EUCLID INDUSTRIES

TECH TIPS

HYDRAULIC BRAKES

Includes:

Hydraulic Wheel Cylinders
Master Cylinders
Hydraulic Disc Brake Rotors
Hydraulic Disc Brake Calipers

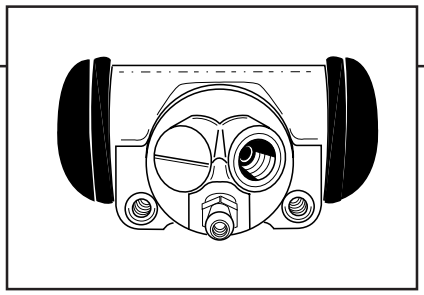
MODULE TWO

EUCLID

TECH TIPS

HYDRAULIC BRAKE WHEEL CYLINDERS

(Product Code 203)



WHEEL CYLINDER BASICS

Fluid pressure is transferred from the brake pedal through the master cylinder, is power assisted, then is transferred to the wheel cylinder which applies the activating force on the brake shoes. As the fluid pressure to the wheel cylinder increases, the cups and pistons are forced apart. In most cases, this force is carried from the piston to the shoes through piston pins. However, some special shoe configurations do not utilize piston pins. (Example: Wagner Front E-2549.) Two types of wheel cylinders are commonly used in today's hydraulic brake systems: single-ended and double-ended.

SINGLE-ENDED

Wheel Cylinder uses one cup, piston, and dust boot.

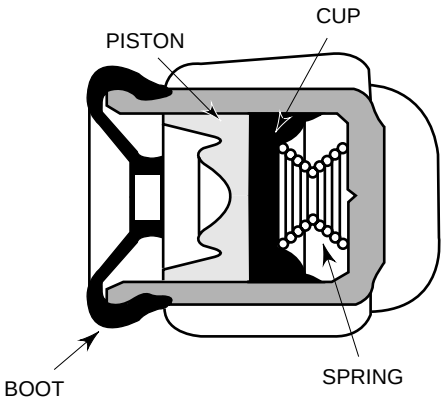


FIGURE 1

DOUBLE-ENDED

Wheel Cylinder uses two cups, pistons, and dust boots with the same size bore*.

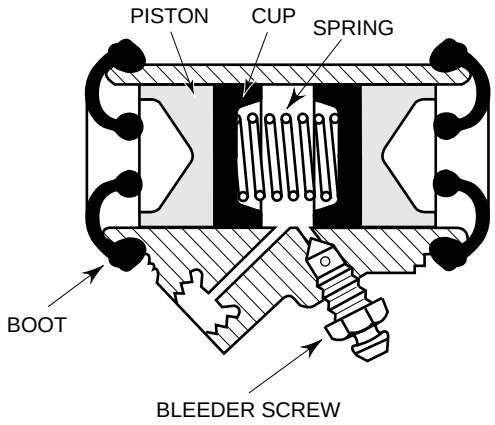


FIGURE 2

***NOTE:** In a few double-ended wheel cylinders, the bore size at each end may be different. This "step bore" wheel cylinder is used to apply different forces to the brake shoes depending on the direction of the drum rotation. While rarely used, this special type must be recognized in ordering parts or servicing. Some double-ended cylinders have a baffle between the opposed bores. These baffles have small holes that create a dampening effect. Baffled cylinders cannot be honed.

TUBE SEAT CHARACTERISTICS

Both single-ended and double-ended wheel cylinders may be supplied with or without tube seats depending on the type of hydraulic line connection used. The majority of light and meduim-duty vehicles use $^{3}/_{8}$" or $^{7}/_{16}$" port sizes. These port sizes may also contain different thread pitches (ie. $^{7}/_{16}$"-20 vs. $^{7}/_{16}$"-24). Be careful to identify the thread pitch as well as thread size. Several metric threaded port sizes (M7, M8, M10, etc.) exist and need to be identified (Figure 3). Cylinders manufactured with tube seats are not interchangeable with cylinders manufactured for use without tube seats. It is normally not possible to convert wheel cylinders from one style to the other by removing or adding tube seats.

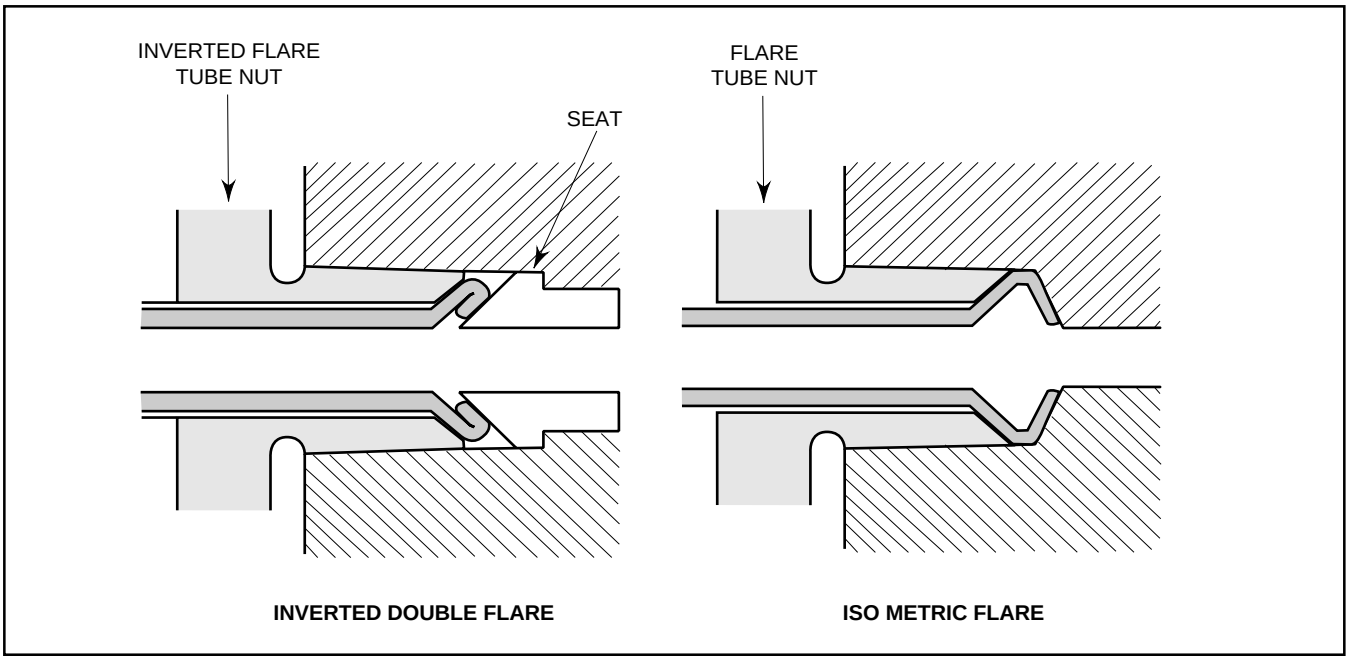


FIGURE 3

SERVICE INFORMATION

The wheel cylinder must be serviced whenever brake shoes and linings are replaced. Inspect the cylinder for leakage. A leak not immediately apparent may be detected by pulling back the cylinder boot. The presence of any brake fluid retention in the boot is an indication of a leak. A slight dampness may be present from condensation and is not evidence of a leak. Dripping fluid is evidence of a leak.

