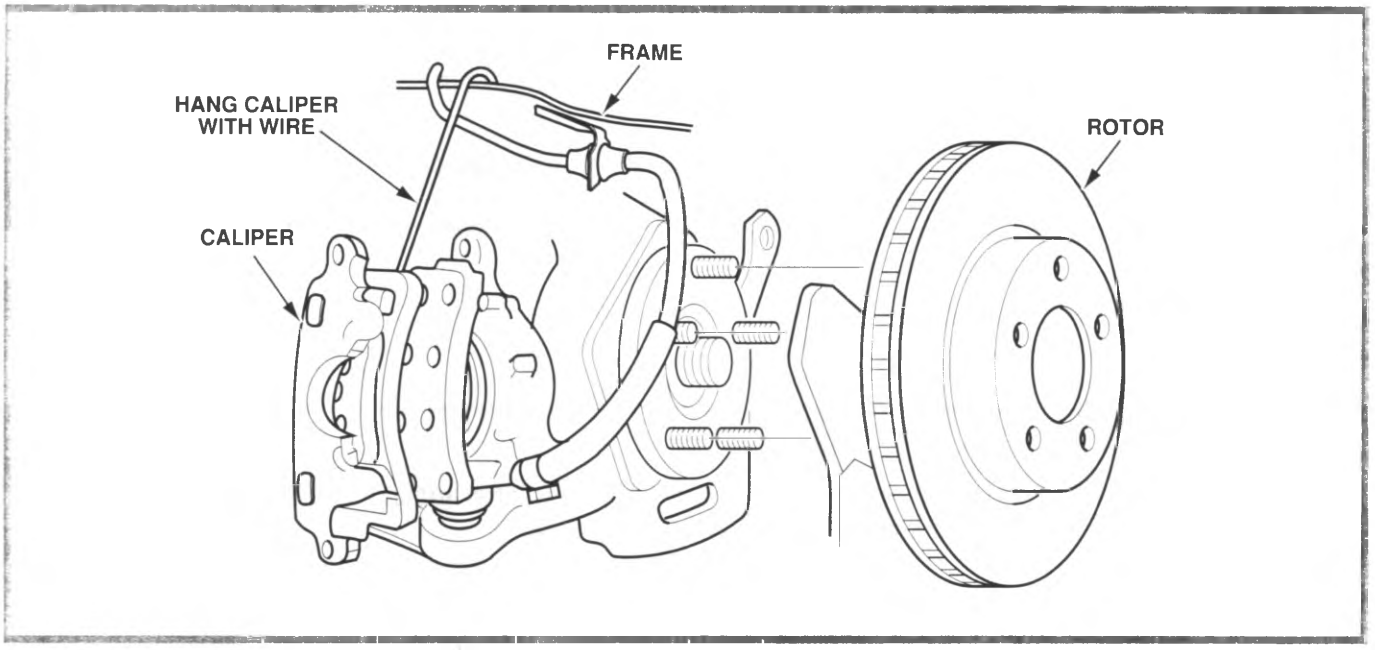


Figure 6-9, **Suspend Caliper**

Removal Procedure

Use only GM replacement brake lining material. GM replacement brake parts provide the proper brake balance for stopping distance and for braking control. The intended brake balance for this vehicle can change if GM replacement brake lining materials are not used.

— IMPORTANT —

Do not disconnect the brake hose from the caliper.

1. Remove the caliper.

— NOTICE —

Do not allow the brake components to hang from the flexible brake hoses. Damage to the brake hoses could result.

2. Suspend the caliper (figure 6-9).
3. Remove the anchor bracket (if necessary).
4. Remove the inboard lining from the caliper (figure 6-10).
5. Remove the retainer spring from the inboard brake shoe.
6. Remove the outboard lining from the caliper.

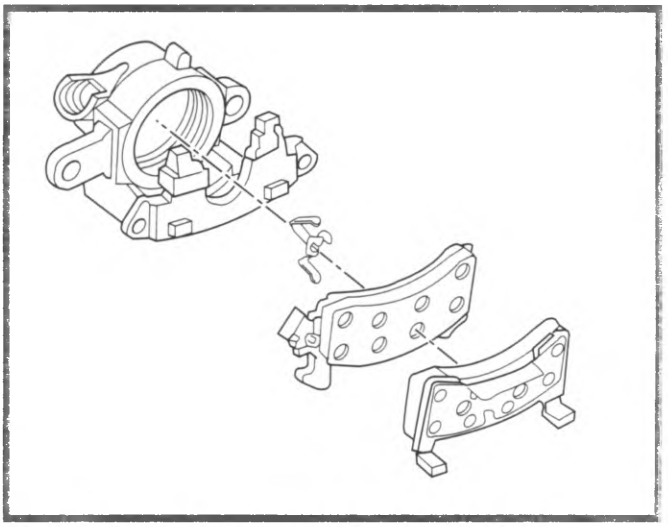


Figure 6-10, **Remove Inboard Lining**

Installation Procedure

1. Install the anchor bracket and tighten. Tighten the anchor bracket mounting bolts to 110 N•m (81 lb. ft.).

— NOTICE —

Refer to Fastener Notice in Cautions and Notices. Keep grease, oil and dirt from contacting the brake pad surface during service.

2. Install the outboard lining.
3. Install the retainer spring on the inboard brake shoe.
4. Install inboard lining in the caliper.

— NOTICE —

Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

5. Install the caliper.

— IMPORTANT —

Before moving the vehicle, pump the brake pedal several times in order to make sure the pedal is firm. Do not move the vehicle until you get a firm brake pedal. Check the brake fluid level in the master cylinder reservoir after pumping the brake pedal.

Rear Brake Pad Replacement

Removal Procedure Example

1. Remove caliper.
2. Remove the outboard shoe and pad (figure 6-11). Use a screwdriver to disengage the buttons on the shoe from the holes in the caliper housing.
3. Remove the inboard shoe and pad.

Installation Procedure

1. Before installing new shoes and linings, clean the outside surface of the boot. Use clean denatured alcohol.
2. Bottom the piston into the caliper bore. Use a C-clamp over the caliper and piston, tighten it slowly to press the piston into the bore. Be careful not to damage the piston or the boot.

— IMPORTANT —

The boot must lay flat. Ensure the convolutions are tucked back into place.

3. After bottoming the piston, use a small plastic or wood tool to lift the inner edge of the boot next to the piston, and press out any trapped air (figure 6-12).
4. Connect the inboard shoe and lining by snapping the shoe retainer spring into the piston (figure 6-13). The shoe must lay flat against the piston. After installing the shoe and lining, check that the boot is not touching the shoe. If it is, remove the shoe and lining and re-set or re-position the boot.
5. Connect the outboard shoe and lining with the wear sensor at the trailing edge of the shoe during forward wheel rotation. The back of the shoe must lay flat against the caliper.
6. Install the caliper.
7. Apply approximately 778 N (175 lb.) force three times to the brake pedal to seat the lining.

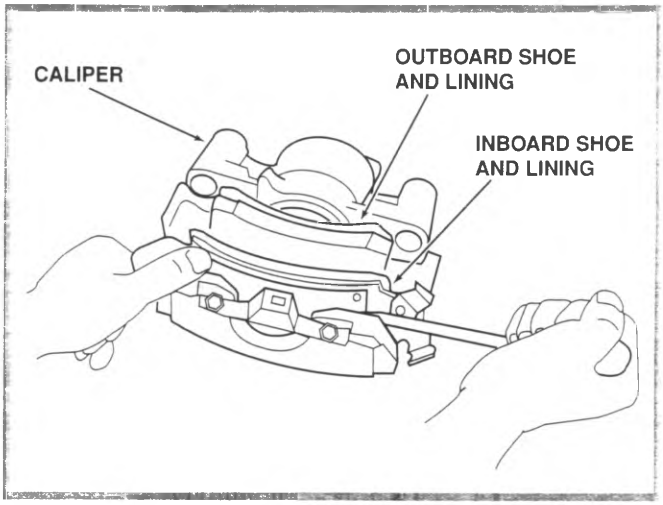


Figure 6-11, **Remove Outboard Shoe**

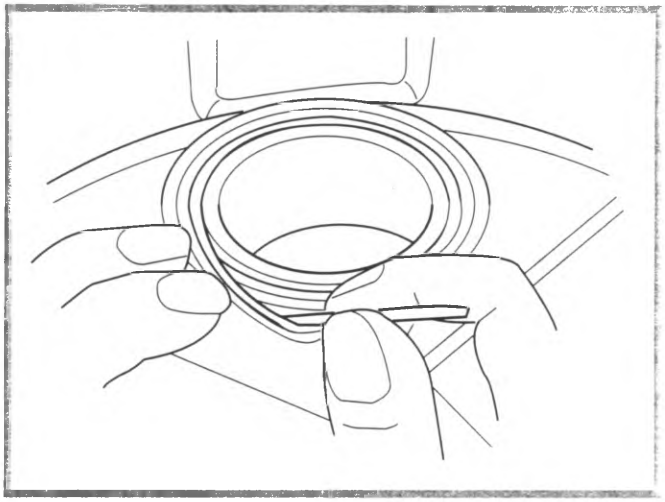


Figure 6-12. **Lift Inner Edge of Boot**

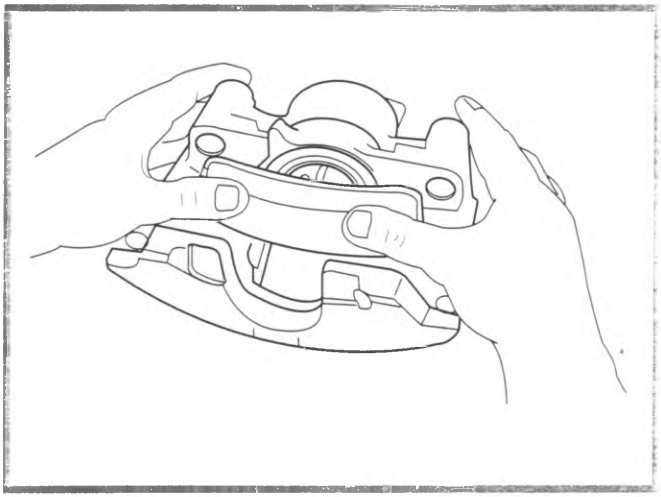


Figure 6-13, **Connect Inboard Shoe**

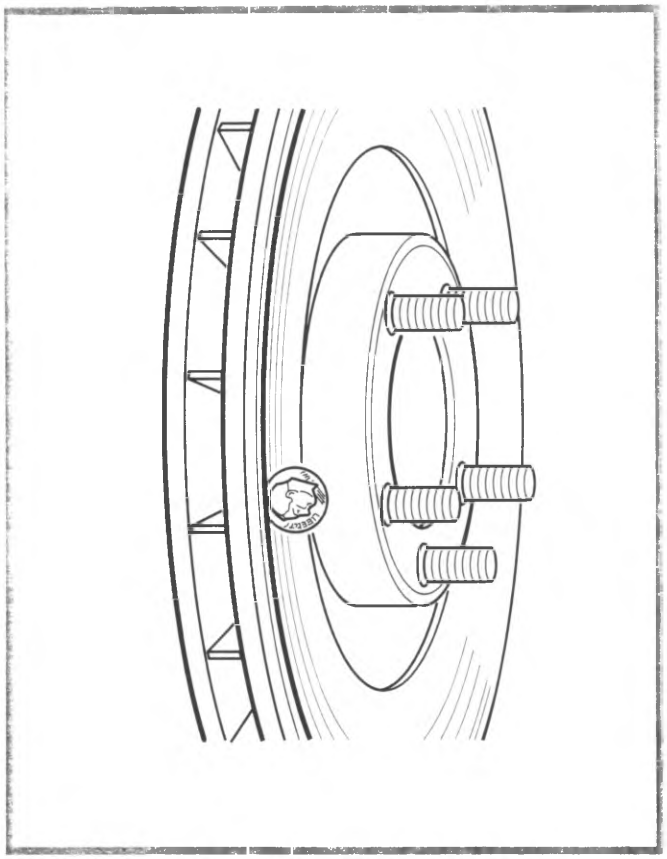


Figure 6-14, **Checking Rotor Surface Scoring**

Rotor Inspection

Inspect and measure disc brake rotors:

- When installing new linings
- If you note pulls, pulsations, or poor braking
- After refinishing the rotor, if required

Rotor Tolerance and Surface Finish

New rotors on General Motors' vehicles have a surface finish of 0.25 to 1.27 micrometers (10 to 50 microinches) with a non-directional swirl pattern. Although it is not customary to measure the surface finish of rotors, check them for deep scoring, which may require rotor refinishing or replacement.

Refinish rotors only in cases of:

- Excessive surface scoring
- Excessive thickness variation
- Excessive lateral runout

Surface Scoring

Do not refinish or replace the rotor if the surface has light scoring less than 1.5 mm (0.060 in.) in depth. A dime may be used as a quick check to determine disc brake scoring groove depth. Place a dime in the scored groove, with Roosevelt's head toward the scored groove. If the dime goes into the scored groove beyond the top of his head, the groove exceeds 0.060 in. and the rotor may need to be replaced or machined (figure 6-14).

Further rotor service procedures are covered later in this section.

Micrometer Reading

Accurate micrometer reading is critical to disc brake service. Obtaining a correct micrometer measurement is accomplished by combining three readings on the micrometer.

English Standard Micrometers

1. Figure 6-15 illustrates a 2-3 inch micrometer. All readings will fall between two and three inches (see A).
2. The numeral scale on the barrel, which measures 0.100 in. increments, is pulled back to reveal the whole number two, indicating 0.200 in. (see B).
3. A closer look shows the barrel is pulled back to reveal the first segment to the right of the number two. These individual segments measure 0.025 in. increments (see C).
4. The numbers and segments on the thimble measure 0.001 in. increments. Since the 15 on the thimble is aligned with the horizontal scale on the stem, this indicates 0.015 in. (see D).
5. Letter key E in the inset comes from the Vernier Scale. To read the scale, identify the Vernier number that is perfectly aligned with a thimble number and/or segment. In this case, the 3 on the Vernier Scale lines up with the 20 on the thimble. Note: Disregard the special thimble number when using the Vernier Scale. What matters is the alignment of a thimble marking, not the thimble number.
6. By adding each of the individual readings, an overall reading is obtained (2.000 + 0.2000 + 0.0250 + 0.0150 + 0.0003 = 2.2403 in.).

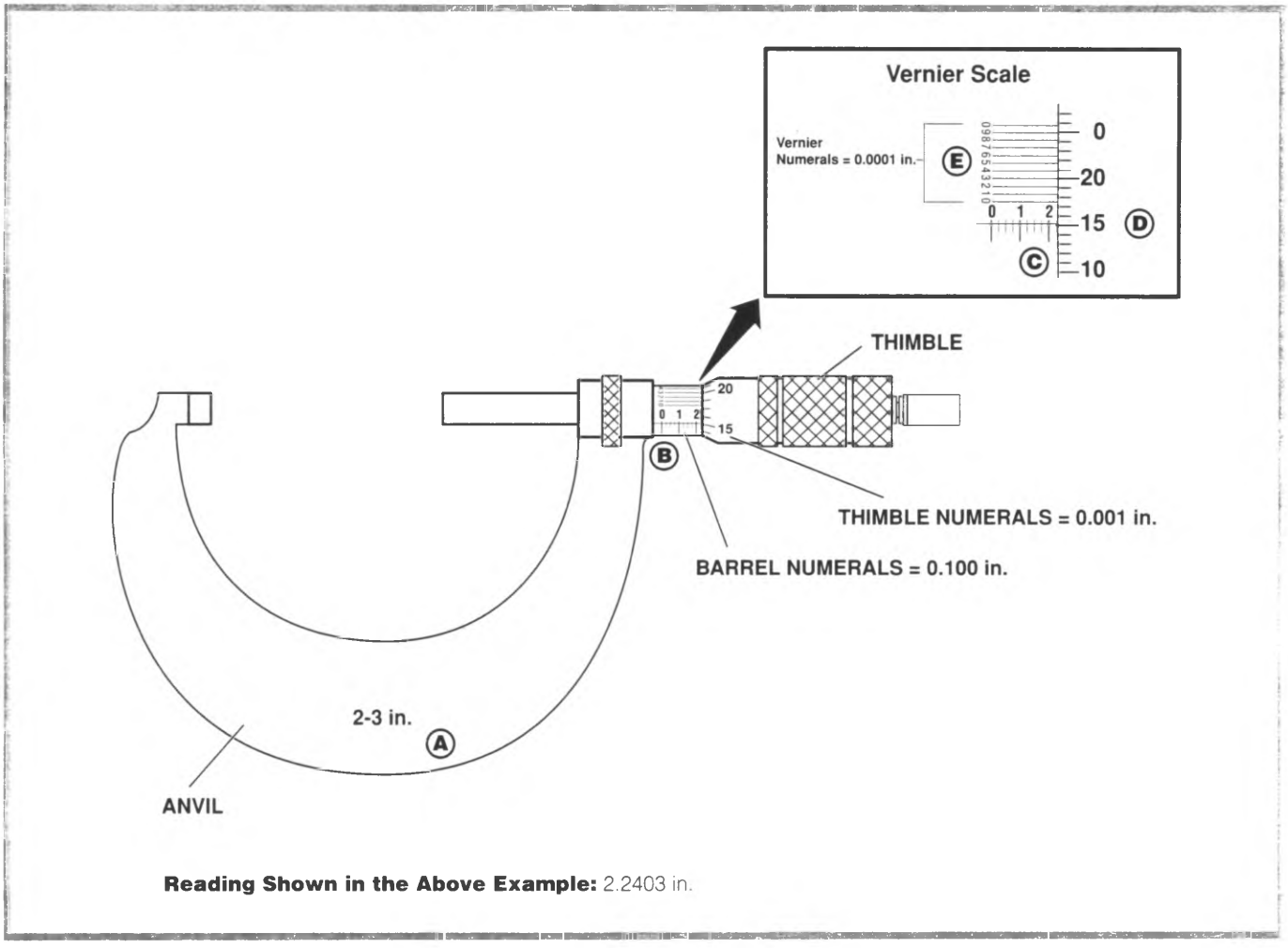


Figure 6-15, **Using a Micrometer**

Using Metric Micrometers

Reading a metric micrometer is accomplished in a similar manner as reading an English micrometer.

1. Figure 6-16 illustrates a 50–75 mm micrometer. All readings will fall between 50 and 75 mm (see A).
2. The numeral (upper) scale on the barrel, which measures 1.0 mm increments, is pulled back to reveal the number 69 indication (see B in the inset).
3. The lower individual barrel segments measure 0.5 mm increments. A closer look shows that the barrel is pulled back to reveal the lower segment to the right of the 69 indication (see C in the inset).
4. The numbers and segments on the thimble measure 0.01 mm increments. Since the 45 on the thimble is aligned with the horizontal scale on the stem, this indicates 0.45 in. (see D in inset).
5. By adding each of the individual readings, an overall reading is obtained (69.00 + 0.50 + 0.45 = 69.95 mm).

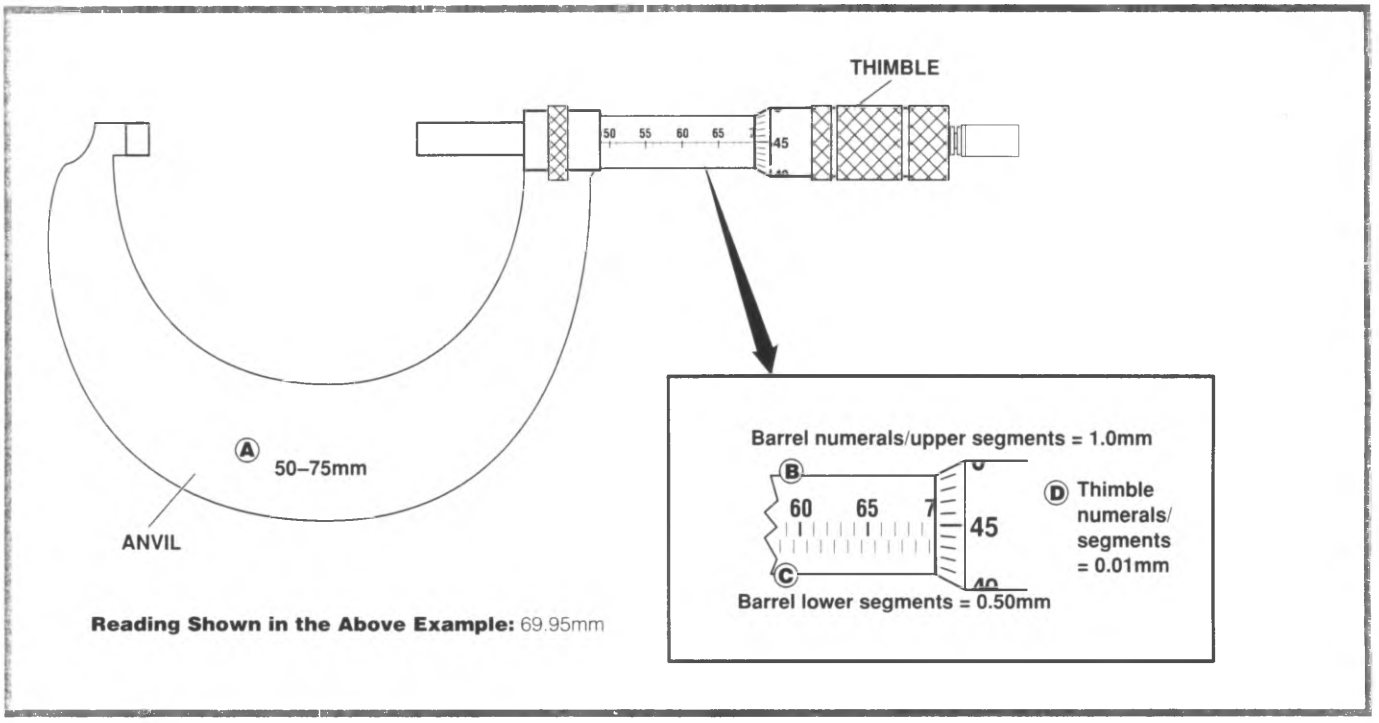


Figure 6-16, **Metric Micrometer**

Measuring Rotor Thickness and Thickness Variation

Brake pedal pulsation may result from a difference in the thickness of the rotor. Pulsation resulting from thickness variation is far more common than pulsation resulting from bent or warped rotors. Thickness variation can result from:

- Bound up calipers
- Rotor wear due to distortion from improper lug nut torquing
- Rotor wear due to lateral runout

To measure rotor thickness, use a micrometer that reads ten-thousandths (0.0001) inch (figure 6-17).

