Braking system

The most vital factor in the running and control of the modern vehicle is the braking system. In order to bring the moving vehicle to rest or slow down, the energy of the vehicle processed by the vehicle must be converted into some other form of energy. The rate of slowing down or retardation is governed by the speed of conversion of energy. The means of slowing down or bringing to rest a moving vehicle in a shortest possible distance is called brakes. Brakes provided by the manufacturer must be effective, safe in operation, progressive and consistence in response to pedal as well as reasonably easy to adjust.

Basic requirement of a braking system

- In consistence with safety, the brake must be strong enough to stop the vehicle during emergency within the shortest distance. This is only possible when there is no skidding and the driver has proper control over the vehicle during emergency.

- The fade characteristics of the brakes should be quite good, in other word; the effectiveness of the brakes should remain consistence even with prolonged application, as in hill descending. This is possible if the cooling of the vehicle is quite efficient.

Drum brakes

Early automotive brake systems, after the era of hand levers of course, used a drum design at all four wheels. They were called drum brakes because the components were housed in a round drum that rotated along with the wheel. Inside was a set of shoes that, when the brake pedal was pressed, would force the shoes against the drum and slow the wheel. When the pressure is released, return springs pull the shoes back to their rest position. Fluid was used to transfer the movement of the brake pedal into the movement of the brake shoes, while the shoes themselves were made of a heat-resistant friction material similar to that used on clutch plates.

This basic design proved capable under most circumstances, but it had one major flaw. Under high braking conditions, like descending a steep hill with a heavy load or repeated high-speed slow downs, drum brakes would often fade and lose effectiveness. Usually this fading was the result of too much heat build-up within the drum. Remember that the principle of braking involves turning kinetic energy (wheel movement) into thermal energy (heat). For this reason, drum brakes can only operate as long as they can absorb the heat generated by slowing a vehicle's wheels. Once the brake components themselves become saturated with heat, they lose the ability to halt a vehicle, which can be somewhat disconcerting to the vehicle's operator.
Drum brakes consist of a backing plate, brake shoes, brake drum, wheel cylinder, return springs and an automatic or self-adjusting system. As the brake linings wear, the shoes must travel a greater distance to reach the drum. When the distance reaches a certain point, a self-adjusting mechanism automatically reacts by adjusting the rest position of the shoes so that they are closer to the drum.

- **Brake Shoes**

Like the disk pads, brake shoes consist of a steel shoe with the friction material or lining riveted or bonded to it. Also like disk pads, the linings eventually wear out and must be replaced. If the linings are allowed to wear through to the bare metal shoe, they will cause severe damage to the brake drum.

- **Backing Plate**

The backing plate is what holds everything together. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes and assorted hardware. It rarely causes any problems.

- **Brake Drum**

Brake drums are made of iron and have a machined surface on the inside where the shoes make contact. Just as with disk rotors, brake drums will show signs of wear as the brake linings seat themselves against the machined surface of the drum. When new shoes are installed, the brake drum should be machined smooth. Brake drums have a maximum diameter specification that is stamped on the outside of the drum. When a drum is machined, it must never exceed that measurement. If the surface cannot be machined within that limit, the drum must be replaced.

- **Wheel Cylinder**

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

Return springs pull the brake shoes back to their rest position after the pressure is released from the wheel cylinder. If the springs are weak and do not return the shoes all the way, it will cause premature lining wear because the linings will remain in contact with the drum. A good technician will examine the springs during a brake job and recommend their replacement if they show signs of fatigue. On certain vehicles, the technician may recommend replacing them even if they look good as inexpensive insurance.

• **Self Adjusting System**

Parts of a self adjusting system should be clean and move freely to insure that the brakes maintain their adjustment over the life of the linings. If the self adjusters stop working, you will notice that you will have to step down further and further on the brake pedal before you feel the brakes begin to engage. Disk brakes are self adjusting by nature and do not require any type of mechanism.

**Disc brakes**

The disc brake is the best brake we have found so far. Disc brakes are used to stop everything from cars to locomotives and jumbo jets. Disc brakes wear longer, are less affected by water, are self adjusting, self cleaning, less prone to grabbing or pulling and stop better than any other system around. The main components of a disc brake are the Brake Pads, Rotor, Caliper and Caliper Support.