Even if there is no evidence of leakage, the wheel cylinder must be internally cleaned as part of a reline operation. This is necessary since contaminants will have collected behind the cups. If cylinders are pushed back to their initial position without cleaning, the cups generally will be damaged by this contamination and will start to leak soon. The disassembly and assembly of the wheel cylinder is described in the reconditioning procedures. It is generally a good practice to recondition wheel cylinders since the cups, pistons, and boot cost is very small compared to the reline service operation.

Where there is evidence of leakage or parts appear worn on disassembly, then the reconditioning procedure described below is **required**. If any doubt exists, replace the entire wheel cylinder.

If leakage is observed between brake relines, the cylinder must be reconditioned or replaced.

RECONDITIONING

Loosen the bleeder screw before starting to recondition a wheel cylinder. If it is seized and cannot be loosened, the cylinder must be replaced. It is a common practice to recondition wheel cylinders without dismounting them. However, some brakes are equipped with external piston stops which require removal prior to disassembly. Pull the protective dust boots off the cylinder. Internal parts should slide out. If not, slight air pressure may be applied to the fluid inlet. Parts which cannot be removed easily indicate a cylinder which has been damaged beyond reconditioning and the cylinder must be replaced.

Light roughness and/or deposits in the cylinder bore can be removed by fine crocus cloth or a light honing. If the bore cannot be cleaned readily, replace the cylinder. Check the piston clearance after any honing of the cylinder bore (Figure 4). Replace the cylinder if maximum piston clearance is exceeded. Extra clearance causes brakes to release slowly causing excessive lining wear. After honing, remove any burrs from the edges of fluid intake and/or bleeder screw ports.

Clean wheel cylinders with alcohol and/or brake fluid. ***Do not*** allow any hydraulic system parts to come in contact with grease, oil or handle them with greasy hands. Even a trace of **any** petroleum based product is sufficient to damage rubber parts and drastically shorten service life.

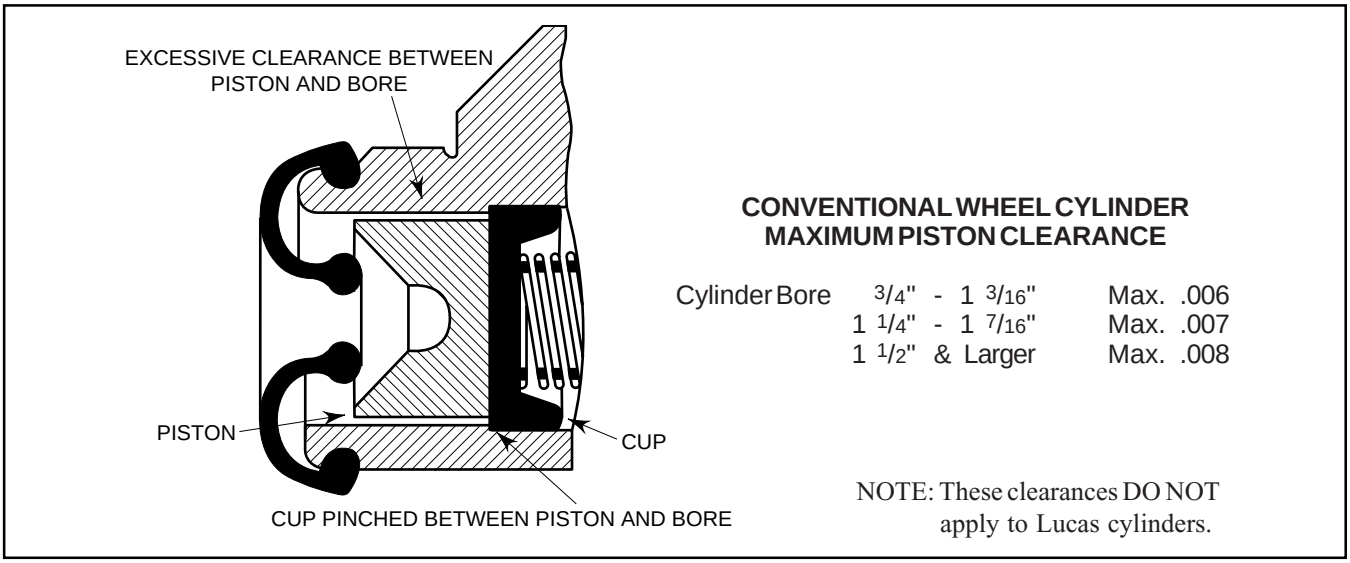


FIGURE 4
Excessive Clearance Between Piston and Bore Wall

REASSEMBLY

When reassembling the cylinder, be sure to lubricate the new cups and pistons with brake fluid. Insert new cups and pistons in each end of the cylinder. DO NOT SLIDE THEM THROUGH THE CYLINDER. This could cut the cup as it passes the inlet ports. Cup lips should always face inward (Figure 5). Many modern wheel cylinders and wheel cylinder repair kits do not contain cup expanders. These cylinders use a conically wound spring that provides the cup expansion function. During reassembly be sure not to distort the spring. Spring distortion will cause cylinder leakage.

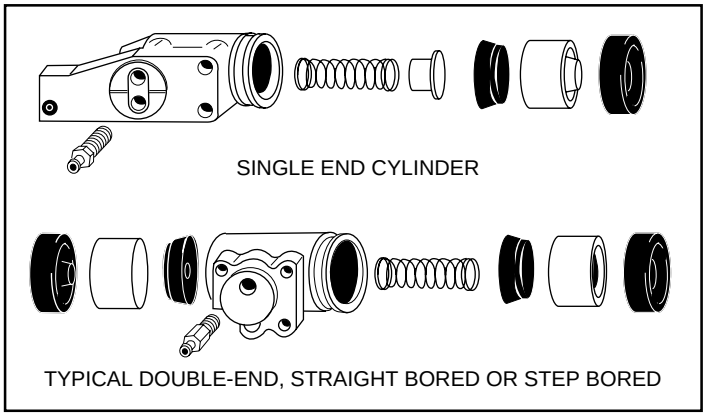


FIGURE 5
Wheel Cylinder Assembly

BRAKE LINES AND HOSES

Hydraulic lines and flexible hoses serve as the arteries of the hydraulic system because they transmit fluid pressure from the master cylinder to the wheel cylinders and calipers. Even a partial blockage in the lines is detrimental to braking action because it restricts the flow of fluid. Although applying pressure may force the fluid past the blockage, the affected brake may not release, or release slowly and drag. During brake inspection, the lines and hoses should be examined for chafing crimps, loose or missing tie clips, kinks or dents, fluid seepage at connections, and stains around hose ends which indicate leakage.

Steel Brake Lines
Hydraulic brake lines are made of steel tubing, flared at both ends to accommodate male fittings. They are available in different lengths and diameters, the most common sizes being 3/16" (4.8mm), 1/4" (6.4mm) and 5/16" (7.9mm) O.D., and can be bent to conform to the application.