1. Take all measurements within the lining contact area of the rotor.
2. Take all measurements the same distance from the outer edge of the rotor.
3. Measure rotor thickness at four or more points, equally spaced around the rotor, and record each measurement (figure 6-18).

If any measurement is less than the minimum allowable specification marked on the rotor, replace the rotor. Thickness variations of more than 0.0127 mm (0.0005 in.) can cause pedal pulsation or vibration when braking. Refinish the rotor to specifications or replace.

All brake rotors have a discard thickness dimension cast into them. This dimension is the minimum wear dimension and not a refinish dimension. The refinish dimension is greater than the discard dimension. Do not use a brake rotor that will not meet final finish thickness specifications.

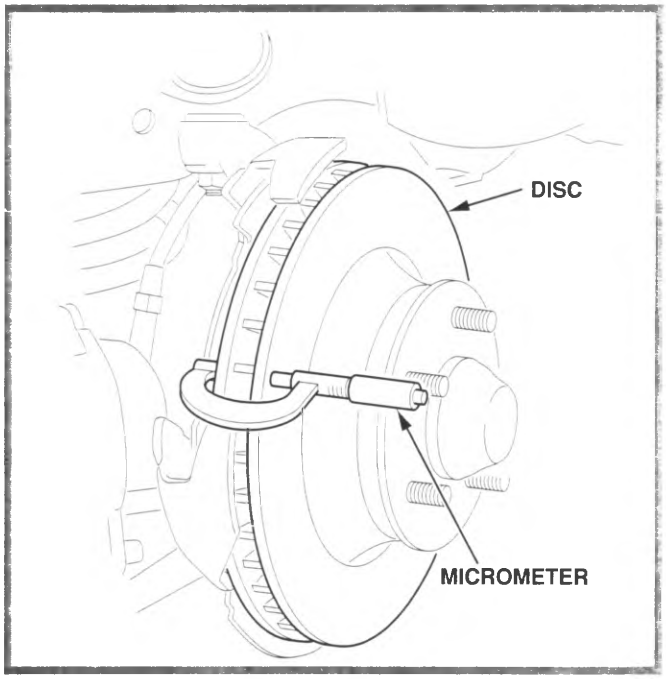


Figure 6-17, **Measuring Rotor Thickness**

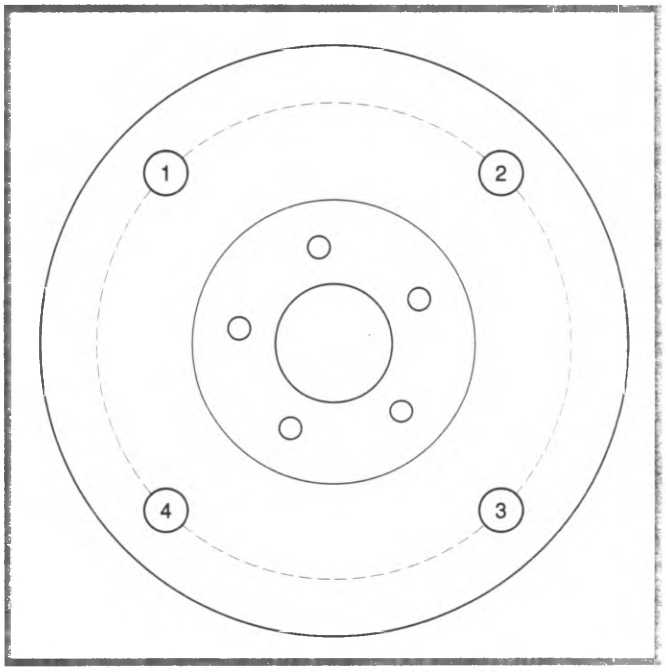


Figure 6-18, **Measuring Rotor Thickness Variations**

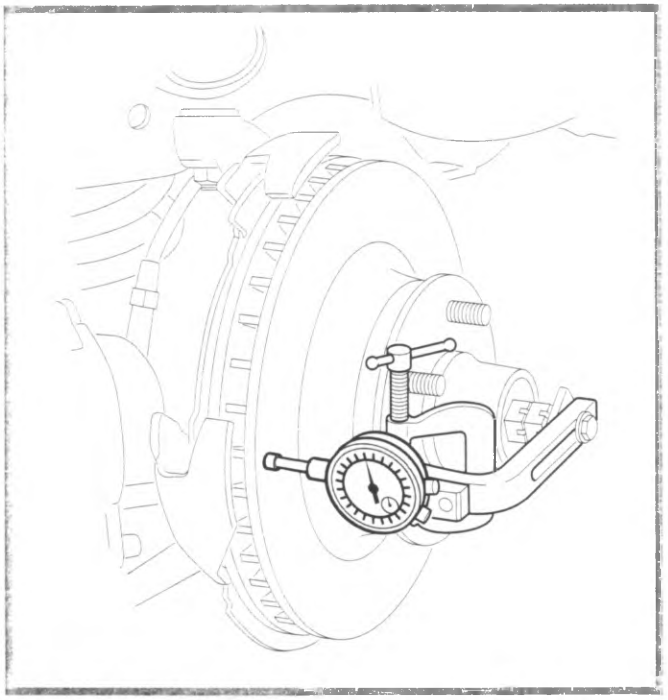


Figure 6-19, **Measuring Lateral Runout**

Measuring Rotor Lateral Runout

Lateral runout can result in worn rotors and pedal pulsation complaints. Lateral runout can be caused by improper lug nut torquing or excessive bearing runout. Lateral runout can also be the result of normal rotor wear or improper refacing procedures.

Measuring for lateral runout requires:

- Dial indicator
- C-clamp or magnetic base stand

— IMPORTANT —

If the wheel has adjustable bearings, temporarily tighten the wheel bearings just enough to remove end play. Then begin the runout check procedure. Failure to re-adjust the wheel bearings correctly after runout measurements are complete may result in damage to the bearings.

To measure lateral runout (figure 6-19):

1. On two-wheel drive vehicles, tighten adjustable wheel bearings slightly to take out any free play. For non-adjustable bearings, refer to the service information on end play diagnosis.
2. Attach the dial indicator to the fixed part of the axle or suspension so the dial indicator tip contacts the rotor face approximately one inch from the outside edge of the rotor. Attach the indicator firmly in place so it does not vibrate.
3. Set the dial indicator to zero.
4. Slowly move the rotor through one complete revolution while observing the dial indicator.
5. As a rule, if the total dial indicator deflection (add maximum readings on both sides of zero) is greater than 0.08 mm (0.003 in.), refinish or replace the rotor. Refer to the specific service information for the vehicle you are servicing.
6. If the wheel bearings were tightened to measure runout, re-adjust to specification.

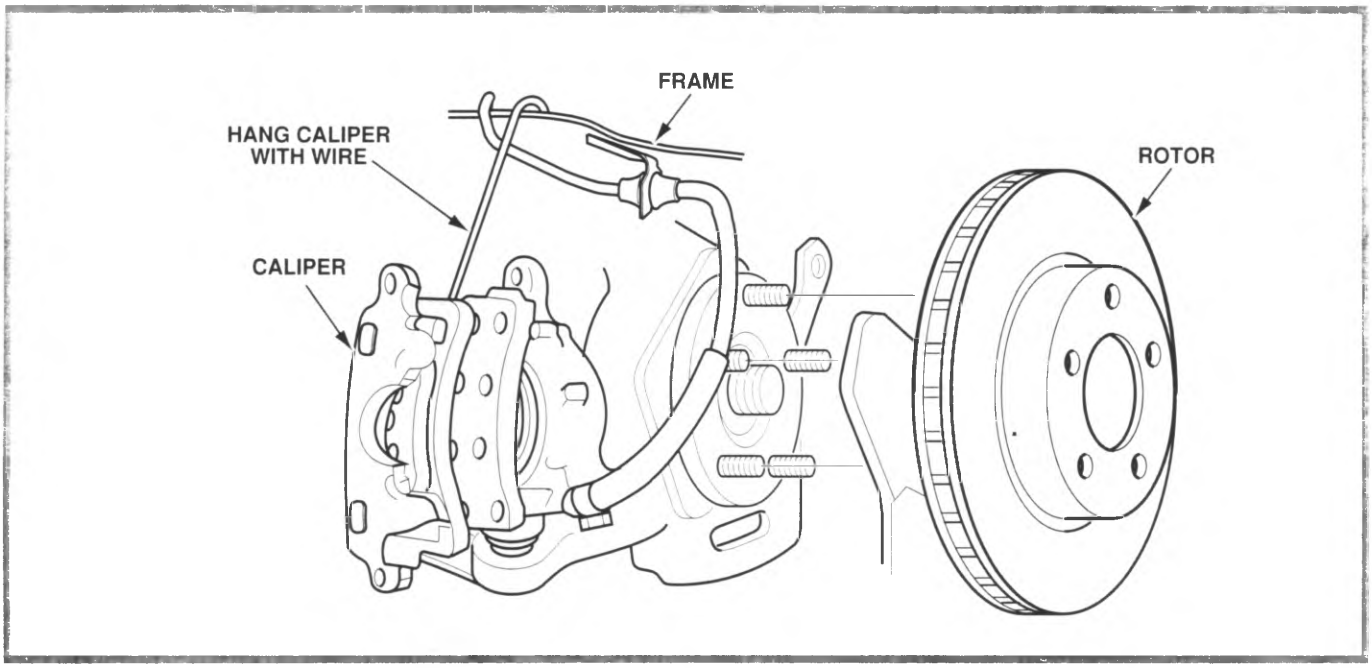


Figure 6-20. **Replacing Disc Brake Rotor (4WD)**

Rotor Remove and Replace–Hubless

1. Raise and support the front of the vehicle, mark the relationship of the tire, hub and rotor assembly, then remove the wheel and tire assembly.
2. Remove the caliper mounting bolts, then lift the caliper from the mounting with the brake hose attached and suspend it from the chassis using a piece of wire (figure 6-20).
3. Slide the disc brake rotor from the hub. Thoroughly clean the mounting contact surfaces of both the rotor and the hub to ensure proper mating during reassembly.
4. Reverse the above procedure to install being careful to realign the index marks. Refer to the disc brake torque and specification chart for the caliper mounting bolt torque.

Rotor Remove and Replace–Hubbed

1. Remove the brake caliper. Refer to front disc brake caliper section of the service manual (section 5).
2. Remove the dust cap from the hub. Remove the cotter pin, nut and washer from spindle.
3. Carefully pull hub assembly from spindle.
4. Remove the outer roller bearing assembly from hub. The inner bearing assembly will remain in the hub and may be removed after prying out the inner bearing lip seal. Discard seal.
5. Inspect the bearing and races for damage or wear. Replace if the bearing and/or race is damaged. Bearings and races must be replaced as a set.

Burnishing Linings and Rotors

After you replace brake linings and/or refinish rotors, it is recommended that the new braking surface be broken in, or "burnished." To do this, make 20 stops from 30 mph using medium to firm brake pedal pressure. During this procedure, use care to avoid overheating the brakes.

Bearing and Bearing Race Replacement

This is a procedure to remove the hub and replace the wheel bearings and bearing races.

Tool Required:

J 29117-A Wheel Bearing Cup Remover

Wheel and tire removed (figure 6-21)

1. Remove the brake caliper. Refer to front disc brake caliper section of the appropriate service information (section 5 of the service manual).
2. Remove the dust cap from the hub. Remove the cotter pin, nut and washer from spindle.
3. Carefully pull hub assembly from spindle.

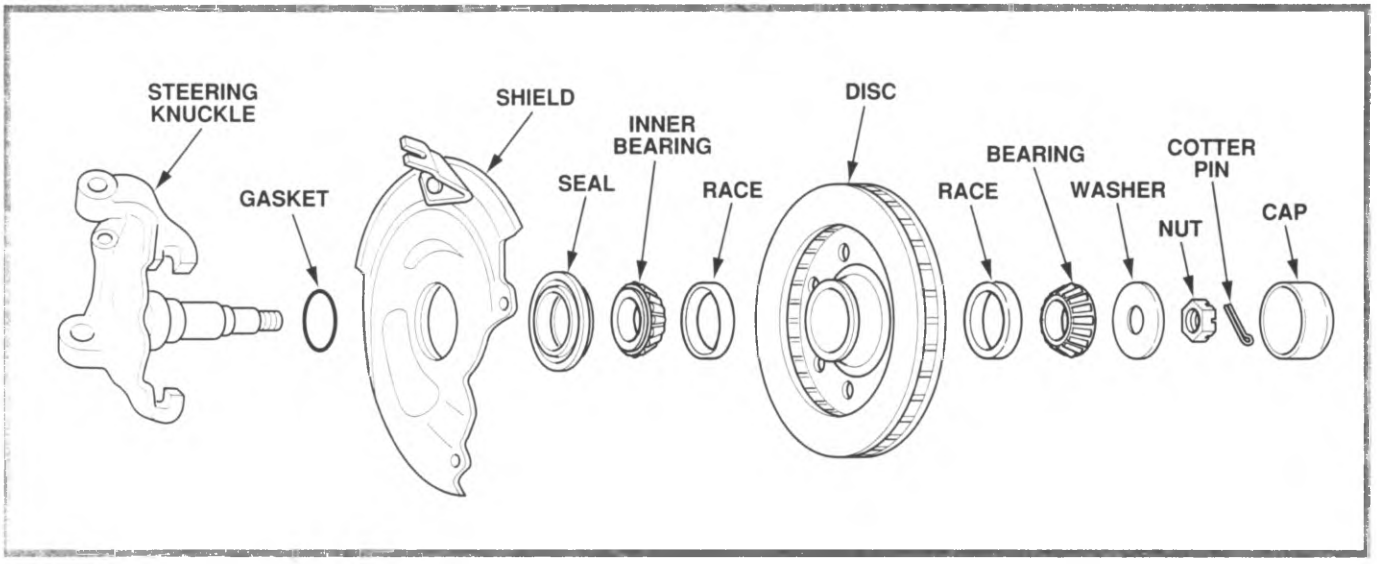


Figure 6-21. **Wheel Bearing Assembly**

4. Remove the outer roller bearing assembly from hub. The inner bearing assembly will remain in the hub and may be removed after prying out the inner bearing lip seal. Discard seal.
5. Inspect the bearing and races for damage or wear. Replace if the bearing and/or race is damaged (refer to figure 6-21). Bearings and races must be replaced as a set.
6. Drive out old races from hub with a drift or J 29117-A inserted behind races (figure 6-22).
7. Clean the brake disc in clean solvent. Air dry.
8. Drive or press the new races into the hub (figure 6-23).

Clean all grease from the hub and spindle, and thoroughly clean out any grease in the bearings. Use clean solvent and a small brush with no loose bristles to clean out all old grease.

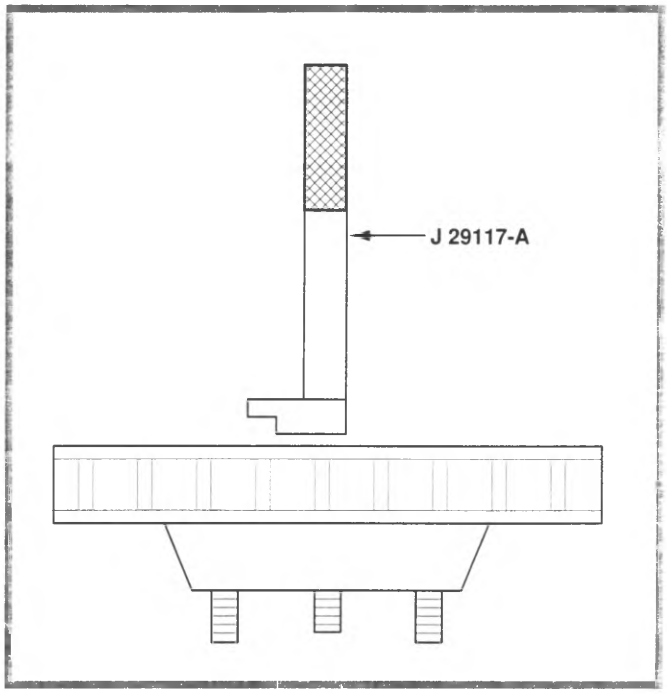


Figure 6-22, **Removing Front Wheel Bearing Race**

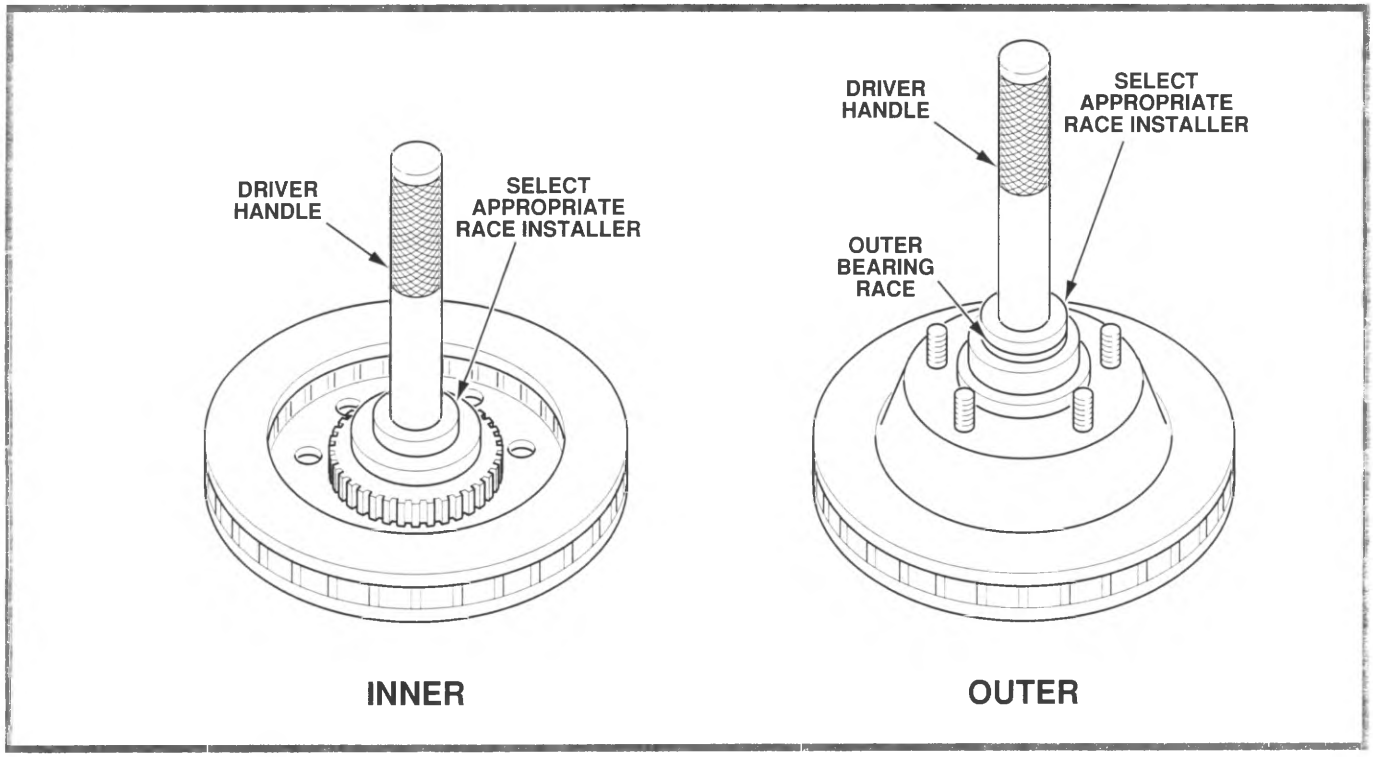


Figure 6-23, **Installing Inner and Outer Bearing Outer Race**

— NOTICE —

Do not spin the bearing with compressed air while drying it or the bearing may be damaged.