But unlike drum brakes, which allow heat to build up inside the drum during heavy braking, the rotor used in disc brakes is fully exposed to outside air. This exposure works to constantly cool the rotor, greatly reducing its tendency to overheat or cause fading.
Brake Pads

There are two brake pads on each caliper. They are constructed of a metal "shoe" with the lining riveted or bonded to it. The pads are mounted in the caliper, one on each side of the rotor. Brake linings used to be made primarily of asbestos because of its heat absorbing properties and quiet operation; however, due to health risks, asbestos has been outlawed, so new materials are now being used. Brake pads wear out with use and must be replaced periodically. There are many types and qualities of pads available. The differences have to do with brake life (how long the new pads will last) and noise (how quiet they are when you step on the brake). Harder linings tend to last longer and stop better under heavy use but they may produce an irritating squeal when they are applied. Brake pads should be checked for wear periodically. If the lining wears down to the metal brake shoe, then you will have a "Metal-to-Metal" condition where the shoe rubs directly against the rotor causing severe damage and loss of braking efficiency. Some brake pads come with a "brake warning sensor" that will emit a squealing noise when the pads are worn to a point where they should be changed. This noise will usually be heard when your foot is off the brake and disappear when you step on the brake. If you hear this noise, have your brakes checked as soon as possible.

Rotor

The disk rotor is made of iron with highly machined surfaces where the brake pads contact it. Just as the brake pads wear out over time, the rotor also undergoes some wear, usually in the form of ridges and grooves where the brake pad rubs against it. This wear pattern exactly matches the wear pattern of the pads as they seat themselves to the rotor. When the pads are replaced, the rotor must be machined smooth to allow the new pads to have an even contact surface to work with. Only a small amount of material can be machined off of a rotor before it becomes unusable and must be replaced. A minimum thickness measurement is stamped on every rotor and the technician doing the brake job will measure the rotor before and after machining it to make sure it doesn't go below the legal minimum. If a rotor is cut below the minimum, it will not be able to handle the high heat that brakes normally generate. This will cause the brakes to "fade," greatly reducing their effectiveness to a point where you may not be able to stop!

Caliper & Support

There are two main types of calipers: Floating calipers and fixed calipers. There are other configurations but these are the most popular. Calipers must be rebuilt or replaced if they show signs of leaking brake fluid.

Single Piston Floating Calipers are the most popular and also least costly to manufacture and service. A floating caliper "floats" or moves in a track in its support so that it can center itself over the rotor. As you apply brake pressure, the hydraulic fluid pushes in two directions. It forces the piston against the inner pad which in turn pushes against the rotor. It also pushes the caliper in the opposite direction against the outer pad, pressing it against the other side of the rotor. Floating calipers are also available on some vehicles with two pistons mounted on the same side. Two piston floating calipers are found on more expensive cars and can provide an improved braking "feel".
Four Piston Fixed Calipers are mounted rigidly to the support and are not allowed to move. Instead, there are two pistons on each side that press the pads against the rotor. Four piston calipers have a better feel and are more efficient, but are more expensive to produce and cost more to service. This type of caliper is usually found on more expensive luxury and high performance cars.

Drum Vs Disc today

In today's automotive pantheon, it's not uncommon to find four-wheel disc brakes as standard equipment on medium-priced, non performance-oriented models. The majority of new vehicles, however, continue to utilize a front-disc/rear-drum brake setup. What does this say about the current state of braking systems? Are these manufacturers sacrificing vehicle safety in order to save a few bucks by installing disc brakes on only the front wheels? While a "yes" answer would certainly be great for increasing Town Hall traffic, the truth is that today's disc/drum setups are completely adequate for the majority of new cars. Remember that both disc and drum brake design has been vastly improved in the last 20 years. In fact, the current rear drum brake systems on today's cars would provide better stopping performance than the front disc setups of the '70s. And today's front disc brakes are truly outstanding in terms of stopping power. Combined with the fact that between 60 and 90 percent of a vehicle's stopping power comes from the front wheels, it's clear that a well-designed, modern drum brake is all that's required for most rear wheel brake duty.

High performance cars like the Viper, 911 and Corvette can justify a four-wheel disc brake system, especially if their owners participate in some form of sanctioned racing activity on the weekends. The rest of us get more of a benefit from the lower cost of drum brakes. Expecting every vehicle built today to come with four-wheel disc brakes would require an across-the-board increase in purchase price, and that could stop new car buyers much quicker than any brake system.

Hydraulic Brake System

The typical brake system consists of disc brakes in front and either disc or drum brakes in the rear connected by a system of tubes and hoses that link the brake at each wheel to the master cylinder. Other systems that are connected with the brake system include the parking brakes, power brake booster and the anti-lock system.
When you step on the brake pedal, you are actually pushing against a plunger in the master cylinder which forces hydraulic oil (brake fluid) through a series of tubes and hoses to the braking unit at each wheel. Since hydraulic fluid (or any fluid for that matter) cannot be compressed, pushing fluid through a pipe is just like pushing a steel bar through a pipe. Unlike a steel bar, however, fluid can be directed through many twists and turns on its way to its destination, arriving with the exact same motion and pressure that it started with. It is very important that the fluid is pure liquid and that there are no air bubbles in it. Air can be compressed which causes sponginess to the pedal and severely reduced braking efficiency. If air is suspected, then the system must be bled to remove the air. There are "bleeder screws" at each wheel cylinder and caliper for this purpose.