Most lines are made of double walled, welded steel tubing that is coated to resist rust. The ends are double flared or have an ISO-type flare to guard against leakage. Couplings require high pressure seals. A tube nut forces each flared tube end against a matching seat. It is important to start the male fitting into the wheel cylinder or hose using fingers only to prevent cross-threading and subsequent stripping of the threads. Tighten to manufacturer's specifications.

CAUTION: **DO NOT use copper tubing for brake systems.**

Flexible Brake Hoses
Hoses form a flexible link between the brakes and the vehicle frame or body. They must withstand high fluid pressures without leakage and must be free to flex during chassis deflection and wheel turns without damage. Hoses come in different sizes, lengths, materials and end fittings. It is important to use the correct size hose for a given application. A hose which is too long will rub against the chassis and eventually wear its cover through. In extreme cases, this abrasion can wear all the way through the hose and cause a hydraulic failure. A hose which is too short can break in tension. Aging and constant exposure to weather can result in hardening and cracking of a hose. The connections at the metal couplings are especially critical. Blisters in a hose suggest seepage in the hose joint which has penetrated underneath the outer hose covering and could indicate a torn liner which can act as a check valve in the line. Never take a chance with a faulty hose; replace it.

Servicing: Most hoses have a male fitting on one end and a female fitting on the other. Disconnect the female end first. Remove the clip or the jam nut that fastens down the female end, then unscrew the male end. Make sure the replacement hose is equal in length to the original hose and has the same end fitting.

When installing, connect the male hose end first and, if a copper gasket was used, replace it with a new gasket. Install the female end in a position which will turn the curve of the hose away from any point of contact. Replace the hose suspension spring, if present. Check for interference of the hose suspension spring, if present. Check for interference of the hose with the chassis, suspension, and body during chassis spring deflection and rebound, and when the wheels are steered to the extreme left and right. Eliminate any interference by loosening the female end of the hose and repositioning it.

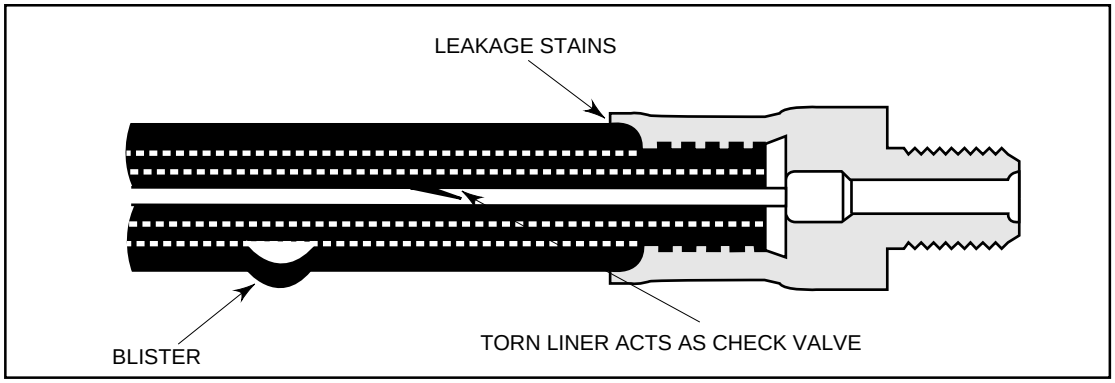


FIGURE 6

BRAKE FLUID

Brake fluid is one of the most important components of a hydraulic brake system since it ties all of the other parts of the system together into an integral operating unit.

Fluid Characteristics
Brake fluid is a specially blended liquid that provides a means of transmitting hydraulic pressure from the master cylinder to the wheel cylinders and calipers. Federal laws require that a brake fluid must meet certain standards and specifications before it is sold. The most important characteristics that any brake fluid must possess are:

- Viscosity: it should be free flowing at all temperatures.
- High boiling point: it should remain in a liquid state at the highest operating temperatures that might be encountered.
- Non-corrosive: it should not attack rubber or metal parts, and it should inhibit various types of corrosion and act as an anti-trust agent.
- Water tolerant: it should be able to absorb and retain moisture that collects in the system.
- Lubricating ability: it should lubricate pistons and cups to reduce wear and internal friction.
- Low freezing point: it should remain fluid and flow at low operating temperatures.

The federal government has set specifications for three types of brake fluid for automotive use: DOT 3, DOT 4, and DOT 5. Each type must be a specified color if manufactured after September 1978. DOT 3 (or SAE J1703), and DOT 4 are amber to clear in color. The major difference between the two is that DOT 4 has a higher wet boiling point and absorbs moisture more slowly than DOT 3 fluid. (See BRAKE FLUID BOILING POINT TABLE.) DOT 5 brake fluid is silicone based, is purple, and has a higher boiling point than DOT 3 or 4. Note that DOT 3 and 4 may be mixed with each other, but DOT 5 should not be mixed with DOT 3 or DOT 4. Other characteristics of DOT 5 brake fluid, such as lubricity, corrosion resistance, ABS compatibility, etc., have been highly debated. Manufacturer's recommendations for fluid types should be followed at all times.

Brake Fluid Boiling Point

Boiling Point	DOT 3	Euclid DOT 3 Plus	DOT 4	DOT 5 (Silicone)
Dry (Min.)	401°F	450°F	446°F	500°F
Wet (Min.)	284°F	284°F	311°F	356°F

Changing Brake Fluid

Brake fluid, like engine oil or antifreeze, eventually becomes contaminated with moisture and dirt. Depending on the type of contamination, a fluid may look dark, and the boiling point will have become lower. Brake fluid should be changed at each major brake repair. Any mineral or petroleum-based substance (gasoline, carbon tetrachloride, paint-thinner, diesel fuel, etc.) attacks the rubber compounds used in brake systems. Soft or swollen rubber parts in the hydraulic system are an indication that the brake fluid is contaminated. Usually, the first sign is brake drag (or lock) caused by swollen rubber parts preventing brake release.

The only remedy is to drain the fluid, flush the system, clean the cylinders, replace all rubber parts including brake hoses, and refill the system with clean brake fluid.

> ***CAUTION:*** **Rubber parts should only be cleaned in isopropyl (denatured) alcohol or brake fluid. If metal parts are degreased or washed in any solvent, rinse them thoroughly with alcohol or brake fluid to remove every trace of solvent residue. Always use clean containers for brake fluid and make sure stored fluid is tightly capped.**

Handling & Storing Brake Fluid

Always keep brake fluid clean. Do not allow any foreign material or petroleum product (gasoline, kerosene, oil, grease, etc.) to get into the fluid. Never use containers contaminated with dirt, oil, grease, rust, etc.

> ***CAUTION:*** **DO NOT leave brake fluid cans partially filled, always keep them tightly capped.**

It is a natural tendency of all brake fluids (except silicone) to absorb moisture when exposed to air, and this greatly reduces their boiling point. High temperature fluids (specified for heavy-duty and disc brake use) lose their boiling point more quickly than regular fluids. Absorption of even 3% moisture brings down the boiling point of high temperature fluids by about 50%. This can happen if the master cylinder cap is left off overnight or if a can is left partially filled with brake fluid even for a day or two.