— NOTICE —

Apply an approved high temperature front wheel bearing grease. Do not mix greases. Mixing may change the grease properties and result in poor performance.

9. Clean and inspect spindle for wear or damage.
10. Grease the hub and bearings carefully:
    - Apply a thin film of grease to the spindle at the inner bearing seat and at the outer bearing seat, shoulder and seal seat.
    - Put a small quantity of grease inboard of each bearing cup in the hub. This can be applied with your finger, forming a dam to provide extra grease to the bearing and to keep thinned grease from flowing out of the bearing.
    - Fill the bearing cone and roller assemblies full of grease. A preferred method for doing this is with a cone type grease machine (J 33067) that forces grease into the bearing. If a cone greaser is not available, the bearings can be packed by hand.

— NOTICE —

If hand packing, it is extremely important to work the grease thoroughly into the bearings between the rollers, cone, and the cage. Failure to do this could result in premature bearing failure.

    - Place the inner bearing assembly in the hub. Then, using your finger, put an additional quantity of grease outboard of the bearing.
11. Install a new grease seal using a bearing installer until the seal is flush with the hub. Lubricate the seal lip with a thin layer of grease.
12. Carefully install the hub and rotor assembly taking care not to damage the inner seal. Place the outer bearing cone and roller assembly in the outer bearing cup. Install the washer and nut.
13. Torque the wheel hub spindle nut as specified in the service manual while rotating the wheel assembly by hand.
14. Back off the nut to the zero preload position. Do not back the nut off more than 1/4 turn.
15. Hand tighten the spindle nut. Loosen spindle nut until either hole in the spindle lines up with a slot in the nut (not more than 1/2 flat).
16. Install new cotter pin. Bend the ends of the cotter pin against the nut, cut off extra length to ensure ends will not interfere with the dust cap.
17. Using a dial indicator, check the hub assembly. There should be from 0.03 to 0.13 mm (0.001 to 0.005 in.) end play when properly adjusted.
18. Install dust cap on hub taking care not to damage the cap.

Tapered Roller Bearing Diagnosis

When diagnosing a bearing condition:

- Consider the general condition of all parts during disassembly and inspection
- Identify the bearing wear condition (figure 6-24)
- After identifying the bearing problem, refer to the diagnostic chart to identify the cause and appropriate repair procedures. Whenever a bearing is replaced, the race must also be replaced

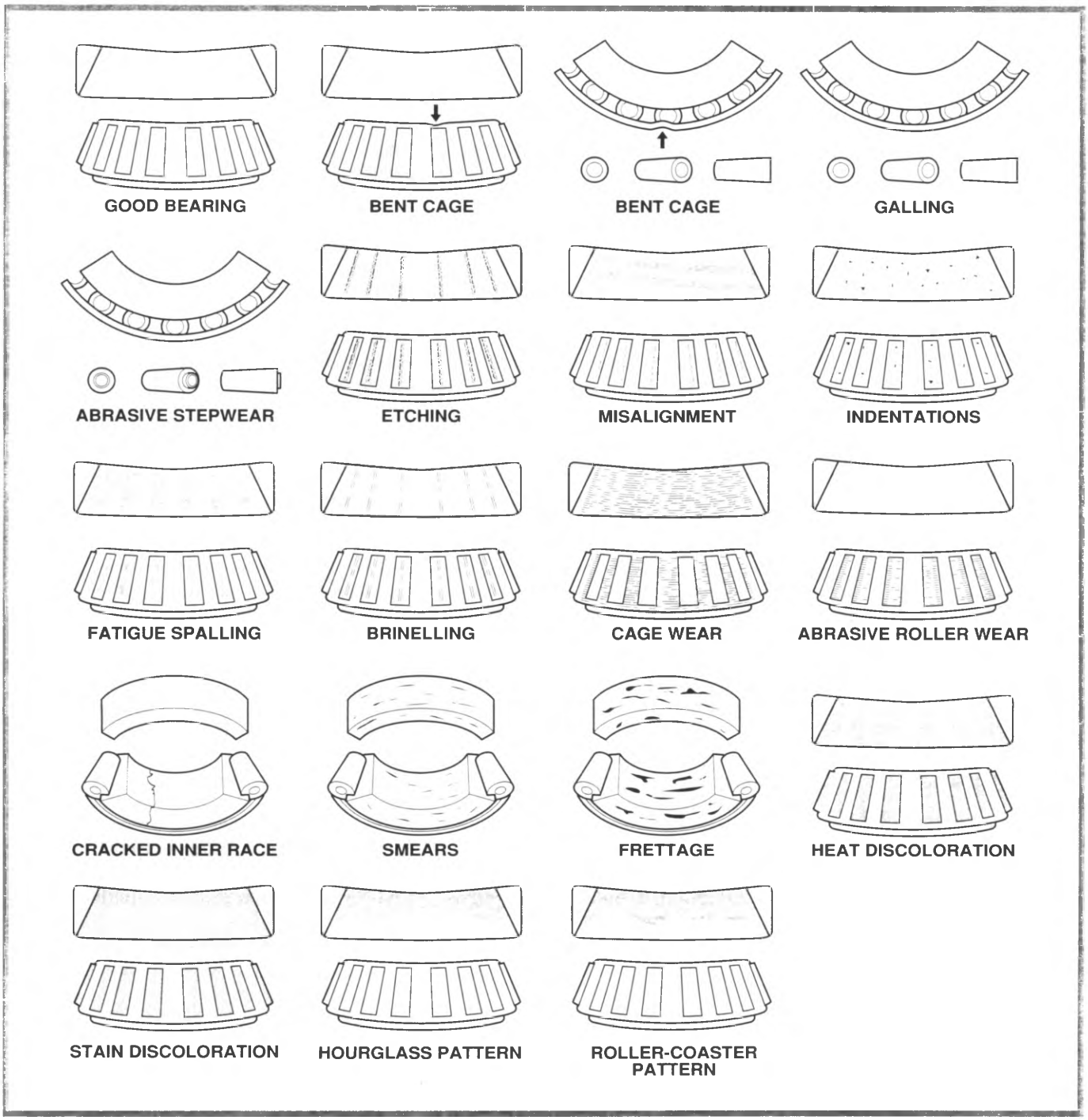


Figure 6-24, **Tapered Wheel Bearing Diagnosis**

Tapered Roller Bearing Diagnosis Chart

Condition	Cause	Repair Procedure
Bent Cage	Damage due to improper handling or tool usage.	Replace bearing and race.
Galling	Metal smears on roller ends due to overheating. Lubricant failure or overload.	Replace bearing and race. Check seals. Ensure proper lubrication.
Abrasive Step Wear	Pattern on roller ends caused by fine abrasives.	Clean all parts and housings. Check seals, bearings and races. Replace if leaking, rough, or noisy.
Etching	Bearing surfaces appear gray or grayish black in color with related etching away of material usually at roller spacing.	Replace bearings and races. Check seals. Ensure proper lubrication.
Misalignment	Race misalignment due to a foreign object or improper installation.	Clean related parts and replace bearing and race. Make sure races are properly seated.
Indentations	Surface depressions on race and rollers caused by hard particles of foreign material.	Clean all parts and housings. Check seals and replace bearings and races if rough or noisy.
Fatigue Spalling	Flaking of surface metal resulting from fatigue.	Replace bearing and race. Clean all related parts.
Brinelling	Surface indentations in raceway caused by rollers either under impact loading or vibration while bearing is not rotating.	Replace bearing and race if rough or noisy.
Cage Wear	Wear around outside diameter of cage and roller packets caused by abrasive material and insufficient lubrication.	Replace bearing and race. Check seals. Ensure proper lubrication.
Abrasive Roller Wear	Pattern on races and rollers caused by fine abrasives.	Clean all parts and housings. Check seals, bearings and races. Replace if leaking, rough, or noisy.
Cracked Race	Race cracked due to improper fit, cocking, or poor bearing seats.	Replace race and bearing.
Smears	Smearing of metal due to slippage. Slippage can be caused by poor fits, poor lubrication, overheating, overloads, or handling damage.	Replace bearings and races. Clean related parts and check for proper fit and lubrication. Replace shaft if damaged.

Tapered Roller Bearing Diagnosis Chart (cont'd)

Condition	Cause	Repair Procedure
Frettage	Corrosion set up by small relative movement of parts with no lubrication.	Replace bearing and race. Clean related parts. Check seals for proper lubrication.
Heat Discoloration	Discoloration can range from faint yellow to dark blue and can result from overloading or incorrect lubricant, and overheating. Excessive heat can cause softening of the races and rollers. To check for heat damage on races or rollers a file test can be done. A file drawn over a soft part will grab and cut metal. A file drawn over a hard part will glide easily without cutting the metal.	Replace bearings and races if overheating damage is indicated. Check seals. Ensure proper lubrication.
Stain Discoloration	Discoloration can range from light brown to black and can be caused by incorrect lubricant or moisture.	Reuse bearings and races if stains can be removed by light polishing and if there is no evidence of overheating. Check seals and related parts for damage. Check for proper lubrication.
Roller Coaster Pattern	Pattern is inconsistent around the outer race due to misalignment or insufficient preload.	Replace bearing and race assembly. Properly adjust wheel bearings.
Hourglass Pattern	Pattern is inconsistent in two areas 180° apart. The housing is most likely damaged or incorrectly machined.	Replace the hub/housing.

Rotor Refinishing

Rotor refinishing requires:

- Brake lathe
- Non-directional attachment
- 150 grit sanding block

Refinishing Guidelines

There are three basic conditions that a brake rotor needs to be effective when stopping a vehicle.

- Both sides of the rotor need to be flat and parallel
- The surface finish needs to be 50 RA (roughness analysis) or lower
- The machined sides of the rotor need to be perpendicular to the center line of the hub

— IMPORTANT —

Improper rotor refinishing techniques will cause a high pedal effort comment.

- Do not reface new rotors from stock unless excessive runout is apparent
- Do not reface rotors as a routine part of lining replacement unless there is excessive runout, scoring or thickness variation
- Do not reface rotors due to minor surface rust, discoloration, hot spots or brake squeal
- After refacing, always sand each side 60 seconds with 150 grit aluminum oxide sandpaper to provide a smooth, non-directional finish
- Always clean the rotor with brake cleaning solvent after turning and sanding to remove sanding grit. Rotate rotor 180° on mounting and measure runout
- Pad replacement does not necessitate rotor refacing or surface deglazing

— IMPORTANT —

The peaks and valleys on a turned rotor reduce the friction contact surface area. Sanding each side reduces the peak height, smoothing the rotor surface and increasing friction area for improved braking.

Qualify Brake Lathe

In order to produce an acceptable rotor surface finish, it is imperative to make sure that the lathe is operating properly. To qualify a brake lathe, use the following generic check list. It emphasizes what is necessary for the lathe to produce the best rotor it is capable of machining.

1. Check for proper operation and that all motors, switches, feed controls, engage and disengage levers function properly.
2. Make sure radius cones, bell clamps, and taper cones are free of all nicks, burrs, rust, and foreign debris. To restore flatness, use an eighty grit silicon carbide hone and WD–40 lubricant. Apply light pressure using short figure eight movements to prevent rounding of the edges.
3. Check the tapered surfaces on the arbor and spindle to ensure these surfaces are totally free of any contamination. The arbor should not run out over two thousandths total indicator reading.
4. The shoulder of the arbor must also be free of nicks or debris. Spray the shoulder of the arbor with WD–40 and use the arbor shaft for a guide to hold the hone perpendicular to the shoulder. Turn the lathe on and hone the shoulder. Apply pressure on the hone with a finger on the arbor.
5. Check fit of the rotor truer and the top of the dovetail way. A one thousandths feeler gauge should not be able to fit between the top dovetail surface and the bottom of the rotor. Remove the rotor truer and hone the top dovetail surface and the bottom of the rotor truer until the feeler gage stock can not be inserted.
6. The tool bit holder slots on the rotor truer should be clean. Make sure the bottom of the tool bit holder is also clean. The tool bit holder bottom can be cleaned by rubbing it on a hone or a single cut file. The carbide bit seat on the tool bit holder should be clean and flat. If the surface is not flat, replace the tool bit holder.
7. All end bell clamps can be remachined to reduce runout. Mount the bell clamp with the machined hub mating with the shoulder of the arbor. Use the two small radius adapters next on the arbor and space out to the threads with available radius adapters or one inch spacer. Tighten the arbor nut. Put a reference mark on the bell clamp that lines up with the two marks on the spindle and arbor. Machine the face of the bell clamp with the rotor truer. True all four bell clamps.
8. Always align the inside bell clamp with the reference mark put on the hub after machining the bell clamp. Keep all mounting surfaces clean and occasionally check accuracy of setup by holding the inside bell clamp and rotating the rotor one hundred eighty degrees. Reclamp and check with the dial indicator. If runout is excessive, hone the adapter. If runout persists, remachine the adapter.
9. The inside of the hat section of the rotor must be cleaned of all rust, burrs, and any foreign matter. If any debris is present on this surface, the rotor will not reference properly while machining.
10. All surfaces of the lathe, arbor and all of the adapter surfaces must be free of all nicks and burrs, and free of all foreign debris.

Follow lathe manufacturer's specific operating and maintenance instructions.

Mounting Hubbed Rotors

1. Select the correct self-aligning spacer and adapter and slide them onto the arbor shaft.
2. Slide the rotor onto the adapter cone.
3. Install spacer and arbor nut.
4. Install silencer band and proceed with machining.

Mounting Composite (Hubless) Rotors

Composite rotors do not have an integral hub. When mounting a composite rotor on a lathe, the stamped center must be squeezed, just as it would be when the wheel is tightened against it (figure 6-25).

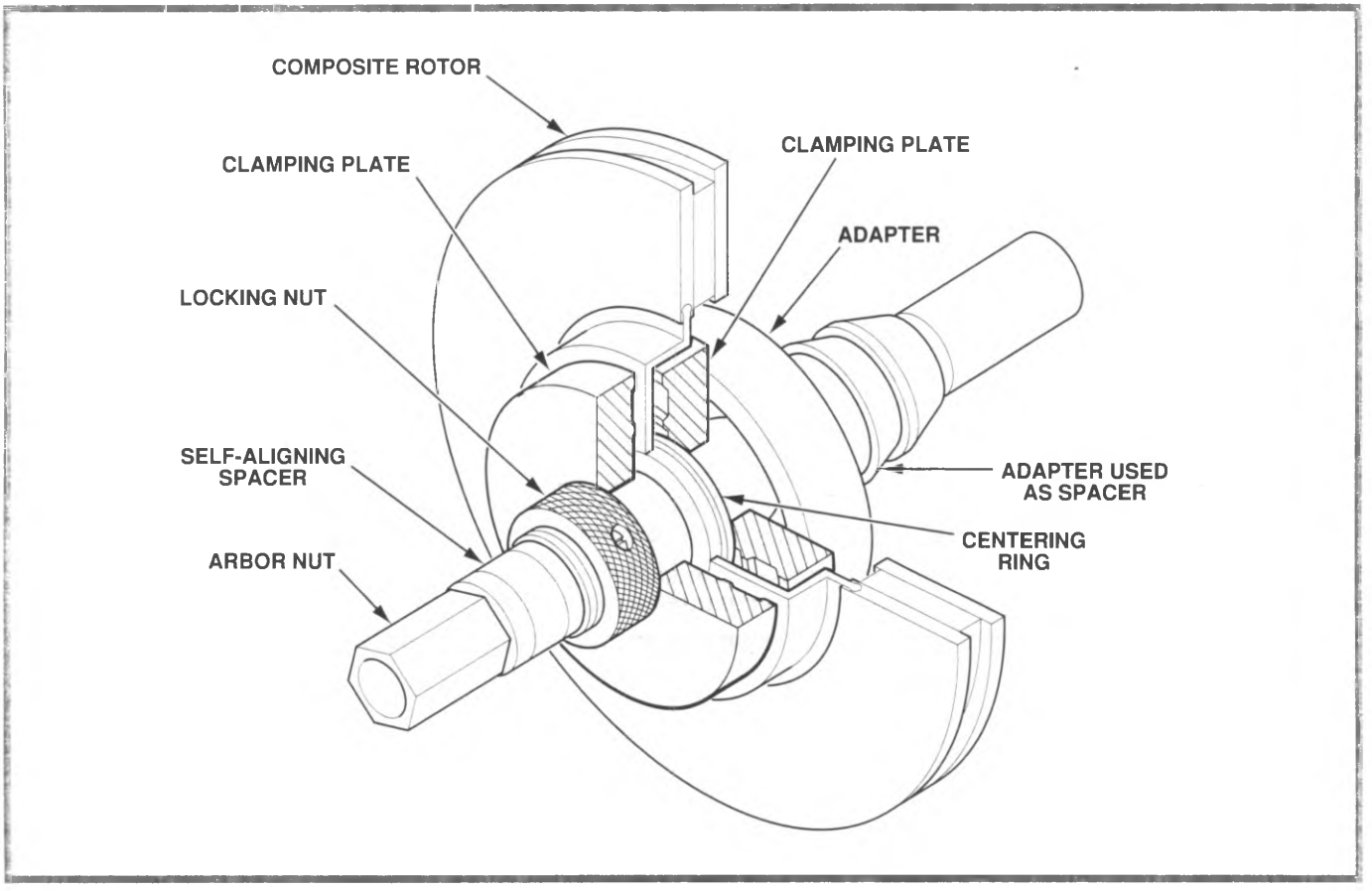


Figure 6-25, **Mounting Composite Rotors**

— IMPORTANT —

An approved support adaptor is required when refacing any composite rotor to ensure proper support.

Adapters that bolt two plates together through the rotor stud holes squeeze the rotor center to provide support.

1. Index the rotor to the hub before removal.
2. Clean the rotor mounting surfaces with a wire brush.
3. File or scrape off any high spots as necessary.
4. Check the rotor for flatness using a straight edge.
5. Before installing adapters, inspect the inside and outside mounting surfaces to ensure they are smooth and free of:
   - Rust
   - Nicks
   - Burrs
6. Select the correct clamping plate and adapter cone and slide them onto the arbor shaft.
7. Slide the rotor onto the adapter cone.
8. Slide the second plate onto the arbor shaft and torque bolt to specification utilizing the approved star pattern.
9. Install spacer and arbor nut.
10. Install silencer band and proceed with machining.

— IMPORTANT —

Clean all corrosion from both the inside hat section of the rotor and the hub flange.

Off-Car Brake Lathe Set-Up

— IMPORTANT —

The Accu-turn® brake lathe (see figure 6-26) uses a single cut operation to resurface rotors.

To machine the rotor:

1. Mount the rotor and install the vibration dampener.
2. Bottom the tip of the tool bit in the deepest groove of the rotor. Zero the scale and back out the tool bit. Repeat for the other side of the rotor.
3. Move the cutters to the inner edge of the rotor face. Adjust the micrometer knobs for approximately 0.0127 mm (0.005 in.) more than the original reading.
4. Start resurfacing operation.
5. After cutting is complete, dress the rotor for a non-directional finish. Sand each rotor with 150 grit aluminum oxide sandpaper on a sanding block with the rotor turning at the manufacturer's recommended cutting speed for 60 seconds. Then wipe the rotor with brake cleaning solvent.
6. Check that the refinished rotor meets all inspection requirements.

Spindle Speed	105 rpm
Depth of Cut per Side	As necessary
Total Cross Feed per Revolution	0.076 mm (0.003 inch)
Vibration Dampener	Yes
Non-directional Finish	Yes

— IMPORTANT —

Speeds and feeds other than those specified in the table can result in an unsatisfactory finish.

— NOTICE —

Replace the rotor if refinishing reduces rotor thickness to within 0.015 in. of the minimum allowable marked on the rotor.