**Master cylinder**

The master cylinder is located in the engine compartment on the firewall, directly in front of the driver's seat. A typical master cylinder is actually two completely separate master cylinders in one housing, each handling two wheels. This way if one side fails, you will still be able to stop the car. The brake warning light on the dash will light if either side fails, alerting you to the problem. Master cylinders have become very reliable and rarely malfunction; however, the most common problem that they experience is an internal leak. This will cause the brake pedal to slowly sink to the floor when your foot applies steady pressure. Letting go of the pedal and immediately stepping on it again brings the pedal back to normal height.

**Brake fluid**

Brake fluid is a special oil that has specific properties. It is designed to withstand cold temperatures without thickening as well as very high temperatures without boiling. (If the brake fluid should boil, it will cause you to have a spongy pedal and the car will be hard to stop.) Brake fluid must meet standards that are set by the Department of Transportation (DOT). The current standard is DOT-3 which has a boiling point of 460° F. The brake fluid reservoir is on top of the master cylinder. Most cars today have a transparent reservoir so that you can see the level without opening the cover. The brake fluid level will drop slightly as the brake pads wear. This is a normal condition and no cause for concern. If the level drops noticeably over a short period of time or goes down to about two thirds full, have your brakes checked as soon as possible. Keep the reservoir covered except for the amount of time you need to fill it and never leave a can of brake fluid uncovered. Brake fluid must maintain a very high boiling point. Exposure to air will cause the fluid to absorb moisture which will lower the boiling point.
Parking Brakes

The parking brake (emergency brake) system controls the rear brakes through a series of steel cables that are connected to either a hand lever or a foot pedal. The idea is that the system is fully mechanical and completely bypasses the hydraulic system so that the vehicle can be brought to a stop even if there is a total brake failure. On drum brakes, the cable pulls on a lever mounted in the rear brake and is directly connected to the brake shoes. This has the effect of bypassing the wheel cylinder and controlling the brakes directly.

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

The power brake booster is mounted on the firewall directly behind the master cylinder and, along with the master cylinder, is directly connected with the brake pedal. Its purpose is to amplify the available foot pressure applied to the brake pedal so that the amount of foot pressure required to stop even the largest vehicle is minimal. Power for the booster comes from engine vacuum. The automobile engine produces vacuum as a by-product of normal operation and is freely available for use in powering accessories such as the power brake booster. Vacuum enters the booster through a check valve on the booster. The check valve is connected to the engine with a rubber hose and acts as a one-way valve that allows vacuum to enter the booster but does not let it escape. The booster is an empty shell that is divided into two chambers by a rubber diaphragm. There is a valve in the diaphragm that remains open while your foot is off the brake pedal so that vacuum is allowed to fill both chambers. When you step on the brake pedal, the valve in the diaphragm closes, separating the two chambers and another valve opens to allow air in the chamber on the brake pedal side. This is what provides the power assist. In order to have power assist, the engine must be running. If the engine stalls or shuts off while you are driving, you will have a small reserve of power assist for two or three pedal applications but, after that, the brakes will be extremely hard to apply and you must put as much pressure as you can, to bring the vehicle to a stop.

**Anti-Lock Brakes (ABS)**

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

Anti-lock brake systems solve this lockup problem by rapidly pumping the brakes whenever the system detects a wheel that is locked up. In most cases, only the wheel that is locked will be pumped, while full braking pressure stays available to the other wheels. This effect allows you to stop in the shortest amount of time while maintaining full steering control even if one or more wheels are on ice. The system uses a computer to monitor the speed of each wheel. When it detects that one or more wheels have stopped or are turning much slower than the remaining wheels, the computer sends a signal to momentarily remove and reapply or pulse the pressure to the affected wheels to allow them to continue turning. This "pumping" of the brakes occurs at ten or more times a second, far faster then a human can pump the brakes manually. If you step on the brakes hard enough to engage the anti-lock system, you may feel a strong vibration in the brake pedal. This is a normal condition and indicates that the system is working. The system consists of an electronic control unit, a hydraulic actuator, and wheel speed sensors at each wheel. If the control unit detects a malfunction in the system, it will illuminate an ABS warning light on the dash to let you know that there is a problem. If there is a problem, the anti-lock system will not function but the brakes will otherwise function normally.