> ***CAUTION:*** **If hard brake use causes the fluid to boil, a condition called "fluid-boil" or vapor-lock" may occur and braking efficiency will be dangerously reduced.**

Take the following precautions to prevent moisture contamination of the brake fluid:

- Keep the master cylinder tightly covered. Re-install the cover tightly immediately after the master cylinder is filled with new fluid.
- Use the smallest possible can of brake fluid to fill the master cylinder. Use two small cans rather than half of a large can.
- Tightly cap the fluid container after use.
- If the remaining fluid in the can cannot be used the same day, dispose of it. Using small cans helps reduce waste. Discard any fluid that is suspected of being contaminated.
- Keep the fluid reservoir in a pressure brake bleeder tightly closed except when refilling.

The effect of moisture contamination is a reduced boiling point which can result in "fluid-boil". In this condition, the driver runs out of pedal stroke without actuating the brakes. Brake heat boils the fluid into vapor so that the pedal stroke is used up to compress the gas. With a sufficient vapor accumulation, the master cylinder can run out of stroke before the brakes are applied. Often, this condition disappears before being checked, since the vapor reverts back to a fluid when it cools. To be safe, always replace the fluid when in doubt.

Euclid's Master Catalog illustrates each wheel cylinder individually for easy identification. These pictures show single- and double-ended units, with and without bleeders and tube seats. This is the best reference available to identify replacement wheel cylinders. Also, in addition to OEM cross references, Euclid provides a casting number reference.

NOTE: These casting numbers should be used for body identification only. Parts should be checked for proper port threads and mounting holes before ordering.

RECOMMENDED STOCK LIST

Inventory requirements and hydraulic wheel cylinder popularity will vary geographically, but on a national basis the following 10 wheel cylinders (listed in order of popularity) represent approximately 80% of wheel cylinder sales. The E-5148 wheel cylinder alone equals 27% of wheel cylinder sales.

MOST COMMONLY USED WHEEL CYLINDER/WHEEL CYLINDER COMBINATIONS BY VEHICLE MANUFACTURER.—MEDIUM-DUTY TRUCK

CHEVY/GMC	DODGE	FORD	ISUZU	NAVISTAR
E-5148	E-5148	E-5163 E-5164	E-7372	E-5161 E-5162
E-5179 E-5180	E-5161 E-5162	E-5148	E-7375	E-5148
E-5153 E-5154	E-5152	E-5407 E-5408	E-7379	E-5150
E-5150	E-5163 E-5164	E-5177 E-5178	E-7381	E-5149
E-5169 E-5170	E-5159 E-5160	E-5161 E-5162		E-5163 E-5164
E-5157 e-5158		E-5173 E-5174		E-5151
		E-5413 E-5414		
		E-5167		

MOST COMMONLY USED WHEEL CYLINDER/WHEEL CYLINDER COMBINATIONS BY VEHICLE MANUFACTURER.—LIGHT-DUTY TRUCK

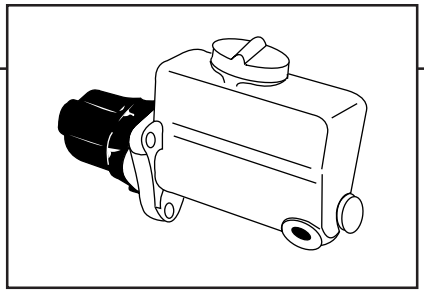
CHEVY/GMC	DODGE	FORD
E-5198	E-8146 E-8147	E-5201 E-5202
E-8160	E-8157	E-8174 E-8175
E-8151	E-8144 E-8145	E-8158 E-8159
E-8152	E-8153 E-8154	E-8146 E-8147
E-8167	E-8142 E-8143	
E-8168		
E-9247		

FOR EASE OF HANDLING, Euclid wheel cylinders are packaged in a master carton of 12 wheel cylinders (per part number) and repair kits are packaged in a master carton of 10 kits (per part number). WDs are encouraged to purchase the most popular numbers in multiples of 12 and 10 respectively in order to take advantage of this handling benefit.

TECH TIPS

MASTER CYLINDERS

(Product Code 204)



FUNCTION

The Master Cylinder is the heart of the hydraulic brake system. It converts the mechanical force on the brake pedal into the hydraulic pressure needed to actuate the wheel cylinders and calipers to brake the vehicle. Although Master Cylinders come in several sizes, styles, and with different types of power assist units, they all contain similar important components (Figure 1).

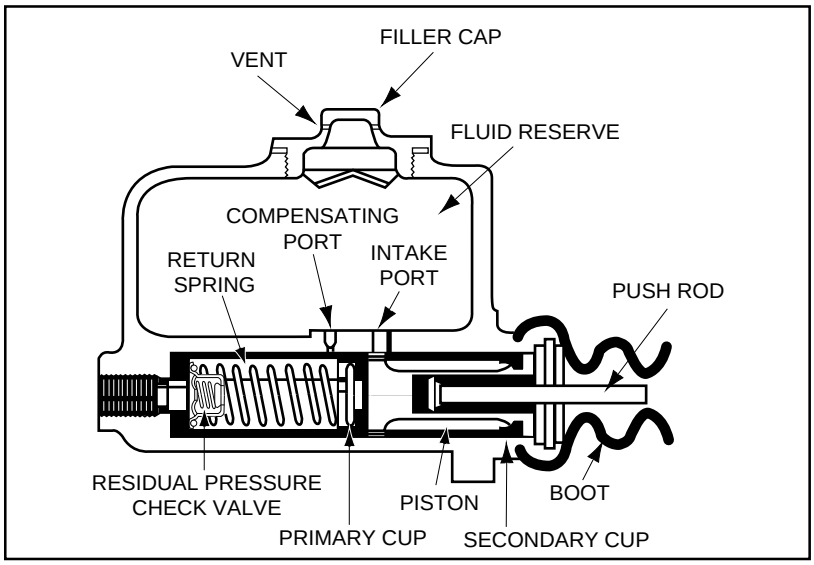


FIGURE 1

In its simplest form, the Master Cylinder consists of a casting with a cylindrical bore containing a piston assembly. At either end of the piston is a rubber sealing surface. The front end is sealed by the primary cup, which is the high pressure seal. The rear end is sealed by the secondary cup. This secondary cup is a low pressure seal which prevents brake fluid leakage from the open end of the Master Cylinder's bore.

The piston is acted upon by a push rod which obtains its force from the effort exerted on the brake pedal. As the piston moves forward, the fluid ahead of it is pressurized. Above the bore is a fluid reservoir. A small hole, directly above the secondary section of the piston called the intake port, allows fluid in the reservoir to enter the bore.

The amount of fluid movement through a brake system is less than one ounce during a full stroke. The fluid reservoir insures that the wheel cylinders and caliper bores are filled with fluid as the brake lining and pads wear. The reservoir also keeps the secondary area full of fluid during a brake application to prevent a low pressure area.

The Master Cylinder is fitted with a return spring to help force the piston to return to its rest position when the brake pedal is released. As the piston retracts, it pulls away from the fluid faster than the fluid can make its way back to the Master Cylinder through the brake lines. In order for the piston to return rapidly and be ready for another stroke, a path is provided to allow fluid to flow to this low pressure area as the piston returns. This path is a series of small holes located near the outer edge of the Master Cylinder piston. These holes allow fluid to flow from the secondary area behind the main cup around the edges of the cup and into the primary area (Figure 2). The reservoir continues to supply the brake fluid through this intake port as necessary to keep the secondary area full during the complete piston stroke.