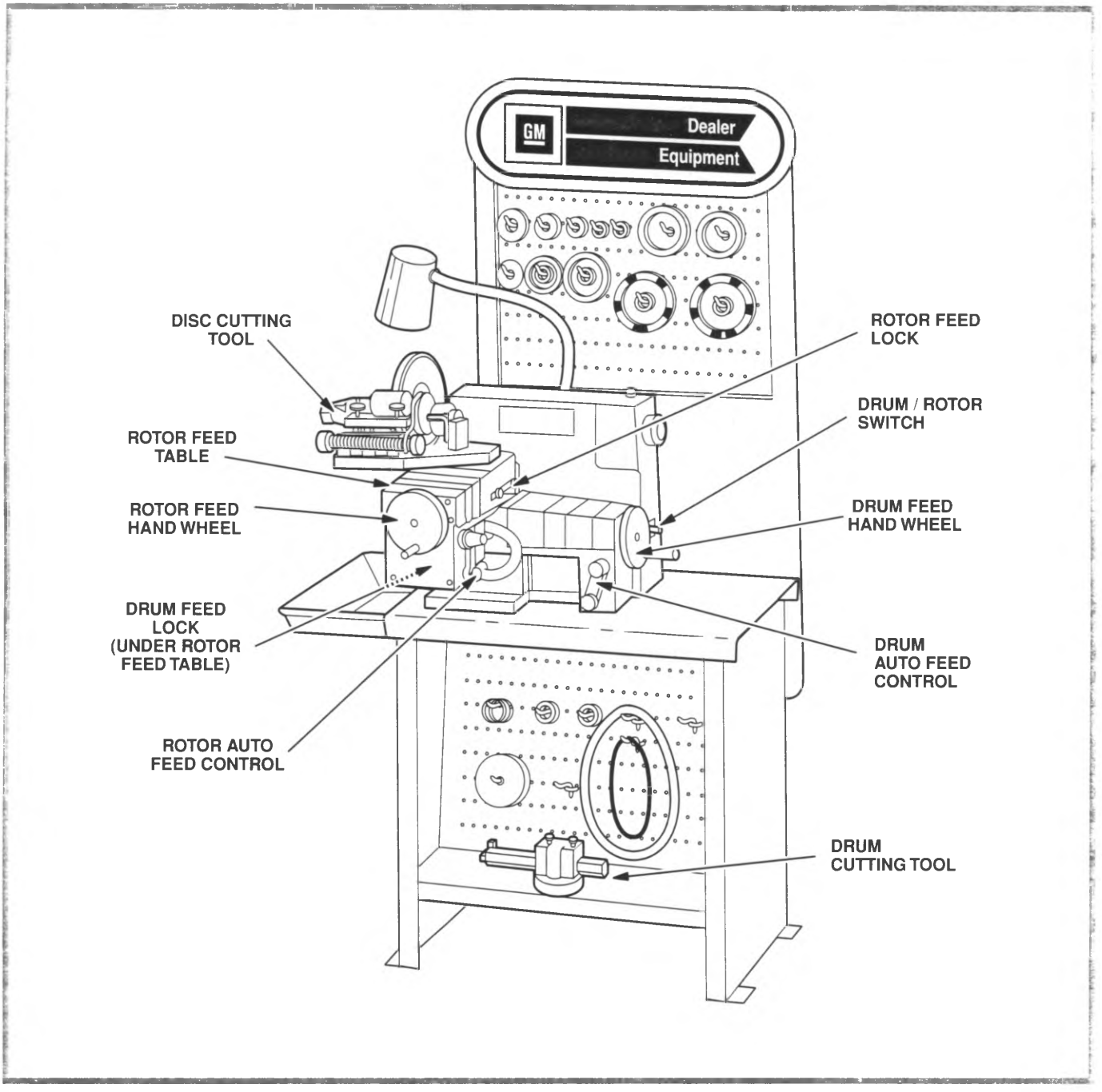


Figure 6-26, **Off-Car Brake Lathe**

On-Car Brake Lathe

Vehicle Preparation

The front wheels should be straight, the parking brake off and the transmission in neutral.

Raise the vehicle until the wheel hub is about belt level.

Remove the wheels. Remove the brake calipers and suspend them out of the way of moving parts such as half shafts and CV joints.

If the rotor is free on the hub, mark and remove it in order to assess the mating surface. Use a Scotch-Brite-type wheel on a die grinder to remove rust or debris. Clean all material from the mounting area.

The rotor on the opposite side of the vehicle should be marked and removed if it is free on the hub. Marking rotors to match a certain alignment on the hub is very important.

Visually inspect for deep rust or grooves.

Lathe Preparation

Cutting Bits

Check the cutting bits and make sure they are ready for use. Each cutting bit has three corners which may be used. A correctly installed bit has the letters V, B and G facing up. An improperly installed bit has no letters facing up, and from the side you can clearly see that it does not fit correctly.

Bit life is affected by variables such as rust or ridges. In order to determine when to rotate bits, monitor rotor finish. If the rotor finish begins to look inconsistent or feels rough to the touch, bits should be rotated. Bits that are chipped or cracked should never be used. The bits can be switched from the left to the right tool holder to use the back sides of each corner.

Be sure that the bit pocket is clean before positioning the bit. Any foreign material pinched under the bit will cause problems and may even break the bit when you tighten the screw.

Use only the bits recommended by the manufacturer.

The Pro-Cut mounts directly to the hub of the vehicle, at the center flange. Begin with the lathe right side up, with the cutting head to the right of the hub, set-up to cut where the caliper normally rides. On a vehicle where the calipers ride in front of the hub, always start on the passenger side. If the caliper rides to the rear of the hub, begin on the driver side.

— IMPORTANT —

The on-vehicle lathe machines both front and rear rotors. The lathe's operations do not change at all in the rear of the vehicle.

— IMPORTANT —

The lathe has a 3/4-hp motor. This requires 20 amp service. All extension cords must be at least 12 gauge and less than 25 feet—drop light cords are not recommended.

Mounting the Lathe

Adapters

First, choose the proper adapter. Most passenger cars use either the four (50-687) or five lug (50-688) adapter. For most trucks and vans, you will use the larger adapter with many holes. See the lathe manufactures equipment manual for more detailed information.

Try each bolt pattern until you find the one that fits the vehicle evenly. Use the nuts and bolts provided.

The adapters are made of cast iron, not aluminum or steel like wheels. They are NOT designed to withstand the use of impact tools.

— CAUTION —

DO NOT USE IMPACT TOOLS TO ATTACH THESE ADAPTERS. ONLY USE *20-30 FT-LBS.* OF TORQUE TO SECURE THE ADAPTER TO THE VEHICLE.

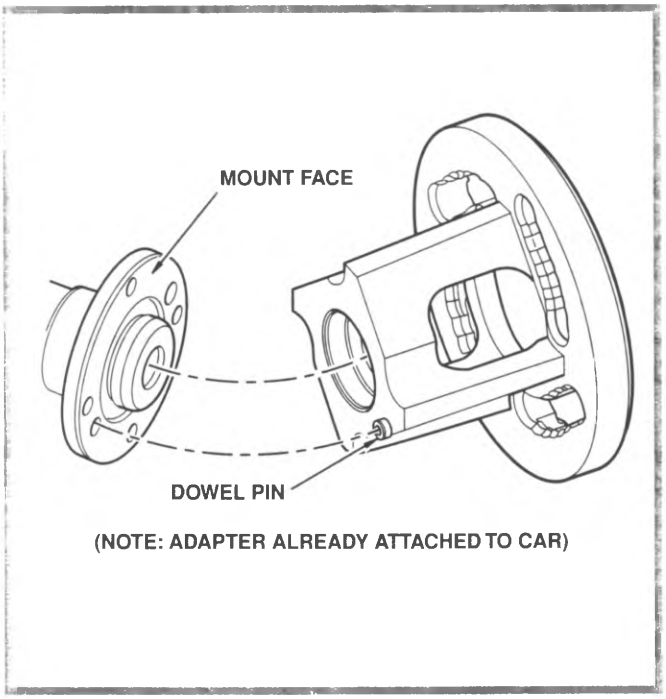


Figure 6-27, **Mount Lathe to the Adapter**

Mount the Lathe to the Adapter

Disengage the feed knob by pulling out the feed engage plunger (figure 6-27). Turn the knob to move the cutting bits away from the middle of the lathe. This allows the tools to clear the rotor when the lathe is being attached to the hub.

Notice the four screws on the face of the mount flange called RUNOUT screws. When tightened, they protrude beyond the face of the mounting flange.

— IMPORTANT —

Make sure that the runout screws are backed out completely so that they do not protrude beyond the face of the mounting flange.

Roll the machine into place and attach it to the adapter. The adapter has a dowel pin which must line up with one of two holes in the mounting flange. Once the flange is flush to the adapter, the shaft of the machine bolts onto the adapter by turning the large mounting knob.

Make sure the trolley handle is loose. Rotate the machine so that the cutting head is in a position where there is enough room to cut the rotor, typically in the brake caliper area. Lock the machine in place by tightening the trolley handle.

With the lathe in the 'right side up' position, notice that the opening in the dust shield is on the right of the hub. Depending on which vehicle you are servicing, this opening will either be on the left or the right. Always begin with the lathe right side up.

Position Cutting Head and Set Shut Off Cam

Use the T-handle 6-mm allen wrench to remove the securing screw found in one of five mounting holes in the slide plate used to lock the cutting head. Center the head so the cutting arms will straddle the rotor.

The cutting head assembly can be secured into any one of the five holes. Clean out these holes as well as the dovetail and plate surfaces when changing cutting head position, as they can easily fill up with metal chips.

It is *absolutely critical* to pull the tool holder plate back into the dovetail so that it is square before tightening the securing screw. Push the cutting head firmly back into the dovetail while tightening the set screw.

— NOTICE —

If the tool holder is not squarely and firmly pressed into the dovetail, a poor surface finish will result.

The cutting head must be moved in or out for each vehicle. On large trucks, the head will actually be mounted as far out as it can possibly go. Even though the head hangs over the edge of the base plate, the lathe will cut smoothly provided the head is squarely pressed into the dovetail.

When cutting on the other side of the vehicle, the lathe will be mounted in the upside down position. The offset of the cutting head will already be set, with the cutting head firmly in the dovetail. That is why it's important to begin with the machine right-side up.

— CAUTION —

DO NOT ATTEMPT TO MOVE THE CUTTING HEAD LATERALLY WITH THE LATHE UPSIDE DOWN.

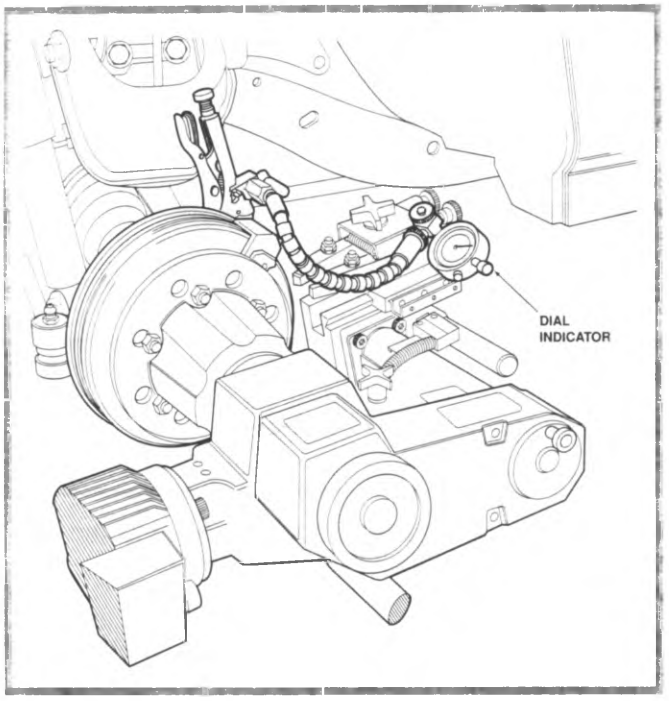


Figure 6-28, **Lathe in Correct Position**

Adjustment for Lateral Runout

Since the lathe is bolted to the hub, any wobble or runout in the hub will be passed on to the machine. Before cutting the rotor, measure the runout in the machine and compensate for it with two of the four runout adjustment screws. Runout should be less than 0.003 inches.

Set Up the Indicator and Measure the Run Out

Attach the visegrip to the vehicle hub and position the dial indicator tip against a flat surface on or near the cutting head or on a flat surface on the motor (figure 6-28). The surface should be parallel to the rotor surface, smooth and not curved.

Disengage the feed by pulling out the feed knob until it clicks. This will stop the cutting head from feeding when the motor is turned on.

Turn on the lathe, observe the movement in the dial indicator. Turn the face of the indicator so that zero is at the low (furthest counter clockwise) point.

Determine the total needle sweep between the high (furthest clockwise) and low (furthest counterclockwise).

— CAUTION —

THE LATHE IS FITTED WITH A KNOB ON THE BACK OF THE MOTOR. DO NOT TOUCH THE KNOB WHEN THE MOTOR IS TURNING. DO NOT REMOVE THE SAFETY COVER.

Compensate for the Run-Out

Stop the lathe so that the needle reaches the extreme low (counter clockwise) or high (clockwise) end of its sweep using the motor crank knob on the back of the motor.

Give the lathe two test pulls, one at either end of the lathe. The test pulls will indicate which runout screw to tighten first. If pulling on the cutting head end causes the needle to go towards the middle of the sweep, tighten the screw nearest the cutting head. If pulling on the motor end causes the needle to go towards the middle of the sweep, tighten the screw nearest the motor end. Tighten the appropriate screw until the dial needle moves about half of the sweep. A little less than half is preferable. Remember the number that is stamped next to this screw.

Turn the lathe on and note the new runout. If runout is still above three thousandths of an inch, repeat the process, with one exception - *If the test pulls indicate to tighten the runout screw directly opposite one previously tightened, loosen the original screw instead.*

— NOTICE —

Runout adjustment is accomplished by turning one, possibly two, screws adjacent to one another. Never turn screws that are across from one another. For example, first turning screw #1, then screw #3.

When the dial indicator shows less than 0.003 in. begin cutting. Realize the dial indicator is much farther out than the rotor, giving an exaggerated runout reading. By ensuring less than 0.003 in. on the indicator, a cut of less than 0.002 in. on the rotor is virtually guaranteed.

If the dial indicator does not make an even back and forth motion like a windshield wiper, this may be an indication of another problem. There may be foreign matter behind the rotor, causing a wobble, or there may even be a driveline part that has been damaged. Runout cannot be eliminated if it is not an even once-per-revolution sweep.

Improper lathe setup can include:

- Loose dial indicator or gooseneck
- Dial indicator tip is on an uneven surface or edge
- Loose dial indicator tip
- Vise-grip attached to a loose part on the vehicle
- The lathe is not fully engaged to the adapter
- The adapter is not fully seated
- Run-out screws were not backed off before you began
- The lug nuts are loose on the adapter

Uneven motion can indicate other vehicle problems and warrants further investigation if one of the issues listed above is not the problem.

Making the Cut

Loosen the clamp knob on top of the cutting head.

Set the shutoff cam.

Crank the feed knob until the bits clear the outside edge of the rotor. Loosen the cam screw and slide the cam back until it contacts the automatic shutoff switch plunger. Tighten the cam screw. This cam will contact the shutoff switch when the bits clear the rotor.

Turn cut depth knobs counter clockwise until the bits can clear both sides of the rotor. Turn on the lathe. Crank the cutting head into the middle of the braking surface of the rotor.

Start with the inside (behind the rotor) tool arm. Turn the depth knob clockwise (tighten) until the tool bit just barely makes contact with the rotor surface. Listen for the contact. Do the same with the outside tool.

Advance the cutting head in towards the center of the rotor.

— IMPORTANT —

Do not to touch the hat of the rotor with the tool bit! This will damage or break the tool holder plate.

At the inside edge of the pad contact surface, adjust the lathe for depth. Each line on the adjustment knob moves the cutting bit 0.002 in. Cut at least 0.002 in. on each side with each pass. The maximum depth is 0.020 in. on each side.

Tighten the clamp knob (over the cutting arms) to minimize vibration. Place the chip deflector/silencer over the cutting bits.

— IMPORTANT —

The silencer should be used on every rotor to prevent vibration.

Press the feed engage crank handle in to engage the automatic feed. The machine will shut off when the cut is finished.

— NOTICE —

If the rotor is severely worn it may be necessary to machine away the ridges on the inside and outside of the pad contact area before machining the pad contact surface.

When finished cutting, loosen all runout adjustment screws. Loosen the mounting knob and remove the lathe from the adapter. Be careful not to bump either the rotor or the wheel well with the brake lathe. Take special care not to bump the bits into the rotor. This can fracture bits.

— IMPORTANT —

Careful cleaning of the adapter prior to removal is important on vehicles with exposed bearings.

If the rotor is loose on the hub, be certain that it is match marked to the hub before removing the adapter.

Clean any dust or debris from the finished rotor with 150 grit sand paper and then a damp rag.

Machining the Opposite Side

To prepare the lathe for the other side of the vehicle, loosen the trolley handle and rotate the machine into the upside down position.

The procedure for cutting in the upside down position is the same. The cutting head has already been moved to the proper position so it will not need to be set. The lathe mounts in the same manner. Often, the shutoff switch will still be depressed from the previous cut, so the machine will not turn on until the head is moved. Measuring and adjusting for runout is exactly the same as in the upright position. The entire cutting process is also the same, right down to the silencer clip which mounts upside down in the exact same position.

Advancing the cutting head towards the hat of the rotor requires even more care in the upside down position. DO NOT BUMP THE HAT OF THE ROTOR.

Front Caliper Service

Unit repair (overhaul) procedures for all front calipers are basically the same. Illustrations are typical. Some parts may vary from those shown.

— NOTICE —

Contamination of the brake hydraulic system with dirt particles or fluids other than clean brake fluid can result in system failure. Repair the calipers on a clean bench away from grinders, sanders and other particle generating equipment.

— NOTICE —

Do not use petroleum-based oil, grease or cleaning compounds at the caliper repair station. Do not repair the calipers with oily or greasy hands. Use only denatured alcohol to clean caliper parts. Use only clean brake fluid to lubricate the parts at assembly.

Preliminary Procedures

1. Disconnect the brake hose fitting and remove the caliper from the vehicle. Discard the copper sealing washers. New copper sealing washers are required during installation.
2. Use a wire brush to clean the exterior of the caliper, removing any corrosion or road dirt. After brushing thoroughly, clean the caliper with denatured alcohol before moving it to a clean work bench for disassembly.

Removing Piston

3. Drain fluid from the caliper. Discard the drained fluid.

— CAUTION —

IN THE FOLLOWING STEP, USE JUST ENOUGH AIR PRESSURE TO EASE THE PISTON OUT OF THE CALIPER. DO NOT PLACE FINGERS UNDER THE PISTON IN AN ATTEMPT TO CATCH OR PROTECT IT. THE PISTON MAY BE EXPELLED WITH SUFFICIENT FORCE TO CAUSE INJURY.

4. Pad the inside of the caliper with clean shop cloths. Remove the piston by gradually directing compressed air into the caliper fluid inlet as shown in figure 6-29. The piston will blow out of the housing with considerable force.
5. Use a screwdriver to pry the boot out of the caliper as shown in figure 6-30. Extend the screwdriver across the caliper bore, under the boot, and pry up. Use care not to scratch the caliper bore or the seal groove.

— CAUTION —

IN THE FOLLOWING STEP, DO NOT USE A METAL TOOL OF ANY KIND TO AVOID DAMAGING THE CALIPER BORE OR SEAL GROOVE.

6. Use a small wood or plastic tool to remove the piston seal from the groove in the caliper bore.
7. Remove the bleeder valve from the caliper.
8. Discard the boot and the piston seal.

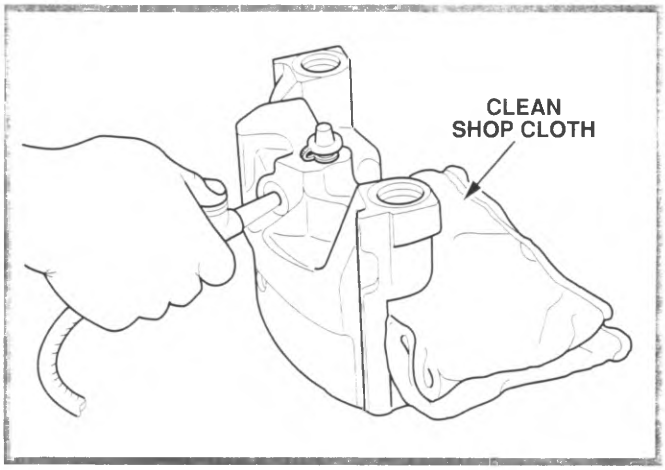


Figure 6-29. **Remove Piston**

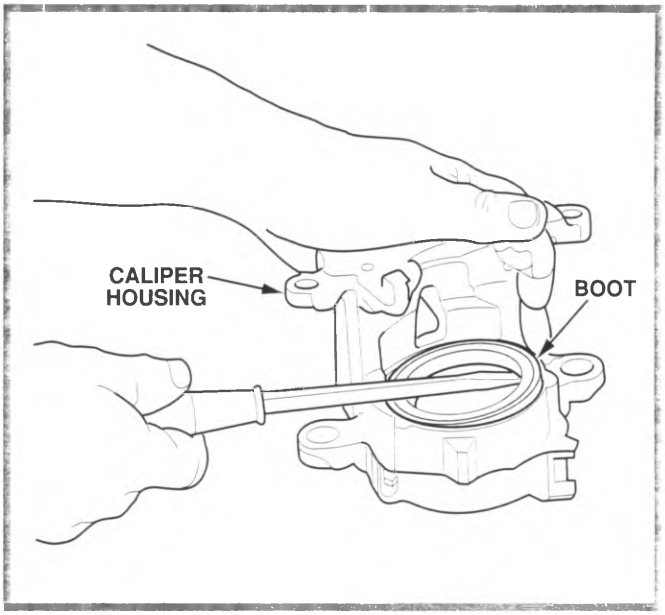


Figure 6-30. **Remove Piston Boot**

Cleaning and Inspection

9. Inspect mounting bolts and sleeves for corrosion. ***DO NOT*** attempt to clean corrosion from sleeves and bolts. Replace corroded bolts and sleeves. (See the appropriate service information.)