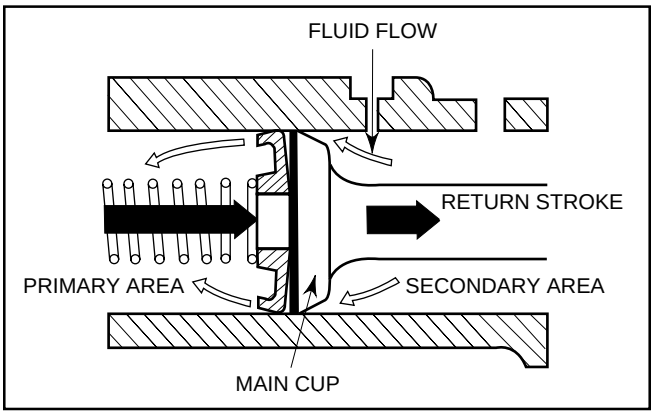


FIGURE 2

The compensating port allows any excess fluid to return to the reservoir when the brake pedal is released. This port is open to the system only when the Master Cylinder is in its released position.

Hydraulic drum brake systems usually make use of a residual pressure check valve in the Master Cylinder. This valve holds an average of 6 to 20 psi pressure in the brake lines and wheel cylinders. This pressure helps to keep air from entering the system and also allows the brake to react faster than if pressure had to be built up from "zero" for each brake application. Thus, the brake return spring must be replaced at every brake reline to insure that the piston returns and its brakes "do not drag".

Hydraulic disc brakes do not use brake return springs to pull the brake pads away from the rotor. Therefore, residual pressure is not desired in this system, and a residual pressure check valve is not used.

INSPECTION AND TROUBLESHOOTING

Most often fluid leakage is internal and not easily noticed. However, it sometimes does show up externally as well.

A low or "spongy" brake pedal can be caused by air in the system, in which case the entire system, including Master Cylinder, must be bled. A leaking Master Cylinder secondary cup, or a faulty residual pressure valve, may also be the cause, requiring the rebuilding or replacement of the Master Cylinder.

Master Cylinder problems can also cause the brake pedal to go all the way to the floor with little or no effort. This is mostly the symptom of fluid leaking past the primary cup during light brake applications. This can only be cured by rebuilding or replacing the Master Cylinder.

Excessive pedal effort or dragging brakes can be caused by a seized or sticking Master Cylinder piston. Dragging brakes also can be caused by a blocked compensation port, faulty residual pressure valve or swollen cups in the Master Cylinder. All these failures can be solved by rebuilding or replacing the Master Cylinder.

Master Cylinder wear can result from use, age or fluid contamination. Although these are some of the most common Master Cylinder failures, many other hydraulic brake abnormalities can be traced to Master Cylinder problems. As with the other components of the brake system, the Master Cylinder should be serviced at regular intervals. Seals are usually the first components to wear. The Master Cylinder seals may need replacement even though all the other brake system components are in good condition.

REBUILDING

When rebuilding Master Cylinders, never reuse old brake fluid. Many problems with Master and Wheel Cylinders are caused by fluid contamination. See "BRAKE FLUID" on pages 4, 5, and 6 in the Hydraulic Brake Wheel Cylinders' section of this Tech Tips.

1. Remove lines and fasteners that secure the Master Cylinder to the fire wall or power booster. Prevent any dirt or grease from contaminating the exposed end of the Cylinder and hydraulic lines.

2. Drain all brake fluid from reservoir. Remove all piston stop bolts and/or stop wires. Remove both the primary and secondary pistons. If the piston cannot be removed easily, a low air pressure (under 30 psi) can be used to aid in its removal. Higher pressure can result in Cylinder damage or personal injury.

3. Inspect for the presence of check valves by probing with a wire through the outlet ports. Tube seats may be removed to replace check valve components. Remove the tube seat inserts, if required, by partially threading a self-tapping screw into each tube seat and using two screwdrivers to pry the seats out of the master cylinder (Figure 3). Remove the residual pressure check valve (if present) and the spring from the outlet(s).

4. Thoroughly clean all components with alcohol. If slight corrosion or pitting is found, steel piston bores can be cleaned with crocus cloth or a hone designed for Master Cylinders. Excessive honing can cause an insufficient seal (even with new primary cups), resulting in failure. If aluminum Cylinders are found to have scratches or pitting, they must be replaced. **Caution: Do not use crocus cloth or hones on aluminum Cylinders. Honing aluminum Cylinders will result in rapid seal wear and brake failure.**

5. Use brake fluid generously to aid reassembly. Reassemble the Master Cylinder in the reverse order of disassembly. Make sure all cups and seals are replaced facing in the correct direction. Be extremely careful not to damage any rubber cups or seals when installing them in the bore. **Note: Some Master Cylinder rebuilding kits contain check valves to cover several applications. Do not install check valves if the Master Cylinder did not originally contain them.**

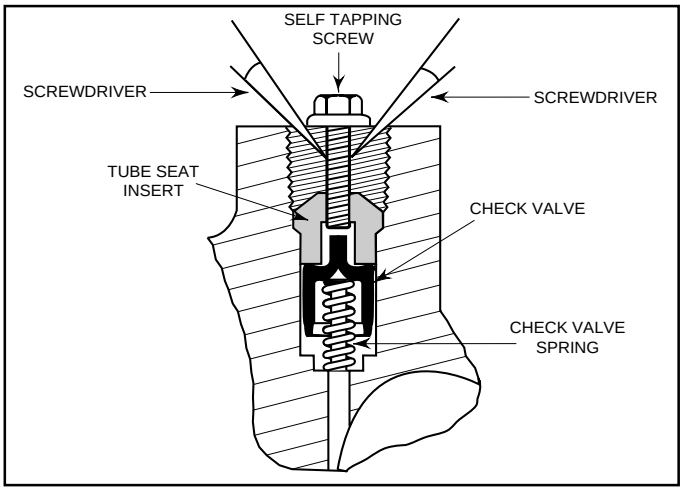


FIGURE 3

BLEEDING

Master Cylinder Bench Bleeding

Master Cylinders must be bench-bled after any disassembly. The following instructions are for use when specially made bleeding equipment is not available.

1. Mount the Master Cylinder by its mounting flange in a vise, with the bore at a slight, downward angle.

2. Route two shortened brake lines (purge tubes) from the outlet connections into the fluid reservoirs below the normal fluid level (Figure 4). These purge tubes should contain check valves unless the port(s) they are connected to contain check valves.