— NOTICE —

Do not use lubricated shop air to dry brake parts. Drying with lubricated shop air will leave a film of oil on the parts. This may damage the rubber parts.

Clean the parts in denatured alcohol, using a bristle brush if necessary. Use dry, filtered, compressed air to dry parts and blow out all passages in the caliper and the bleeder valve.

— CAUTION —

THE OUTSIDE DIAMETER OF THE PISTON IS THE PRIMARY SEALING SURFACE IN THE CALIPER. IT IS MANUFACTURED AND FINISHED TO CLOSE TOLERANCES. NEVER REFINISH OR USE ABRASIVES TO REMOVE CORROSION ON METAL PISTONS.

10. Carefully check the OD of the piston for scoring, nicks, corrosion or worn or damaged plating. If surface defects are noted, replace the piston.
11. Check the piston bore and seal groove in the caliper for scoring, nicks or corrosion. The caliper bore is not plated. Minor stains and corrosion can be polished away by using crocus cloth. Do not use emery cloth or any other form of coarse abrasive. Thoroughly clean the caliper after using the crocus cloth. If the caliper bore cannot be cleaned up in this manner, replace the caliper. Make sure all parts are clean and dry.

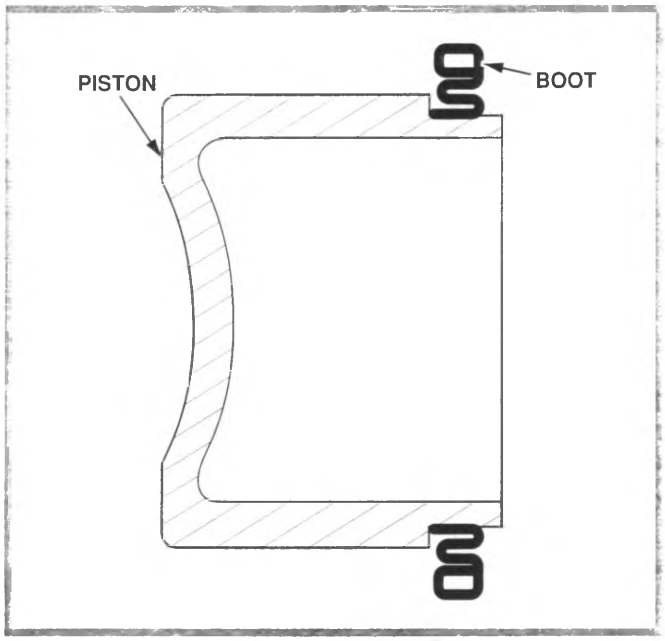


Figure 6-31, **Assembled Boot in Piston Groove**

Assembly

— NOTICE —

In the following step do not over-torque the bleeder valve.

12. Install the bleeder valve in the caliper and torque it to 9-16 N•m (80-140 in. lb.).
13. Lubricate the bore of the caliper and the new piston seal with clean brake fluid. Fit the piston seal in the groove in the caliper. Make sure the seal is not twisted.
14. Lubricate the piston with clean brake fluid. Put the new boot into the piston groove (figure 6-31).
15. Lubricate the bore of the caliper with clean brake fluid and insert the piston. Use care not to unseat the piston seal. Force the piston to the bottom of the caliper bore (a force of 50-100 pounds may be required) (figure 6-32). Use care not to tilt or jam the piston in the bore.
16. Position the OD of the boot in the caliper counter bore and seat it with the boot seating tool (figure 6-33). On some applications it is necessary to install the boot into the caliper bore prior to installing the piston.
17. Check the boot installation. Make sure the metal retainer molded into the boot is not bent and that the boot is seated fully and evenly all around.
18. Install new mounting bolt sleeves and bushings or caliper slides, as needed.

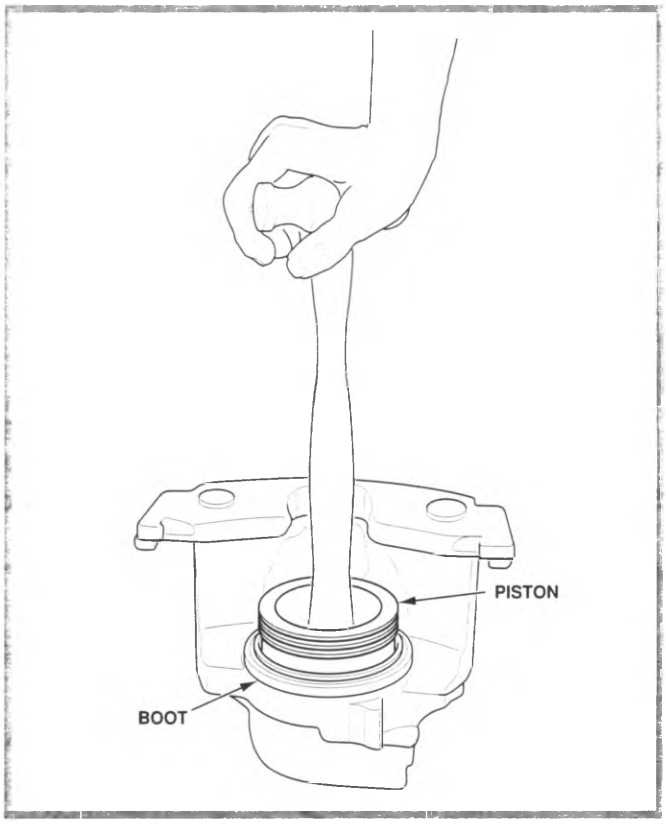


Figure 6-32, **Installing Piston**

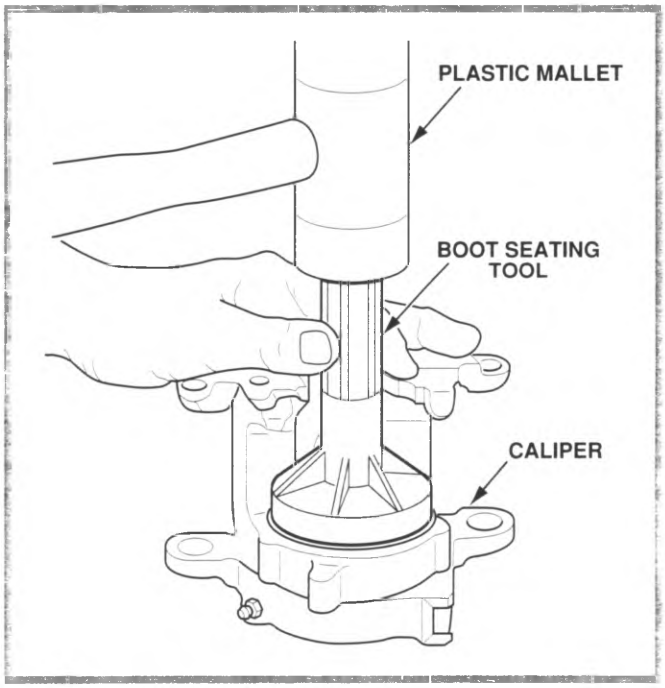


Figure 6-33, **Seating Boot**

Caliper and Mounting Bracket Wear Adjustments

Before returning the vehicle to the customer, measure the caliper-to-knuckle clearance. If wear is excessive, a rattle sound can be heard from the front brake area, if the clearance is too little, brake lead and excessive pad wear may result. Refer to service information for specifications.

Example:

1. Remove caliper.
2. Clean contact surfaces with a wire brush.
3. Smooth any deep nicks and/or gouges with a file.
4. Measure clearance between the caliper and mounting bracket (figure 6-34) with a feeler gauge. Total clearance should be 0.010 to 0.024 in. (0.26 to 0.60 mm) and constant from top to bottom. Caliper clearance may vary. Check the service manual for correct specification.
5. Adjust for correct clearance as necessary, as described in the service information.

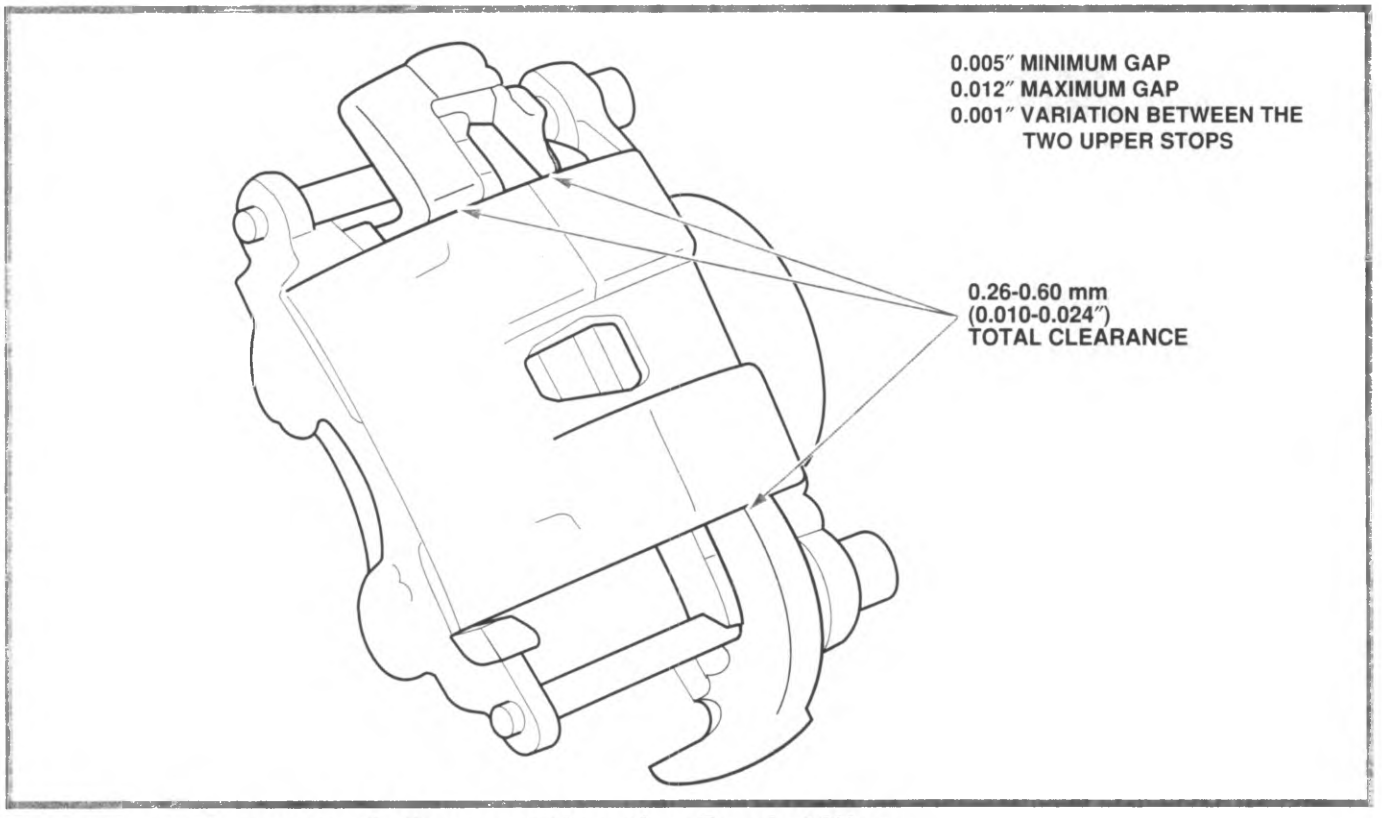


Figure 6-34, **Measuring Caliper and Mounting Bracket Wear**

Measure caliper slide clearance on calipers utilizing machined guides (figure 6-35). Correct if necessary, utilizing approved service manual procedures.

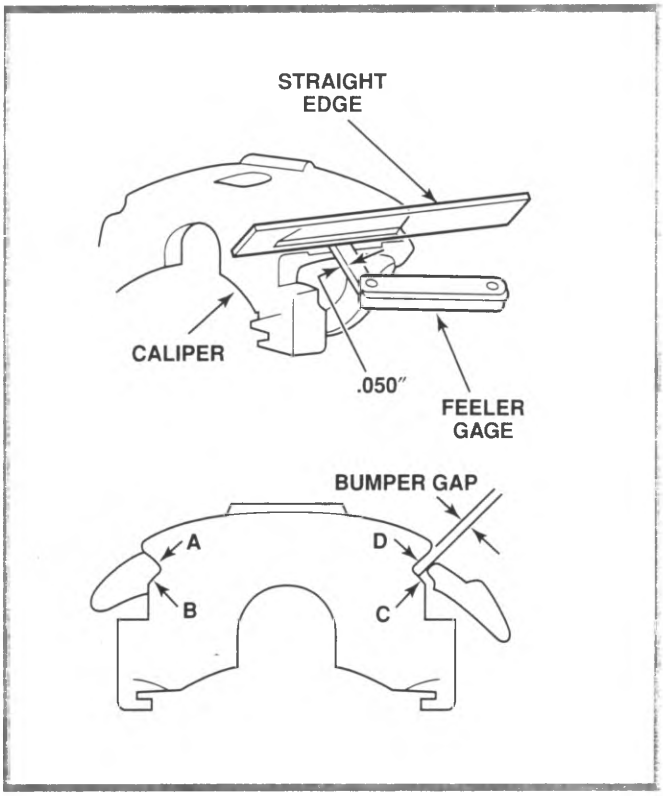


Figure 6-35, **Bendix® Caliper Wear Adjustment**

Bendix® Caliper Wear Shim Specifications

MORE THAN	BUT NOT EXCEEDING	SHIM THICKNESS	SHIM P/N
0	0.058 inch	None Required	None Required
0.058 inch	0.101 inch	0.025 inch	15625734
0.101 inch	0.145 inch	0.045 inch	15625735
0.145 inch	—	See Note	See Note

Note: If the bumper gap exceeds 0.145 inch, remove old caliper and replace with a new caliper and remeasure the bumper gap. If the bumper gap with the new caliper is between 0.058 inch and 0.145 inch, select a shim from the table. If the bumper gap with the new caliper exceeds 0.145 inch, replace the anchor plate also. Use a new key and spring when assembling the new components.

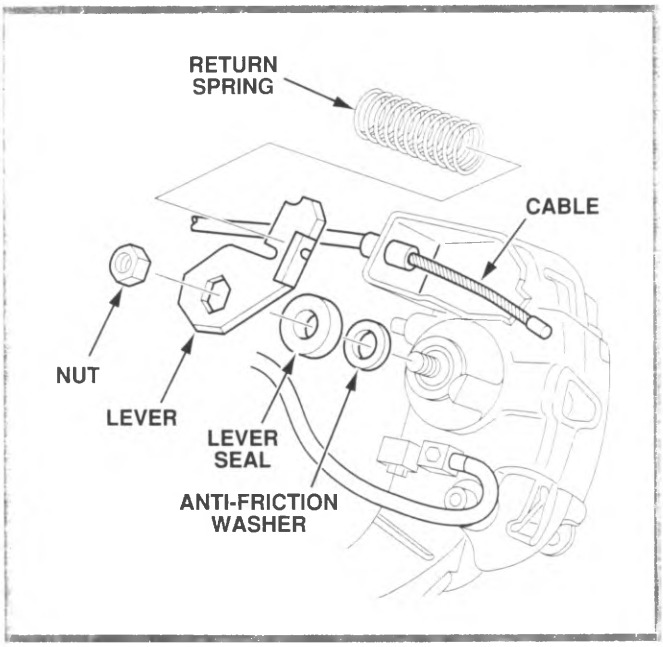


Figure 6-36, **Remove Parking Brake Lever**

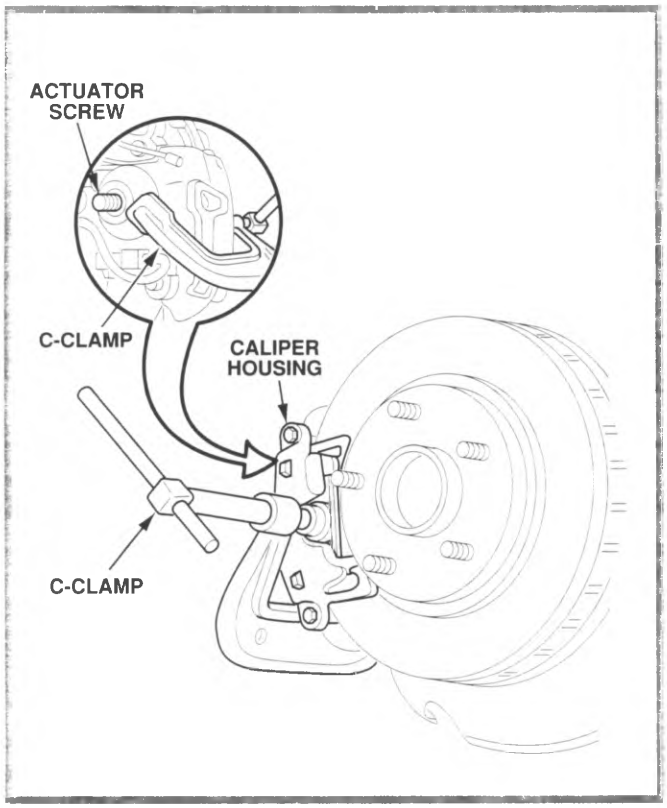


Figure 6-37, **Pushing Piston Back**

Rear Caliper Service – Integral Parking Brake

— IMPORTANT —

If the caliper pistons are to be depressed in their bore, make sure the master cylinder reservoir is approximately one-third full. Remove fluid if necessary.

Brake fluid is removed to prevent master cylinder overflow when piston is pushed back into caliper bore.

Example:

1. Loosen the tension on the parking brake cable at the equalizer and disconnect the cable from the parking brake lever (figure 6-36). Remove the spring. Holding the lever, remove the nut. Remove the lever, lever seal and anti-friction washer.

— NOTICE —

In the following step, do not allow the C-clamp to contact the actuator screw.

2. Position a large C-clamp across the inboard side of the caliper housing and outboard shoe, at the caliper cutout (figure 6-37). Tighten the C-clamp to push the piston back into the caliper bore.
3. Temporarily reinstall the anti-friction washer, lever seal, lever and nut.

4. Remove the bolt attaching the caliper inlet fitting (figure 6-38). Discard the copper sealing washers.
5. Remove the mounting bolts. Lift the caliper from the rotor and mounting bracket.