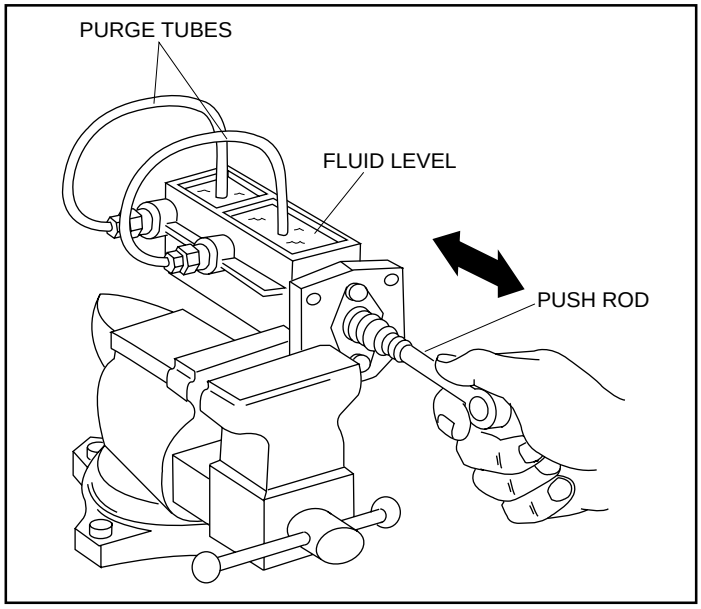


FIGURE 4

3. Fill the reservoirs with fresh brake fluid and pump the push rod back and forth until air bubbles no longer appear in the reservoir. If there is no check valve in the outlet port or the purge tube, close off the end of the tubing on every return stroke. Use your finger for this, but make sure it is clean.

4. When all air has been purged, install the Master Cylinder on the vehicle, leaving the purge tubes in place.

5. Remove the purge tubes and attach the brake lines to the Master Cylinder.

6. Tighten the tube connections and fill the Master Cylinder reservoir with new brake fluid.

7. Attach the proper bleeder adapter to the Master Cylinder reservoir and pressure bleed the system.

System Bleeding

A) Manual Bleeding
On most vehicles equipped with power brakes, exhaust the vacuum reserve from the power unit by depressing the brake pedal several times. Ensure Master Cylinder fluid level is adequate at all times during bleeding procedure. Install bleeder hose on the wheel cylinder farthest from the Master Cylinder. Submerge the other end of the tube in a clean transparent container, partially filled with new brake fluid.

Depress brake pedal slowly through its full range of travel and hold open bleed screw 3/4-1 turn, close bleed screw and then release brake pedal. Repeat this step until fluid shows no signs of air bubbles. This complete procedure should be repeated on all wheel cylinders and/or calipers, moving from the farthest point to the closest to the Master Cylinder.

B) Pressure Bleeding
Fill pressure tank approximately half full of new brake fluid of the proper DOT specification for the application. (See "BRAKE FLUID" on pages 4, 5 and 6 in the Hydraulic Brake Wheel Cylinders' section of this Tech Tips.) Make sure release valve is closed. Charge pressure tank to the tank manufacturer's recommendation. Attach the pressure tank to the Master Cylinder. A variety of adapters are available to facilitate this connection. Open release valve on pressure tank. Install bleeder hose on the wheel cylinder farthest from the Master Cylinder. Submerge the other end of the hose in a clean transparent container partially filled with new clean brake fluid. Open bleed screw 3/4-1 turn, close bleed screw. This complete procedure should be repeated on all wheel cylinders and/or calipers until fluid shows no signs of air bubbles.

EUCLID vs. COMPETITION

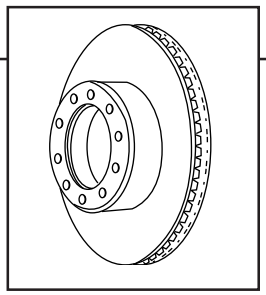
- Every Euclid Master Cylinder has been completely tested on computer controlled hydraulic testers to insure adherence to rigid quality specifications.
- Euclid Master Cylinders are competitively priced.
- Euclid Master Cylinders are individually boxed for protection and for easy handling and storage.
- The addition of Master Cylinders broadens Euclid's Hydraulic Brake Parts Program to make it one of the most complete in the aftermarket.

With high order fill rate and prompt shipping, Euclid serves your hydraulic parts needs better than any other company in the industry.

TECH TIPS

HYDRAULIC DISC BRAKE ROTORS

(Product Code 207)



ROTOR BASICS

There are two basic designs of Rotors used for medium-duty hydraulic disc brakes: U-Shaped and Hat Shaped. The U-Shaped rotor has its mounting flange turned outward from the "barrel" section of the rotor. The Hat Shaped rotor has its mounting flange turned inward from the "barrel" section of the rotor (Figure 1). Light-duty truck applications make use of five different assembly designs; Types H, J, K, L and M. These designs are completely explained in Euclid's Master Catalog. Vents must be kept clean to allow for the proper air flow and cooling. Excessive heat buildup can contribute to rotor and/or pad failure as well as brake inefficiency. Solid type rotors are used in some applications.

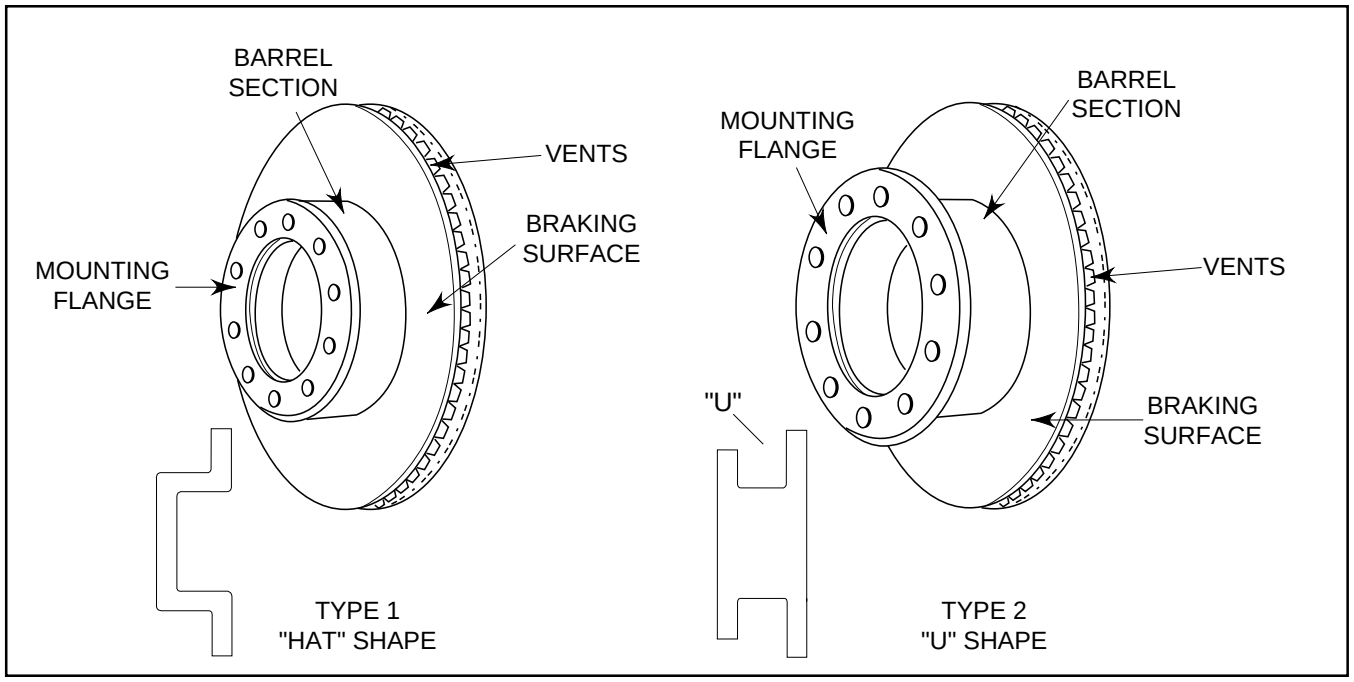


FIGURE 1

To identify the proper rotor when the part number is unknown, use the dimensions provided in the Rotors and Calipers Section of Euclid's Master Catalog.