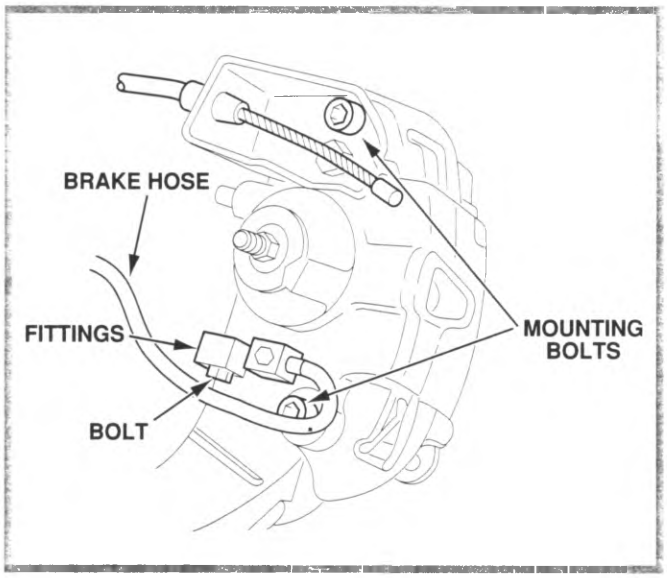


Figure 6-38, **Inlet Fitting and Mounting**

Disassembly

1. Remove the caliper from the vehicle (figure 6-39).

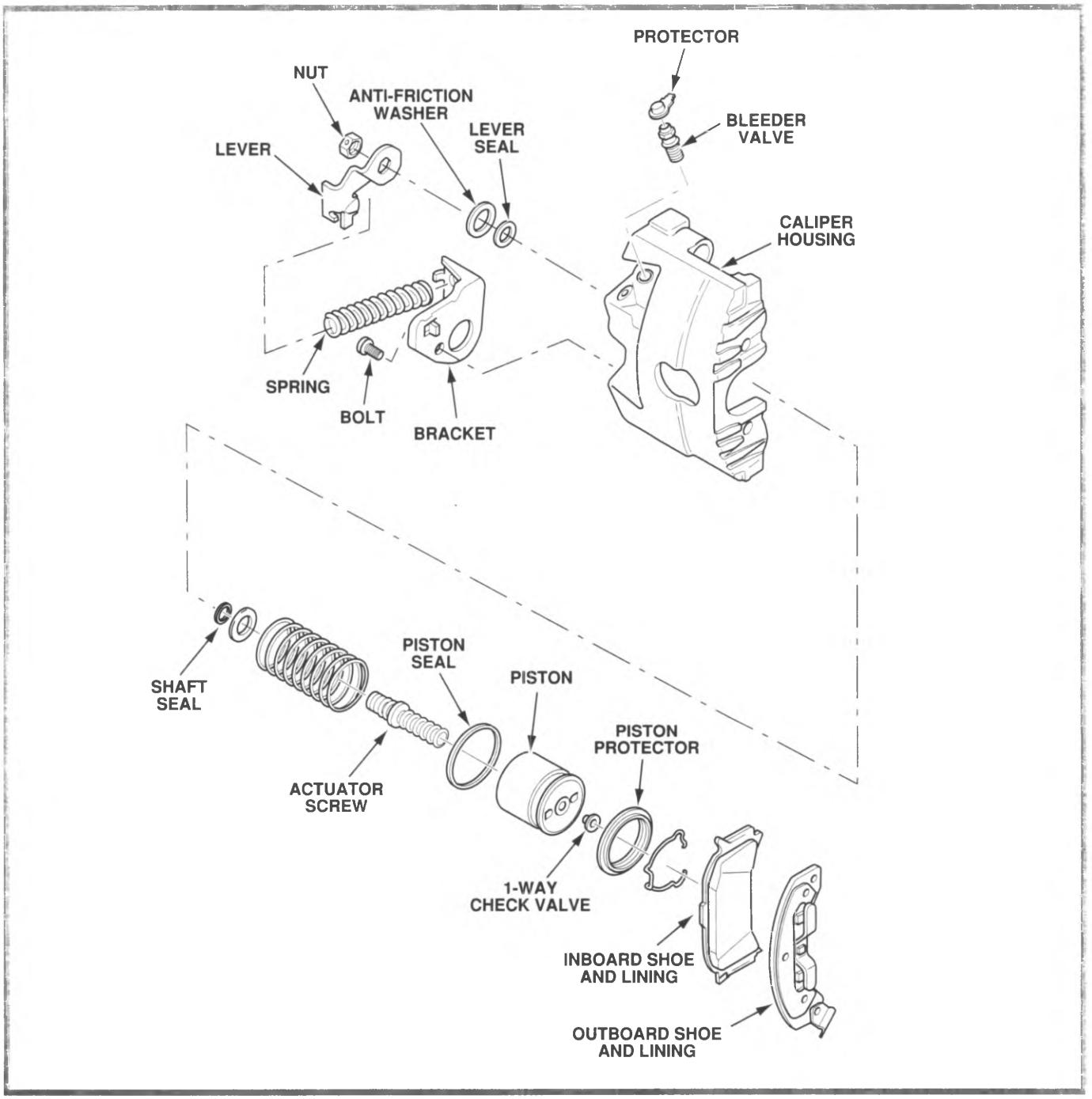


Figure 6-39, **Rear Caliper Disassembly**

2. Clean the exterior of the caliper with a wire brush and brake cleaner before moving the caliper to a clean work bench for disassembly.
3. Drain fluid from the caliper and discard safely.
4. Remove the shoe dampening spring from the end of the piston. Remove the two-way check valve and discard.
5. Remove the parking brake lever. Remove and discard lever seal and anti-friction washer.
6. Support caliper in a vise (figure 6-40). Pad the inside of the caliper with shop cloths. Using a wrench on the hex of the actuator screw, turn the actuator screw to move the piston out of the bore.
7. Remove the balance spring.
8. Press on lever end of actuator screw to remove from housing. Remove shaft seal and discard. Retain the thrust washer.
9. Pry boot out of caliper (figure 6-41). Extend screwdriver across caliper bore under the boot and pry up. Do not scratch the caliper bore, the piston seal groove or the boot groove. Discard boot.
10. Use a small wood or plastic tool to remove the piston seal from the caliper bore. Discard seal.
11. Remove bleeder valve.

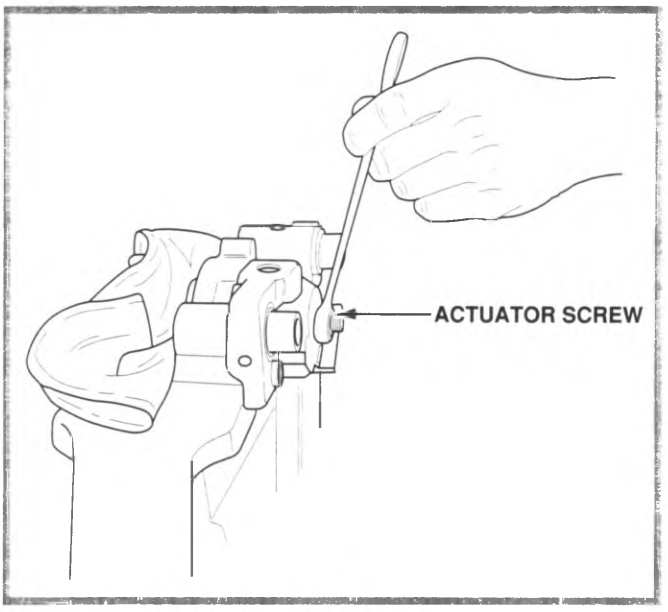


Figure 6-40, **Remove Piston**

Cleaning and Inspection

1. Clean the piston by wiping with a clean cloth. Do not use solvent.
2. Clean other parts with alcohol-based brake cleaner. Use a bristle brush if necessary. Dry with dry shop air.

— NOTICE —

Do not use lubricated shop air

3. Carefully check the outside of the piston. Replace if there is:
   - Scoring
   - Nicks
   - Corrosion
   - Worn or damaged plating
4. Check piston bore and piston seal grooves for scoring, nicks, or corrosion. Minor stains or corrosion can be cleaned up with crocus cloth. Do not use emery cloth or other form of abrasive. Replace caliper if corrosion does not respond to crocus cloth.

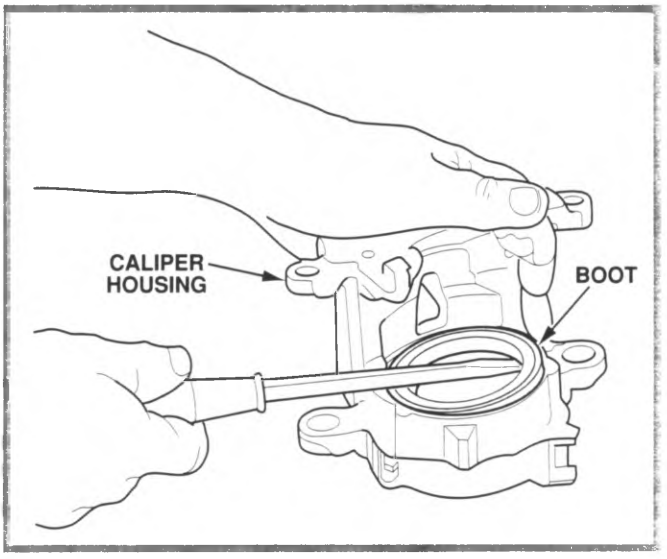


Figure 6-41, **Remove Piston Boot**

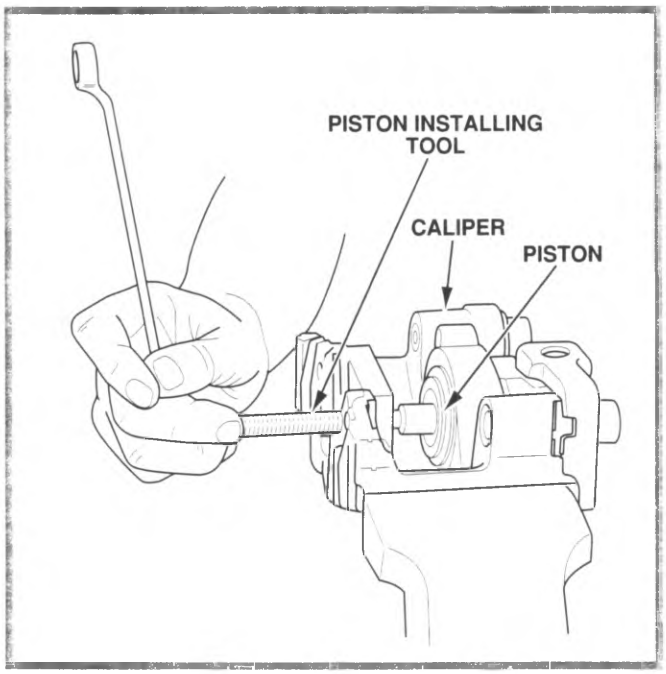


Figure 6-42, **Reinstall Piston**

Assembly

1. Install bleeder valve in caliper.
2. Lubricate caliper bore and piston seal with clean brake fluid. Fit piston seal into groove in the caliper bore. Make sure the seal is not twisted.
3. Lubricate the piston and new two-way check valve with clean brake fluid. Install the check valve in the piston. Install new boot on piston with inside bead of boot in piston groove. Fold the boot away from the caliper.
4. Position thrust washer on actuator screw.
5. Lubricate the shaft seal with clean brake fluid and fit it in the groove on the actuator screw.
6. Lubricate the actuator screw with clean brake fluid and install it with the thrust washer in the piston.
7. Position balance spring in the piston recess and start the piston into the caliper bore. Use the appropriate piston installation tool (figure 6-42).

8. Before removing piston installation tool, lubricate a new anti-friction washer and lever seal with silicone grease. Install in the end of the actuator screw. Make sure the lever seal bead is against the housing.
9. Install the lever on the actuator screw and rotate the lever away from the caliper stop. Hold the lever and install nut with appropriate torque. Move the lever back against the stop. Remove the piston installing tool.
10. Position the outside of the boot in the caliper counterbore and seat with a boot seating tool (figure 6-43).
11. Check boot installation to make sure its metal retainer is not bent. The boot should be seated firmly and evenly.
12. Install shoe vibration dampening spring in the groove at the end of the piston (figure 6-44). Move the parking brake lever if necessary. Install new pads. Reinstall caliper.

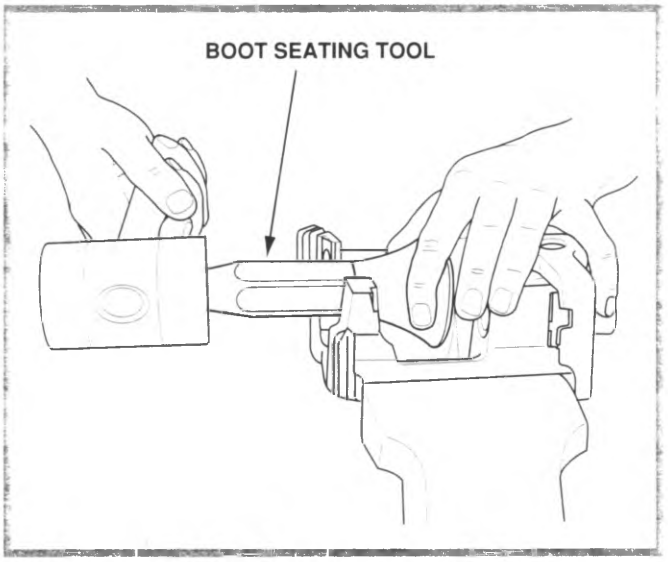


Figure 6-43, **Install Piston Boot**

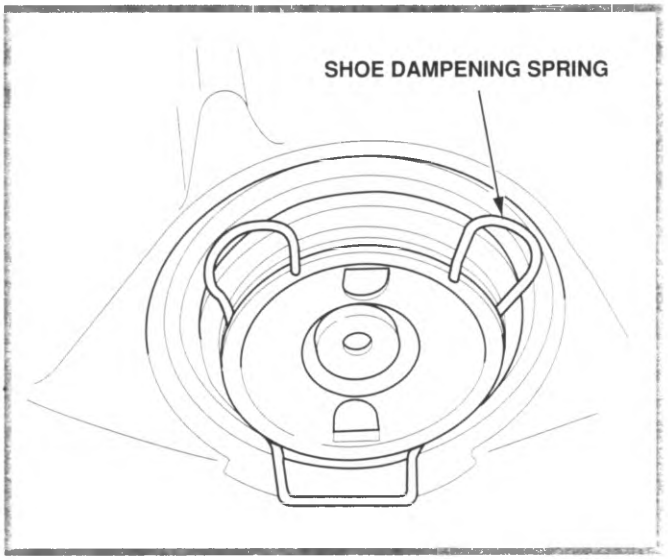


Figure 6-44, **Install Shoe Vibration Dampening Spring**

Installation

1. Inspect the mounting bolts and sleeves for corrosion. Lubricate the bolts with silicone grease.

— IMPORTANT —

If the bolts or sleeves are corroded, use new parts when installing the caliper. Do not attempt to polish away the corrosion.

2. To install, position the caliper over the rotor in the mounting bracket. Align the holes and install the mounting bolts. Torque the bolts as specified in the service manual.
3. Install the inlet fitting with the new copper sealing washers and torque the attaching bolt as specified in the service manual.
4. Remove the nut and lever temporarily installed at step 3. Remove and discard the old lever seal and the old anti-friction washer. Clean any contamination from the caliper surface in the area of the lever seal and lubricate it with silicone grease. Lubricate the new anti-friction washer and the new lever seal with silicone grease. Install with the sealing bead on the lever seal against the housing.
5. Install the lever in position with the lever away from the stop on the caliper housing. Holding the lever away from the stop, install the nut and tighten to the torque specified in the service manual. Then, rotate the lever back against the stop.
6. Install the spring and connect the parking brake cable to the lever.
7. Tighten the parking brake cable at the equalizer until the lever just moves off the stop on the caliper housing. Loosen the adjustment until the lever moves back against the stop. Lock the adjustment at the equalizer.

7. Balance Control Systems

Objectives:

After completing this section, the student will be able to:

- Describe the purpose of brake balance control
- Describe the purpose of a metering valve
- Describe the purpose of proportioning valves and the different types
- Describe a combination valve
- Describe the operation of all valves

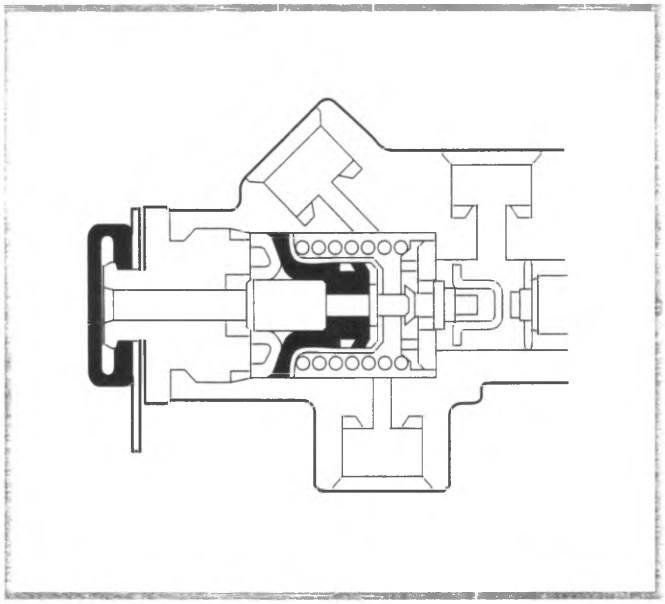


Figure 7-1, **Metering Valve**

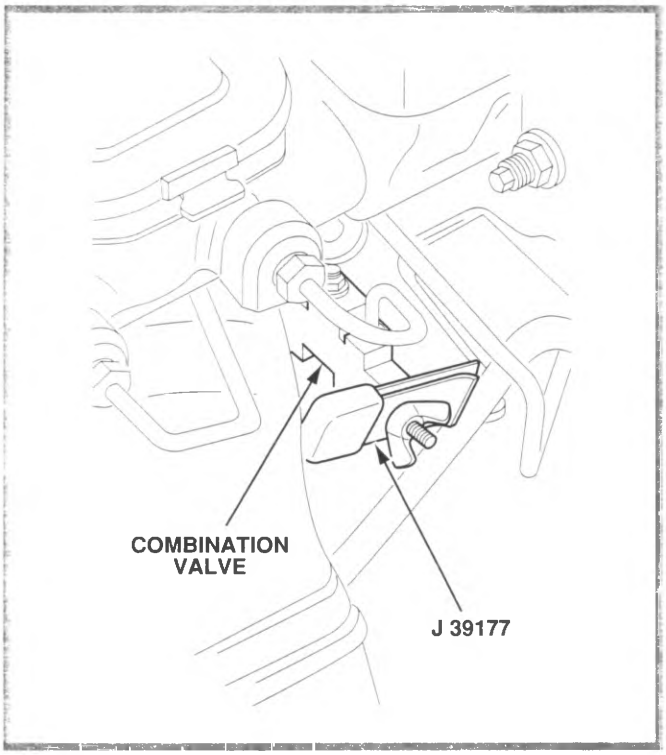


Figure 7-2, **Holding Metering Valve Stem**

Balance Control Systems

The brake balance control system helps to balance braking between the front and rear wheels. Balance controls are required to compensate for vehicle load and system design. Balance controls include:

- Metering valve
- Fixed pressure proportioning valve
- Height sensing pressure proportioning valve
- Combination valve which includes the pressure differential switch

Metering Valve

The metering valve is used on rear-wheel drive vehicles equipped with front disc/rear drum brakes (figure 7-1). The valve is in the hydraulic circuit to the front disc brakes. It is located in the combination valve block (figure 7-2).

Disc brakes react more quickly to initial brake application than drum brakes due to the tighter hardware clearances. The metering valve delays front brake application for a fraction of a second so rear brakes actuate at the same time as the front brakes. The delay increases vehicle stability during braking.

In some instances, the metering valve can prevent fluid flow to the front wheels during pressure bleeding. Therefore the valve may have to be disabled when pressure bleeding. Special tools are available to disable the valve by depressing the valve's pin.

Metering Valve Operation

Under low pressure (0-25 psi), the metering valve generally remains open. From 25 to 100 psi, the metering valve seals, closing off brake fluid from the front brakes. The master cylinder delivers brake pressure to the rear brakes only. Hydraulic pressure acts against the drum brake return springs to bring the brake shoes in contact with the drums.

Above 100 psi, the hydraulic pressure begins to overcome valve spring pressure, opening the metering valve seal. Metering valve pressure operation may vary depending upon brake system design.

— IMPORTANT —

Depressing the metering valve pin disables metering valve operation. After bleeding brakes, always remember to remove the metering valve pin depressor tool before road testing or returning the vehicle to the customer.

Pressure Proportioning Valve

Proportioning valves improve front-to-rear brake balance during hard braking (figure 7-3). GM vehicles have been equipped with two types of proportioning valves:

- Fixed pressure
- Height-sensing

During a hard stop, a portion of the vehicle weight is transferred to the front wheels. The resulting loss of weight on the rear wheels could contribute to premature rear wheel lockup, reducing directional stability. The proportioning valve reduces brake pressure to the rear brakes during hard braking.

Fixed Pressure Proportioning Valve

The fixed pressure proportioning valve is located in the rear brake hydraulic circuit. Fixed pressure proportioning valves can be:

- Integral with the master cylinder
- Screwed into the master cylinder outlet ports
- Inside the combination valve
- In series with the brake pipes under the vehicle

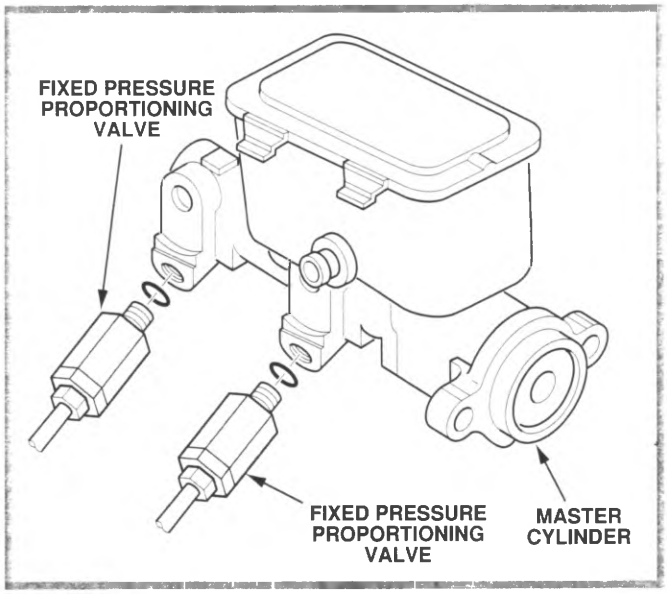


Figure 7-3, **Fixed Pressure Proportioning Valve**

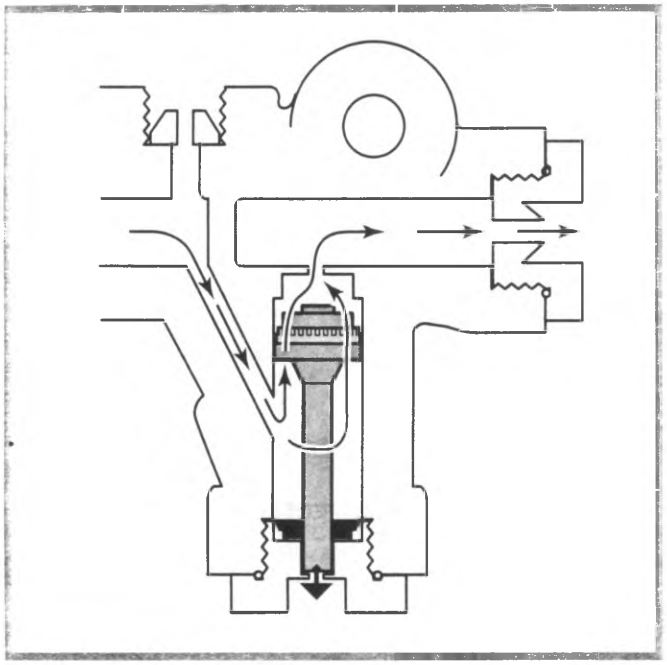


Figure 7-4, **Fixed Pressure Proportioning Valve–Most Braking**

During most braking, the passage to the rear wheel circuit remains open (figure 7-4).

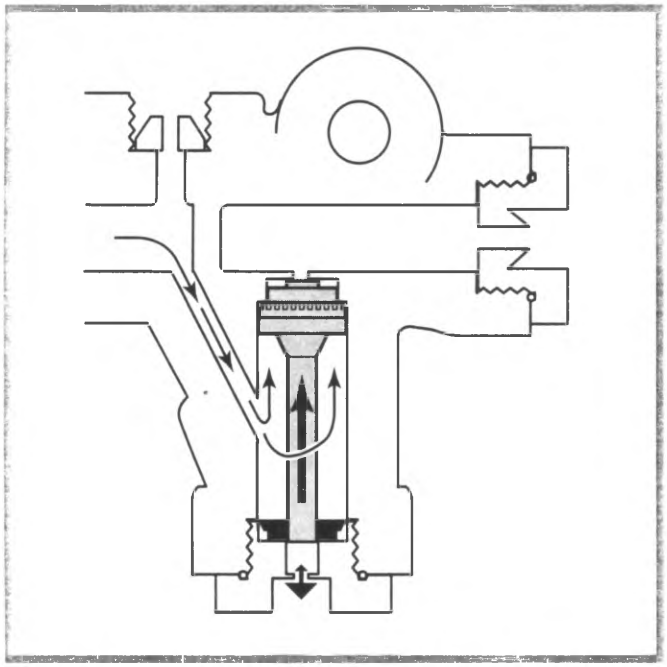


Figure 7-5, **Fixed Pressure Proportioning Valve–Hard Braking**

Under hard braking, a sudden pressure increase closes the outlet to the rear wheels (figure 7-5).

Height Sensing Proportioning Valve

The height sensing proportioning valve is used primarily on trucks and vans (figure 7-6). The valve is mounted on the frame near the rear axle. It is installed in the rear brake hydraulic circuit. A heavily-loaded truck is less likely to lock the rear wheels during hard stops and requires more brake pressure.

The height sensing pressure valve:

- Senses the load on the rear axle during braking by sensing chassis height above the axle
- Changes pressure proportioning during braking accordingly

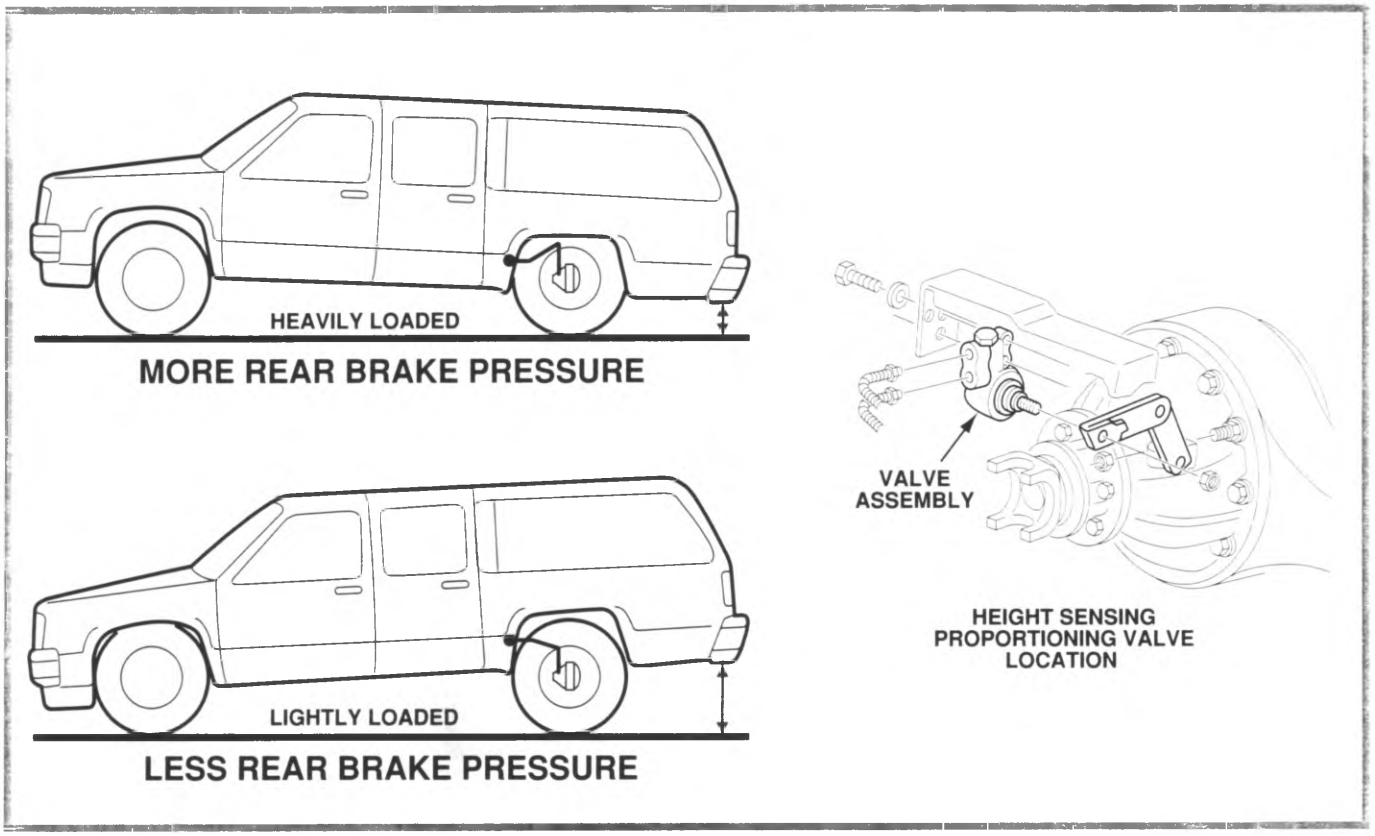


Figure 7-6, **Height Sensing Proportioning Valve Operation**

Combination Valve

Some vehicles are equipped with a combination valve that contains (figure 7-7):

- A metering valve, delaying front brake application
- A proportioning valve, adjusting front-to-rear brake balance
- Pressure differential warning switch

Although the pressure differential, metering, and proportioning valves were originally developed as separate components, they may be incorporated into a single combination valve.

The combination valve is used primarily on vehicles having both:

- Rear wheel drive
- Disc and drum brakes

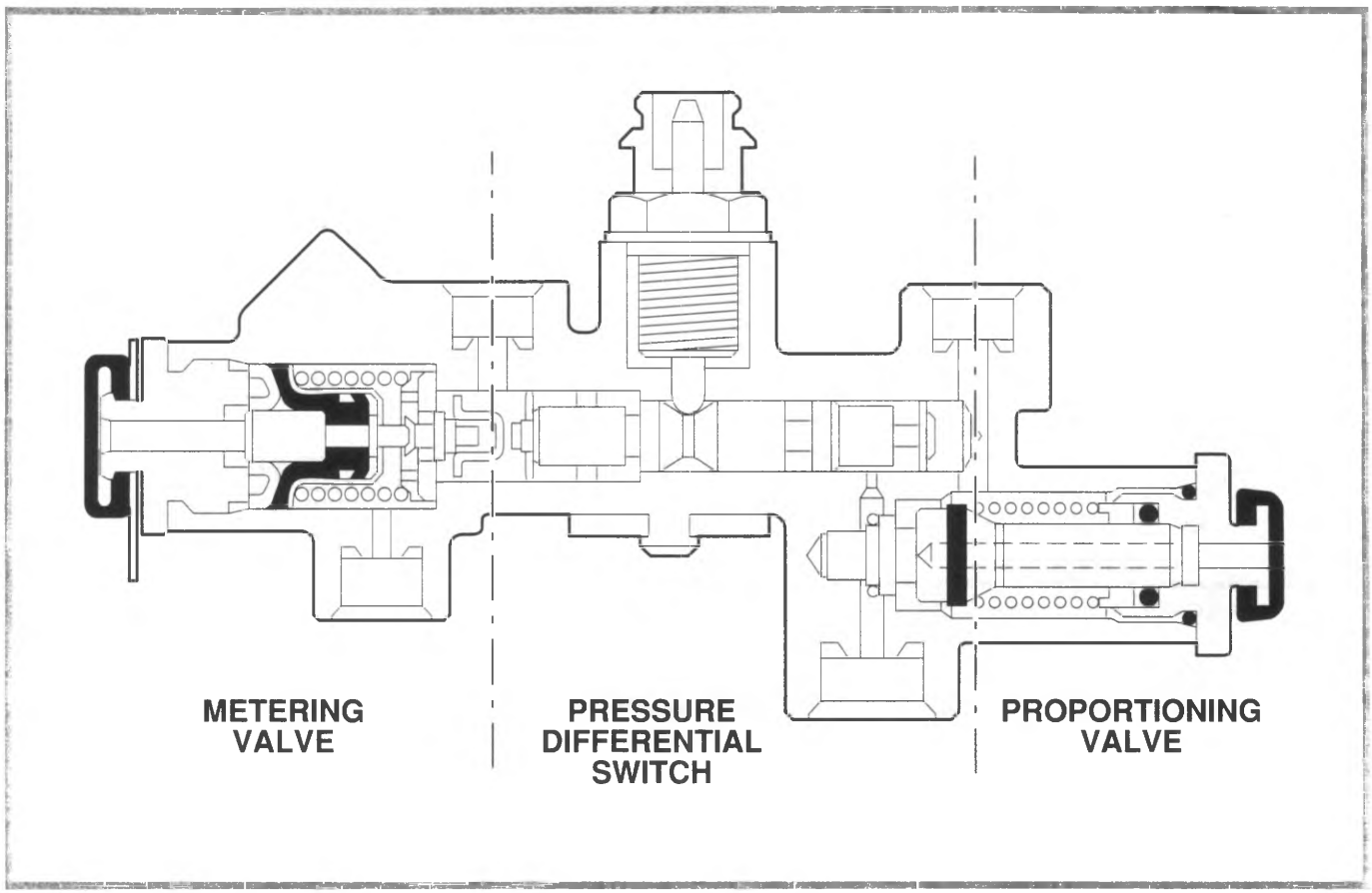


Figure 7-7, **Combination Valve**

8. Warning Systems

Objectives:

After completing this section, the student will be able to:

- Describe the operation of the Red BRAKE Warning Lamp (RBWL)
- Describe the operation of the Pressure Differential Switch and its function
- Describe the operation of the master cylinder fluid level sensor and its function
- Describe the operation of the brake low vacuum sensor and its function
- Describe the operation of the disc brake pad wear sensor and its function

Warning Systems

Red BRAKE Warning Lamp (RBWL)

The Red BRAKE Warning Lamp (RBWL) on the dashboard lights under conditions that require the driver's attention. Components that may light the Red BRAKE Warning Lamp include:

- Parking brake
- Pressure differential switch
- Brake fluid level sensor
- Power brake vacuum sensor

Some vehicles use a separate parking brake light

Parking Brake

The RBWL lights with the parking brake engaged and the ignition on. The RBWL turns off when the driver releases the parking brake.

Pressure Differential Switch

The pressure differential switch lights the RBWL when it closes (figure 8-1). The switch:

- Closes if either the front or rear hydraulic systems fail
- Remains closed as long as pressure in both dual master cylinder circuits is unbalanced

After making repairs, reset the valve by bleeding the entire hydraulic system. Bleeding causes the 100-450 psi pressure differential needed to reset the switch.

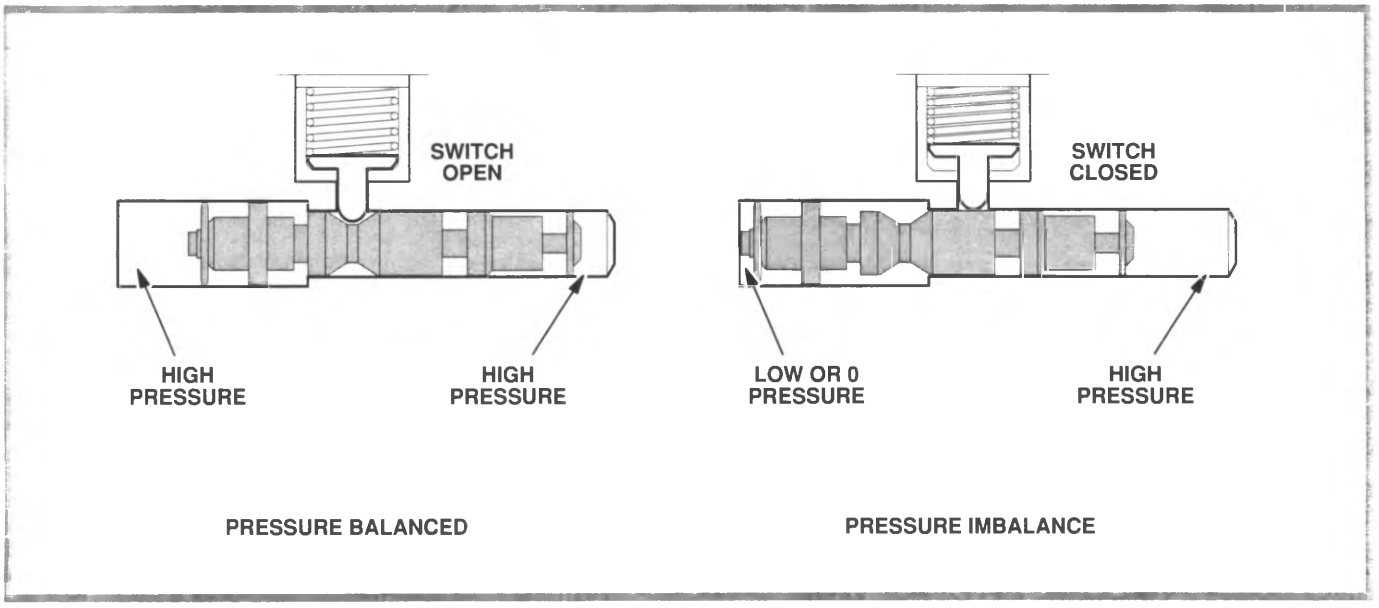


Figure 8-1, **Pressure Differential Switch**

Brake Fluid Level Switch

A brake fluid level switch in the master cylinder reservoir on some vehicles, activates the RBWL when the fluid level inside the master cylinder is too low (figure 8-2). This switch is closed by a magnet attached to a float inside the reservoir.

Power Brake Vacuum Sensor

The RBWL lights when the power brake vacuum switch on some vehicles indicates that the vacuum level is too low to provide power assist.

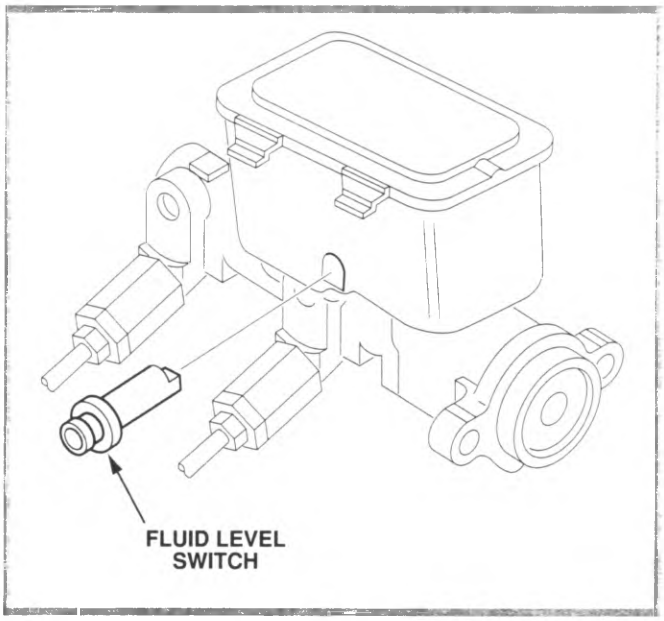


Figure 8-2, **Fluid Level Sensor**

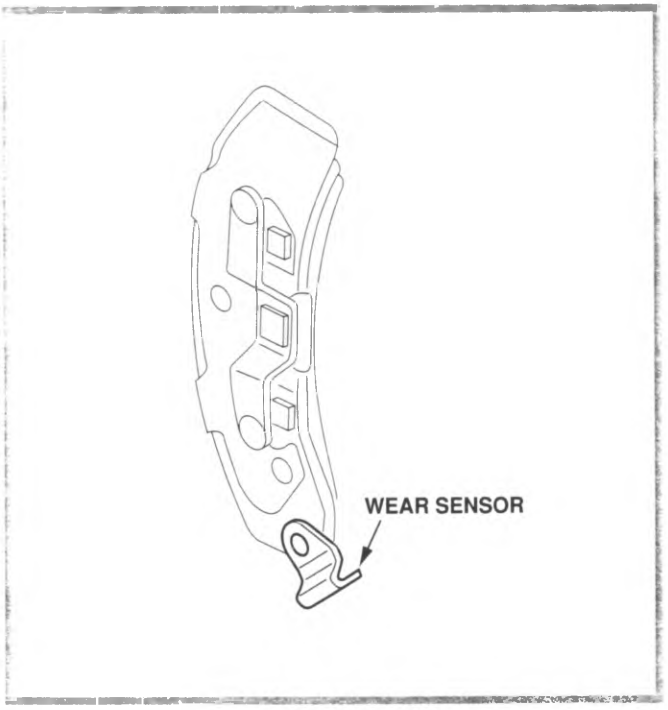


Figure 8-3, **Disc Brake Pad Wear Sensor**

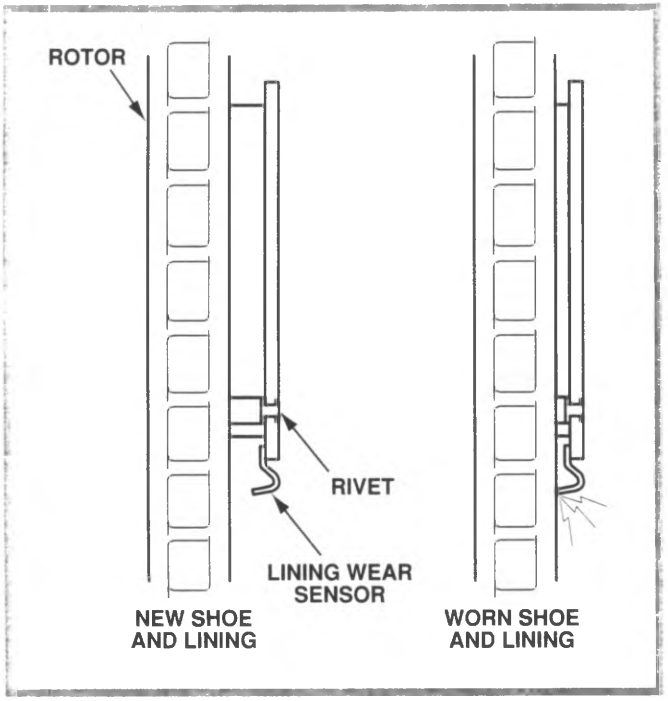


Figure 8-4, **Pad Wear Sensor Operation**

Disc Brake Wear Sensor

Warning Indicator

When brake pad wear reaches the point where it needs replacement, a spring steel clip will come in contact with the rotor, producing an audible squeal signaling the driver when the linings are worn and need replacement (figure 8-3). Replace the brake pads when:

- Pad wear allows the sensor to contact the brake rotor (figure 8-4) when brakes are not applied

The warning signal may eventually cease due to excessive wear to the metal reed.