INSPECTION PROCEDURES

The mechanic should check the following points on a rotor to help ensure suitable braking efficiency.

Rotor Runout (Wobble)
Rotor runout, often called "wobble", can be measured by rotating the rotor with a dial indicator mounted perpendicular to the rotor's face. OE specifications usually call for a runout of less than .010" in the medium and heavy-duty hydraulic disc brake market. In most light-duty and smaller medium-duty truck applications, the OEM specifications range from .002" - .005" for runout. If a rotor exceeds these recommendations, it should be resurfaced or replaced. **NOTE**: Be sure that wheel bearings have been adjusted to OEM specifications prior to checking rotor runout.

Rotor Thickness Variations
Variations are measured by using a micrometer at several points around the rotor, measuring the face to face dimension. Some OE specifications allow for as much as .005" in the medium-duty truck market. Lighter duty vehicles are much more sensitive to thickness variation and most specify no more than .0005". This measurement should also be checked every time a rotor has been resurfaced.

Heat Spotted Rotors
The rotor should be visually inspected periodically for heat spots on its face. Heat spots are shown by dark areas on the rotor face. Resurfacing may remove a heat spot. However, in some cases the heat spot is so deep that resurfacing is not practical and the rotor must be replaced.

Heat Checked and Cracked Rotors
Heat checks will almost always be found on a used rotor. These heat checks must be removed by resurfacing to assure proper disc pad life and performance. Again, be sure not to go below recommended thickness of the rotor. A heat check becomes a crack, as described in SAE SP-642 reports, when it has "progressed radially through the outside diameter of the braking surface and has also traversed axially across the O.D." Cracks are a major factor leading to excessive pad wear. If a crack is present, the rotor must be replaced.

Polished Rotors
This condition is evident by a mirrorlike finish on the braking surface. The brake pad surface should also be inspected for glazing. Although this condition can occasionally be corrected by sanding both rotor and brake pad surfaces with an 80-150 grit emery cloth, we suggest replacing the friction material and only sanding the rotor surfaces. This eliminates the risk of rotor damage resulting from heat damaged brake pads.

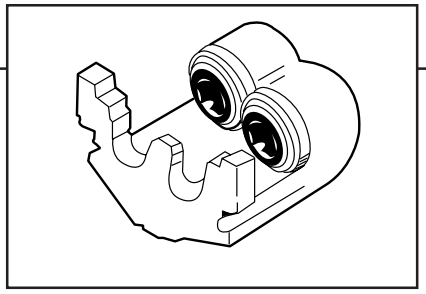
Rotor Surface Condition
Rotors, new or resurfaced, should have a surface finish of 120-150 microinch maximum. (For reference, Euclid's hard chrome anchor pins are in the 32-35 microinch range; smaller numbers refer to a smoother finish.) When resurfacing a rotor, a fine cut is required to obtain a finish below this maximum level.

Rotors must be stored in a dry place to eliminate the chance of rust forming on the braking surface.

Euclid supplies rotors in individual boxes to insure that the braking surfaces are not damaged in shipment.

HYDRAULIC DISC BRAKE CALIPERS

(Product Code 206)



CALIPER BASICS

There are two common types of disc brake calipers: fixed and floating. The basic function of both types is the same, but they use different approaches to do the job.

FLOATING CALIPER DESIGN

The caliper assembly is mounted on the steering knuckle through the use of an anchor plate. A caliper assembly includes the caliper, piston(s), seals, springs, boots, fluid passages, etc. The floating caliper straddles the rotor on a mount that permits limited caliper travel at right angles to the rotor (Figure 1). The piston(s) are located on the inboard side of the caliper housing. Hydraulic pressure on the piston(s) forces the inboard brake pad against the inner surface of the rotor. Continued pressure then causes the entire caliper assembly to react in the opposite direction with the outboard brake pad being drawn against the outer rotor surface. The pads are not drawn away from the rotor after braking but remain positioned immediately next to the rotor in a relaxed state. Therefore, when reapplied, the engagement of the outboard brake pad will follow almost instantaneously the engagement of the inboard brake pad. Although engagement for both brake pads is almost concurrent, the inboard pad may exhibit slightly more wear than the outboard pad since it does engage the rotor first. Braking force is equalized on both sides automatically by the reciprocal action of the caliper responding to actuating force applied in the hydraulic cylinder.

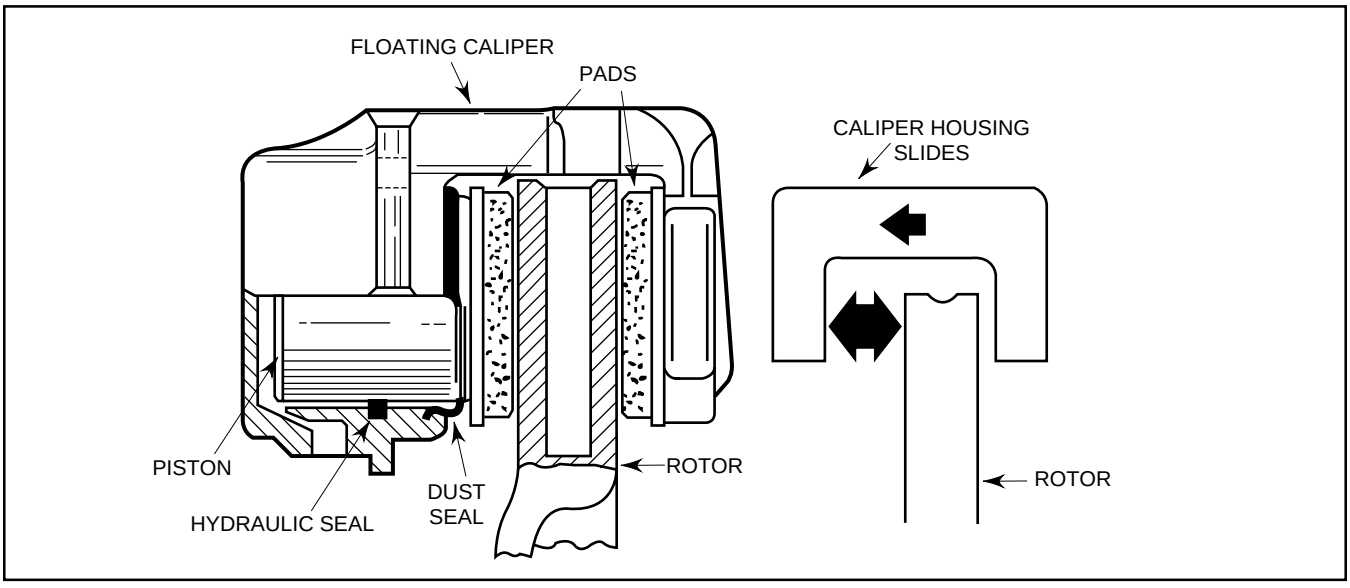


FIGURE 1
Floating Caliper Design

Despite some manufacturing variation, in most designs the caliper is free to "float" in and out slightly on the mounting hardware. Thus, when the brakes are not applied, there can be slight side-to-side movement. The mounting hardware, however, prevents the caliper from rotating with the rotor.