— IMPORTANT —

The pad with the wear sensor is directional specific. Ensure that brake pads are mounted on the proper side of the vehicle.

In 1997, an electronic brake wear sensor system was introduced on some GM vehicles. This system uses a simple electrical circuit with a wear pellet for each brake pad. The wear pellets are designed to open the electrical circuit when the brake pads have excessive wear.

When the circuit is opened, the RBWL will light and a warning message will be displayed on the Driver Information Center (DIC), if equipped.

— IMPORTANT —

The wear sensors are in series. Any open in the circuit can cause the RBWL to light and a warning message to be displayed on the DIC, if equipped.

9. General Brake Diagnosis

Objectives:

After completing this section, the student will be able to:

- Diagnose base brake system failures
- Identify and use Service Manual information
- Explain how to use strategy based diagnostics when diagnosing base brake concerns

General Brake Diagnostics

This section is a guide to diagnosing the cause of base brake hardware faults, following Strategy Based Diagnostics (see figure 9-1).

Diagnostic Hints

When a brake system fault occurs, the cause may be:

- Mechanical
- Hydraulic
- Electrical

To begin diagnostic procedures, remember the principal that brakes use friction to convert kinetic energy into heat energy. The goal of the brake system is to permit controlled, safe stops in a straight line. When a situation occurs that causes incorrect braking, consider the following questions:

- What caused the unequal friction?
- What caused too much friction?
- What caused too little friction?

Verify, Repair, Retest

Servicing should always include a final test drive to verify all repairs and adjustments. Make sure the RBWL indicates proper operation.

1. Verify Customer Concerns

Customer comments are the place to begin. What kind of problem did the customer experience? Under what conditions did the problem occur? This is a data gathering exercise to fully understand exactly all of the conditions of the customer's concern; the whats, the wheres, the whens and the hows. Consider whether the symptoms described could indicate a problem with the:

- Master cylinder
- Brake booster
- Parking brake
- Wheel brakes

After clearly defining the customer comments, proceed with Preliminary Checks.

2. Preliminary Checks

Quick Visual Inspection

After customer comments, diagnostics begins with a quick visual inspection. Perform the quick visual inspection in the service bay or the parking lot, without raising the vehicle on the hoist.

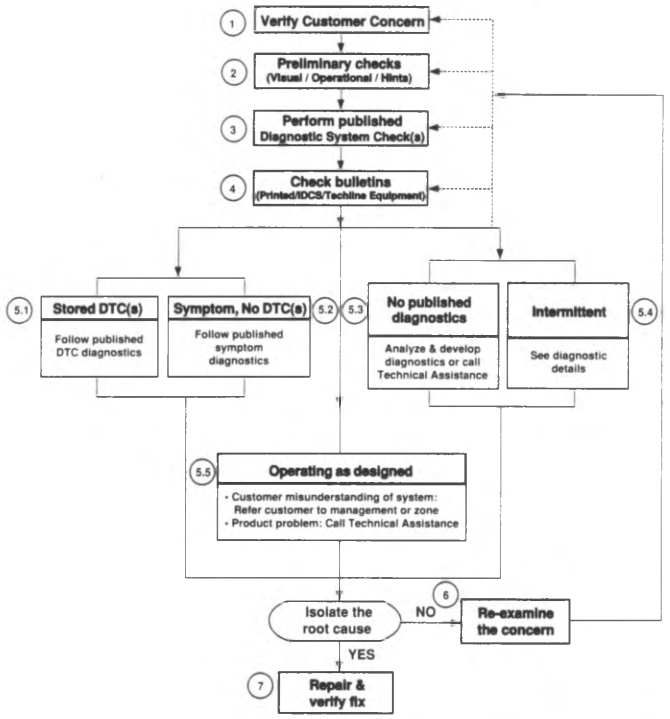


Figure 9-1, **Strategy Based Diagnostics**

Component	Inspect for:	Corrective Action
Fluid Level	– Low fluid	– Low fluid may indicate normal disc brake wear – Look for obvious leaks and correct
External Leaks	– Leaks at brake pipe fittings or components	– Repair as necessary before proceeding with test drive
Parking Brake Operation	– Parking brake pedal engages	– Repair linkage, cables or hardware
Red BRAKE Warning Lamp	– RBWL "ON" at any time the parking brake is disengaged	– Do not test drive. RBWL indicates problems that make the vehicle unsafe to drive, including: • Brake circuit failure • Low fluid • Power booster failure – Diagnose and repair before proceeding – Check for parking brake switch fault

Pedal Checks

Operating the brake pedal can give valuable information about the condition of the hydraulic system and the booster (figure 9-2).

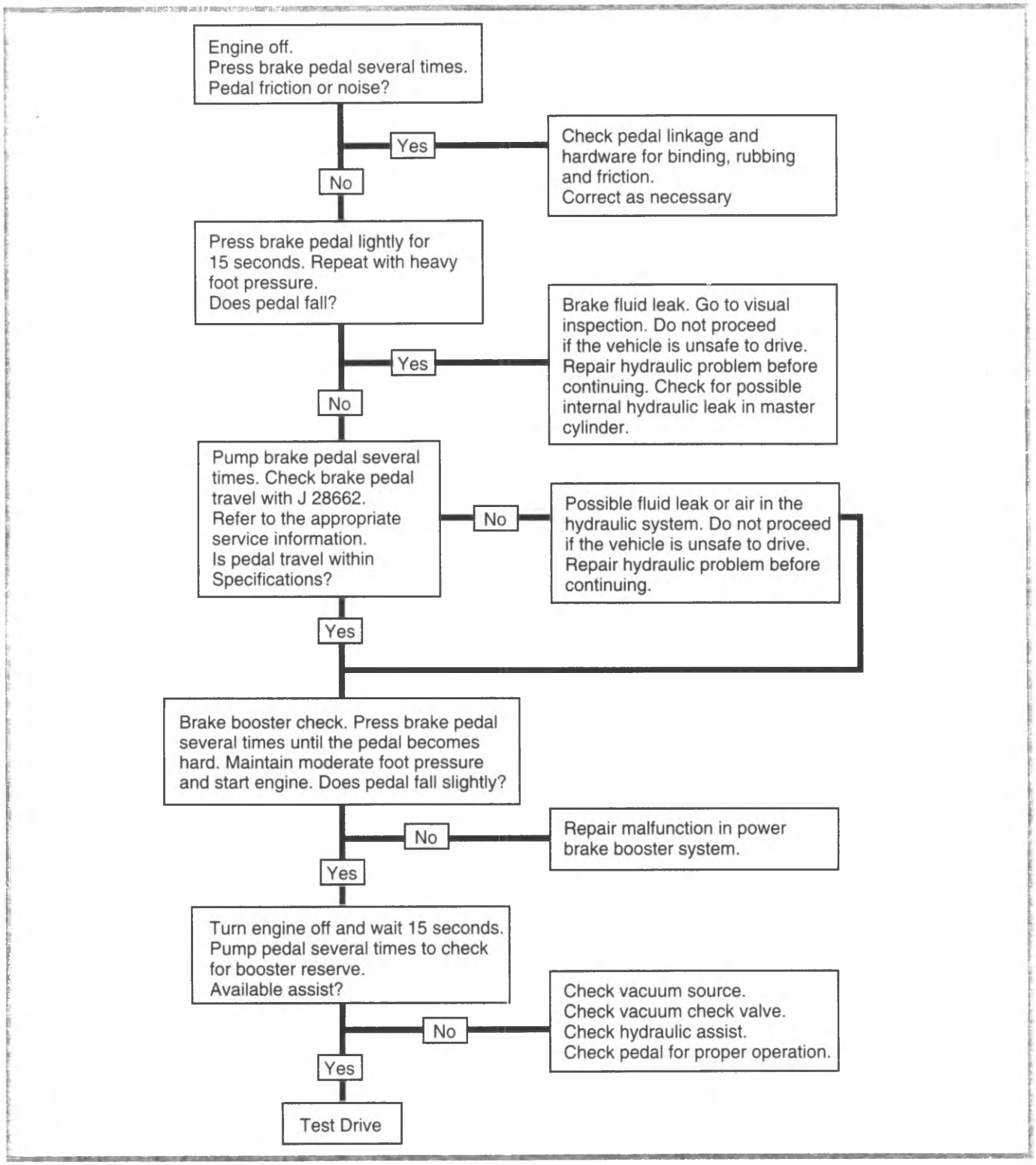
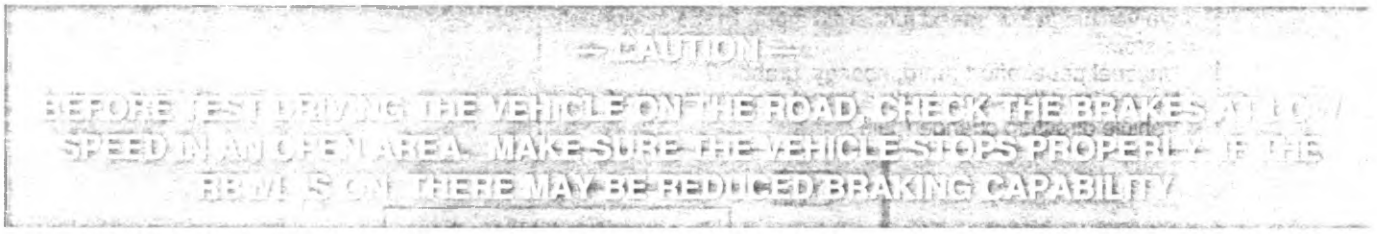


Figure 9-2, **Pedal Check Procedure**

Vehicle Test Drive



Test drive the vehicle in order to evaluate the brake performance and the need for service. When test driving a vehicle, note how the brakes perform.

Conduct road tests on a road that is:

- Dry
- Clean
- Level
- Reasonably smooth

Follow the procedures outlined in the test drive flow chart (see figure 9-3).

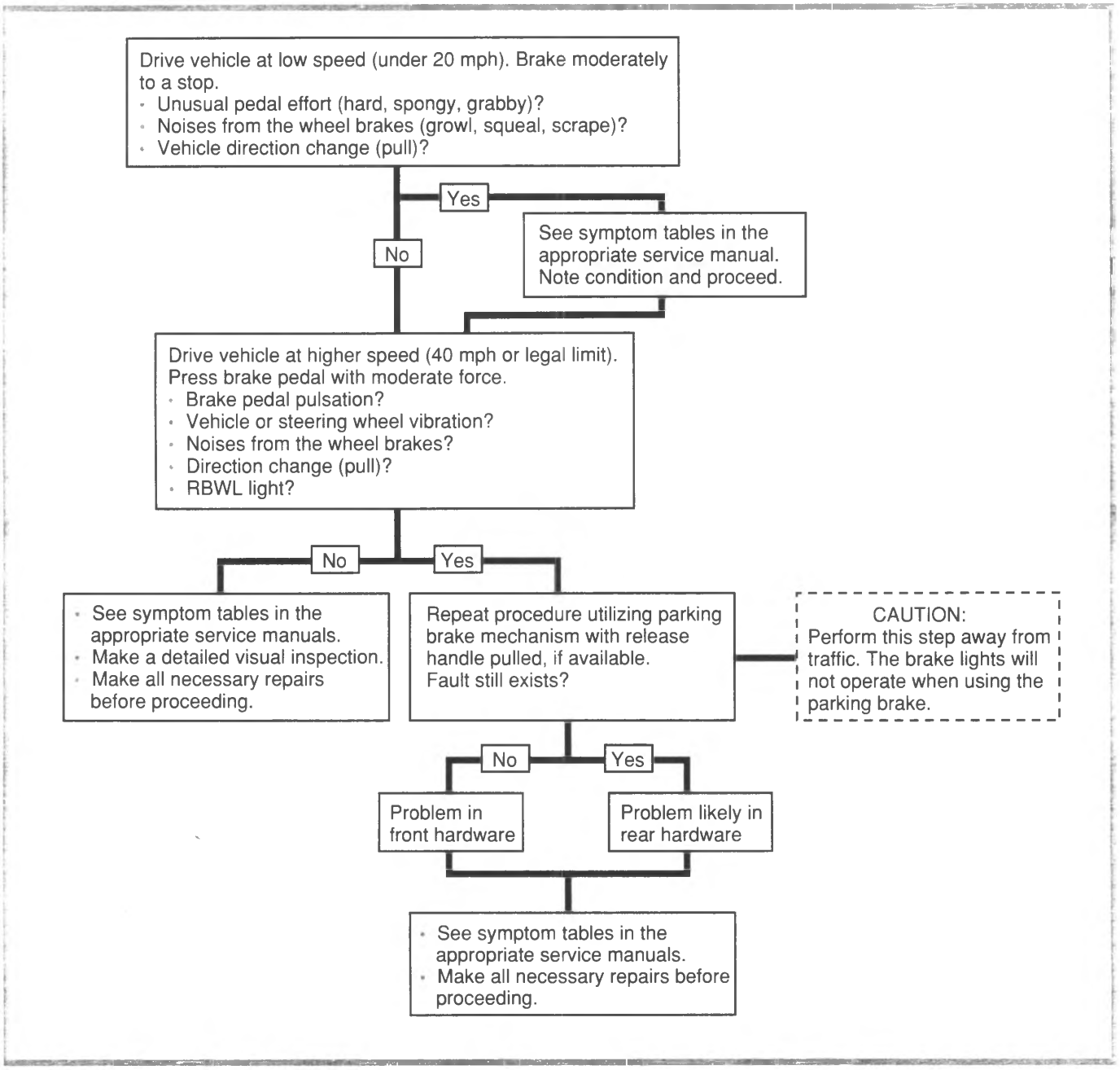


Figure 9-3. **Test Drive Procedure**

Detailed Visual Inspection

Use the detailed visual inspection after road testing the vehicle. The visual inspection can:

- Confirm problems you noticed during the test drive
- Locate problems that were not apparent during the test drive or the quick inspection

Raise the vehicle on a hoist for the detailed visual inspection.

Component	Inspect for:	Corrective Action
Brake pipes and hoses	– Leaks – Crimps or restrictions	– Repair or replace as necessary
Parking brake cables	– Excessive slack – Corrosion that could prevent brake application or release	– Clean, lubricate, adjust or replace as necessary
Parking brake operation	– Proper operation – Wheels rotate (parking brake engaged) – Wheels cannot be rotated without excessive drag (parking brake disengaged)	– Clean, lubricate, adjust or replace as necessary
Brake linings	– Excessive wear	– Replace
Brake hardware and hold-downs	– Damage, wear or corrosion – Missing components	– Replace
Brake Rotors	– Wear (reduced thickness) – Deep scoring or scratches – Thickness variation – Lateral runout – Excessive heat checking	– Replace – Compare to specifications – Machine or replace as indicated
Brake Drums	– Wear (excessive diameter) – Deep scoring or scratches – Taper (bell mouth) – Out of round – Excessive heat checking	– Compare to service limit specifications – Machine or replace as indicated

3. Perform Published Diagnostic Systems Checks

What you should do—

Refer to the appropriate service information manual and follow the published diagnostic information and procedures, if any.

What resources you should use—

Whenever possible, you should use the following resources to perform service manual checks:

- Service Information
- Techline equipment (for viewing DTCs and analyzing data)
- Digital multimeter and circuit testing tools
- Other tools as needed

4. Check For Bulletins

— IMPORTANT —

An estimated 30 percent of successful vehicle repairs are diagnosed using Service Bulletins.

What you should do—

You should have enough information gained from preliminary checks to accurately search for a bulletin and other related service information.

What resources you should use—

You should use the following resources for assistance in checking for bulletins:

- Printed bulletins
- Techline equipment to search for bulletins
- Divisional technical information (not Technical Assistance):
  — Newsletters
  — Service Guild letters
- Videotapes
- Pulsat programs

5.1 Stored DTC

Utilize published diagnostics for electrical concerns that set any DTCs, i.e.; RBWL on, brake switch malfunction, etc.

5.2 Symptom Check

Symptom troubleshooting tables are listed in all service manuals. The chart on page 9-10 is an example of a symptom chart found in the service manual. See the appropriate service information to diagnose and repair faults located during the visual inspection or the vehicle road test.

5.3 No Published Diagnostics

You may have to develop your own diagnostics when a brake malfunction occurs that does not have any published diagnostic support. When this occurs, analyze the system as a whole, then break down the system into smaller sections. For example, isolate the front brakes from the rear. In these situations, it is recommended that technical assistance be called for more information.

5.4 Intermittents

Intermittents are rarely related to base brakes and are usually electrical in nature. Utilize the diagnostic details in the service information to understand the system operation and locate the fault.

5.5 Operating As Designed

When a vehicle is brought in for service, the customer has a perception that something is not right. A vehicle may be operating as designed and the customer is not satisfied. What may be needed is to explain to the customer how the system works. It may also be necessary to take the customer on a test drive with another vehicle that is operating normally. Make sure the test vehicle is equipped exactly as the customer's vehicle, i.e.; same year, make, model, tires, etc.

6. Re-Examine Concern

If the cause of the malfunction was not located, it may be necessary to re-examine the concern. It is possible a diagnostic step was missed, or a test was not performed.

7. Repair and Verify Fix

After the cause of a brake malfunction is isolated and repaired, it is imperitive to verify the repair. The same road test used in Step 2 should be performed to verify the fix.

Notes:

Notes:

Cause \ Symptom	Excessive Brake Pedal Travel	Brake Pedal Travel Gradually Increases	Excessive Brake Pedal Effort	Excessive Braking Action	Brakes Slow to Respond	Brakes Slow to Release	Brakes Drag	Uneven Braking Action (Side to Side)	Uneven Braking Action (Front to Rear)	Scraping Noise from Brakes	Brakes Squeak During Application	Brakes Squeak During Stop	Brakes Pulsate (Roughness)	Brakes Groan at End of Stop	RBWL Lights
Leaking Brake Line or Connection	x	xx							x	x					xx
Leaking Wheel Cylinder or Piston Seal	x	xx		x					x						xx
Leaking Master Cylinder	x	xx													xx
Air in Brake System	xx									x					x
Contaminated or Improper Brake Fluid					x	x	x								x
Leaking Vacuum System			xx		x										
Restricted Air Passage in Power Head			x		xx	x									
Damaged Power Head			x	x	x	x	x								
Improperly Assembled Power Head Valve			x	x	x	x	xx								
Worn Out Brake Lining–Replace			x	x					x	x	x	x		x	
Uneven Brake Lining Wear–Replace and Correct	x			x					x	x	x	x	xx	x	x
Glazed Brake Lining			xx		x				x	x		x	x		
Incorrect Lining Material–Replace			x	x					x	x			x		x
Contaminated Brake Lining–Replace				xx					xx	xx	x	x	x		x
Linings Damaged by Abusive Use–Replace			x	xx					x	x	x	x	x		x
Excessive Brake Lining Dust			x	xx					xx	xx		x	xx		x
Heat Spotted or Scored Brake Drums or Rotors				x					x	x		x	x	xx	x
Out-of-Round or Vibrating Brake Drums													x	xx	
Improper Rotor Thickness Variation														xx	
Excessive Lateral Run-out														x	
Faulty Automatic Adjusters	x							x	x	x					x
Incorrect Wheel Cylinder Sizes			x	x					x	x					
Weak or Incorrect Brake Shoe Retention Springs				x		x	xx	x	x	x	xx	x	xx		
Brake Assembly Attachments–Missing or Loose	x							x	x	x	x		x	x	x
Insufficient Brake Shoe Guide Lubricant							x	x	x	x	xx	xx			
Restricted Brake Fluid Passage or Sticking Wheel Cylinder Piston		x	x		x	x	x	x	x						
Faulty Metering Valve	x		x	x	x	x	x		x						x
Brake Pedal Linkage Interference or Binding			x		x	xx	xx								
Improperly Adjusted Parking Brake							x								
Drums Tapered or Threaded										xx					
Incorrect Front End Alignment								xx							
Incorrect Tire Pressure								x	x						
Incorrect Wheel Bearing Adjustment	x									x			x		
Loose Front Suspension Attachments								x		xx			x	x	
Out-of-Balance Wheel Assemblies													xx		
Operator Riding Brake Pedal	x	x	x				x		x					x	
Improperly Adjusted Booster Pushrod	x					x	xx								
Sticking Wheel Cylinder or Caliper Pistons			x			x	x	x	x						
Faulty Proportioner Valve			x		x	x	x								
Stoplamp and/or TCC/Cruise Control Switch Misadjusted			x			x	xx						x		

XX–Indicates more probable causes X–Indicates causes

Notes:

GM STG

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