Because the pads contact the rotor at right angles, frictional drag carries the pads against the stops on the caliper but the rotation tends to thrust off the pads. Consequently, there is no pad energization or leverage as in hydraulic drum brakes, and the disc brake is sometimes said to be "non-energized" and "automatic adjusting". When the actuating force is released, the system merely relaxes with almost zero clearance between the brake pads and the rotor. In light-duty applications where rotor lateral runout is minimal and caliper weight is low, the distortion of the piston seal is a major factor in pad to rotor clearance. In medium-duty truck applications the piston seal distortion aids in setting pad to rotor clearance, however rotor runout also contributes to this setting. In either light or medium-duty truck applications, should the rotor "lateral runout" exceed the normal specifications, the pads will be "knocked back" much farther than is desirable for proper operation. This will then require a long brake pedal stroke to establish pad contact with the rotor during a stop. The non-energized disc brake requires more actuating force than on a drum brake of similar capacity, and, on all but the lightest vehicles, is used in conjunction with a power brake unit.

FIXED CALIPER DESIGN

A fixed caliper does not move in any direction. Fixed calipers are mounted rigidly to the axle. These calipers straddle the rotor with one or multiple pistons located on both sides of the rotor. The pressure behind all pistons is balanced via cast-in passages or cross tubes. In both fixed and floating caliper designs, pressure may be balanced at all pistons yet not provide balanced piston actuation. If large variations exist in the required force to begin piston movement, actuating timing will be affected. Any variation in piston actuation timing will result in uneven pad wear, rotor fatigue, pull, etc. Due to the increased number of pistons in most fixed caliper designs, this problem may be more significant. Fixed calipers consist of the same components as floating calipers. Fixed calipers are more sensitive to rotor variations due to their direct connection to the axle on the steering knuckle.

Caliper assemblies are somewhat less rugged than drum brake assemblies. Due to their location on the axle, they have little shielding and are directly exposed to grit and dirt. This can partially or completely freeze up the caliper leading to brake pad hang up. Disc brake assembly malfunction is usually evidenced by:

1. Insufficient braking
2. Squealing
3. Premature pad and/or rotor wear
4. Hydraulic fluid leakage due to excessive heat and wear of the seal or piston

When disc brakes are serviced and new, thicker, pads are installed, the pistons must be pushed back into their bores. When this is done without rebuilding the caliper, the portion of the piston previously exposed beyond the seal will be pushed through the seal. The piston will take with it any contamination and any piston scratches will most likely damage the seal. Because of this and the fact that the seals lose their properties with age, it is important to rebuild calipers in pairs each time pads are replaced. When calipers require service, they can be rebuilt. However, since calipers are key to satisfactory braking, unless an experienced service person is available, the caliper should be replaced. Euclid offers a complete line of remanufactured disc brake calipers with light and medium-duty truck coverage.

SERVICING TIPS

1. When removing brake lines to service the caliper, be sure to note the number and locations of gaskets since they must be reassembled correctly to prevent leaks and/or restrictions. New gaskets are recommended.

2. Remove caliper from brake assembly for service.

3. A good method of removing the piston is to apply **very low** air pressure to the fluid inlet port to force the piston out of the caliper bore. Place a small block of wood or several shop towels inside the outboard legs of the caliper for safety and to avoid damage to the piston or caliper when the piston pops out. **Be careful to keep hands and fingers out of the way as the piston comes out.**

4. Use only wood or plastic tools to remove piston hydraulic seal that remains in the caliper bore. Avoid any steel or other tools which may scratch the caliper bore or seal groove.

5. Clean and inspect the caliper bore. Use only alcohol or clean brake fluid with a lint free cloth.

6. Inspect piston for any signs of wear, corrosion or pitting. Damaged pistons **MUST** be replaced.

7. Coat caliper bore and new caliper piston seal generously with brake fluid. (See "Brake Fluid" in the Wheel Cylinder section of this Tech Tip.) Install the hydraulic piston seal in the groove of the caliper bore. Make sure the seal is fully seated and is not twisted. A rotating motion should be used to install piston through the seal. This will allow the seal to recover from any distortion that occurs and prevent immediate damage.

8. Replace the dust boot and install piston using the proper tool. This can be fashioned from a piece of stiff wire. While pulling upward, move the tool around the piston to slide the boot onto the piston. Push piston in a rotating motion into the caliper bore. Be particularly careful when installing phenolic pistons. **NEVER** use a C-clamp directly on a phenolic piston as damage to the piston may occur.

9. If fixed caliper halves have been separated, install new seals between halves. This is a problem and caution should be used during reassembly.

   Most calipers are installed in a position that will allow the bleeder screw to be at the highest point. This is an important factor in the bleeding procedure and brake maintenance.

REMANUFACTURED CALIPERS

Euclid is proud to offer a high quality line of remanufactured hydraulic disc brake calipers for light-duty and medium-duty trucks. This new offering complements Euclid's existing line of new calipers. Euclid customers now have a choice: new or remanufactured.

Euclid calipers are remanufactured, not just rebuilt. As opposed to a quick process limited to washing, painting and reusing worn parts, Euclid ensures the highest quality product through a **SIX STEP Remanufacturing Program** which includes:

1. **Complete disassembly** ensures all surfaces are properly cleaned and inspected.
2. **High pressure washing** removes all grease and oil.
3. **Shot blasting** removes rust and prepares caliper body for surface plating.
4. **Thorough inspection** for any defects. Only acceptable cores are retained.
5. **Reassembly** using **all new** high quality phenolic or aluminum (or remanufactured steel) pistons, boots, seals and bleeder screws.
6. **Final inspection of the finished product** to ensure Euclid Quality.

Euclid's line of high quality, remanufactured calipers is coupled with an uncomplicated, user-friendly Core Return Policy, in-depth cataloguing, and fast order turnaround. This winning combination makes an easy job of identifying, ordering and stocking calipers.

NOTES

OTHER EUCLID TECHNICAL TRAINING MODULES AVAILABLE:

MODULE ONE - FOUNDATION AIR BRAKES
Includes:
Foundation Air Brake Hardware Kits
Camshafts/Camshaft Repair Kits
Automatic Slack Adjusters
Air Wedge Brakes

MODULE ONE-ONE - AIR SYSTEMS
Includes:
Compressors
Governors
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Air Valves / Air Hoses

MODULE THREE - WHEEL ATTACHING PARTS
Includes:
Disc Wheel Parts
Spoke Wheel Parts

MODULE FOUR - SUSPENSIONS
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Neway Air Suspensions
Mack Camel Back Spring Suspension
U-Bolts
Uni-Rods/Maxi-Rods
Air Springs
Shock Absorbers

MODULE FIVE - FRONT END PARTS
Includes:
King Pin Sets
Tie Rod Ends
Drag Links
Light-Duty Front End Parts

MODULE SIX - AIR CONDITIONING AND HEATING PARTS

MODULE SEVEN - ELECTRICAL SYSTEMS
Includes:
Alternators
Starters

MODULE EIGHT - ENGINE COOLING SYSTEMS
Includes:
Water Pumps

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