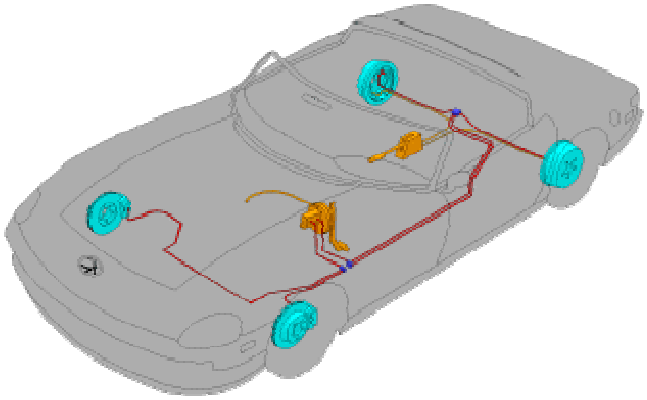
Brake System Overview



Below is an explanation of this system's operation

The Brake System

The braking system is the most important system in your car. If your brakes fail, the result can be disastrous. Brakes are actually energy conversion devices, which convert the kinetic energy (momentum) of your vehicle into thermal energy (heat). When you step on the brakes, you command a stopping force ten times as powerful as the force that puts the car in motion. The braking system can exert thousands of pounds of pressure on each of the four brakes. In modern systems, the master cylinder is power-assisted by the engine. All newer cars have dual systems, with two wheels' brakes operated by each subsystem. That way, if one subsystem fails, the other can provide reasonably adequate braking power. Safety systems like this make modern brakes more complex, but also much safer than earlier braking systems.

The brake system is composed of the following basic components: The "master cylinder" which is located under the hood, and is directly connected to the brake pedal, converts your foot's mechanical pressure into hydraulic pressure. Steel "brake lines" and flexible "brake hoses" connect the master cylinder to the "slave cylinders" located at each wheel. Brake fluid, specially designed to work in extreme conditions, fills the system. "Shoes" and "pads" are pushed by the slave cylinders to contact the "drums" and "rotors" thus causing drag, which (hopefully) slows the car.

In recent years, brakes have changed greatly in design. Disc brakes, used for years for front wheel applications, are fast replacing drum brakes on the rear wheels of modern cars. This is generally due to their simpler design, lighter weight and better braking performance. The greatest advantage of disc brakes is that they provide significantly better resistance to "brake fade" compared to drum type braking systems. Brake fade is a temporary condition caused by high temperatures generated by repeated hard braking. It occurs when the pads or shoes "glaze" due to the great pressure and heat of hard use. Once they cool, the condition subsides. Disc

brakes allow greater air ventilation (cooling) compared to drum brakes. Drum brakes are not internally ventilated because if they were, water could accumulate in them. Disc brakes can rapidly fling off any water that they are exposed to, and so they can be well ventilated.

"Boosters" are present in "power brake" systems, and use the engine's energy to add pressure to the master cylinder. "Anti-lock" (ABS) systems, originally developed for aircraft braking systems, use computer controlled valves to limit the pressure delivered to each slave cylinder. If a wheel locks up, steering input cannot affect the car's direction. With ABS, no matter how hard the pedal is pressed, each wheel is prevented from locking up. This prevents skidding (and allows the driver to steer while panic-braking).

As impressive as these advances are, the basic process of converting a vehicle's momentum into (wasted) heat energy has not changed since the days of the horse and buggy. To stop a horse drawn carriage, the driver would pull on a lever which would rub on the wheel. But today, with the advent of regenerating brakes on electric vehicles, new ways of recapturing this lost energy are being developed. In these types of electric cars, when you step on the brakes, the motor switches into "generator mode", and stores the car's momentum as chemical energy in the battery, to be used again when the light turns green!

Disc Brakes

Disc brakes use a clamping action to produce friction between the "rotor" and the "pads" mounted in the "caliper" attached to the suspension members. Inside the calipers, pistons press against the pads due to pressure generated in the master cylinder. The pads then rub against the rotor, slowing the vehicle. Disc brakes work using much the same basic principle as the brakes on a bicycle; as the caliper pinches the wheel with pads on both sides, it slows the bicycle. Disc brakes offer higher performance braking, simpler design, lighter weight, and better resistance to water interference than drum brakes.

Disc brakes, like many automotive innovations, were originally developed for auto racing, but are now standard equipment on virtually every car made. On most cars, the front brakes are of the disc type, and the rear brakes are of the "drum" type. Drum brakes use two semi-circular shoes to press outward against the inner surfaces of a steel drum. Older cars often had drum brakes on all four wheels, and many new cars now have 4-wheel disc brakes.

Because disc brakes can fling off water more easily than drum brakes, they work much better in wet conditions. This is not to say that water does not affect them, it definitely does. If you splash through a puddle and then try to apply the brakes, your brakes may not work at all for a few seconds! Disc brakes also allow better airflow cooling, which also increases their effectiveness. Some high performance disc brakes have drilled or slotted holes through the face of the rotor, which helps to prevent the pads from "glazing" (becoming hardened due to heat). Disc brakes were introduced as standard equipment on most cars in the early seventies.

Brake Drums

The brake drum is a heavy flat-topped cylinder, which is sandwiched between the wheel rim and the wheel hub. The inside surface of the drum is acted upon by the linings of the brake shoes. When the brakes are applied, the brake shoes are forced into contact with the inside surface of the brake drums to slow the rotation of the wheels.

The drums are usually covered with fins on their outer surfaces to increase cooling. They are not cooled internally, because water could enter through the air vent cooling holes and braking would then be greatly impaired.

Drum brakes are found on the rear wheels of most older cars, but they are increasingly being fazed out in favor of rear disc brakes. Drum brakes were standard equipment on all four wheels of most cars until the early 70's.

Brake Calipers

The caliper works like a C-clamp to pinch the pads onto the rotor. It straddles the rotor and contains the hydraulic "slave cylinder" or "wheel cylinder" piston(s). One caliper is mounted to the suspension members on each wheel. The caliper is usually mounted onto the spindle, allowing it to deliver the torsional force of the wheel to the chassis via the control arms. Brake hoses connect the caliper to the brake lines leading to the master cylinder. A "bleeder valve" is located on each caliper to allow air bubbles to be purged from the system.

"Floating caliper" disc brakes, the most common variety, allow the caliper to move from side to side slightly when the brakes are applied. This is because only one pad moves (in relation to the caliper). Some calipers contain two or four seperate pistons. These calipers are fixed in place; i.e., there is no lateral movement like the floating caliper, the pistons take up the slack on each side of the rotor. These are called "dual cylinder" or "dual piston" calipers, and are standard equipment on many performance cars.

Wheel (Slave) Cylinder

Wheel cylinders, also called the "slave" cylinders, are cylinders in which movable piston(s) convert hydraulic brake fluid pressure into mechanical force. Hydraulic pressure against the piston(s) within the wheel cylinder forces the brake shoes or pads against the machined surfaces of the drum or rotor. There is one cylinder (or more in some systems) for each wheel. Drum brake wheel cylinders are usually made up of a cylindrical casting, an internal compression spring, two pistons, two rubber cups or seals, and two rubber boots to prevent entry of dirt and water. This type of wheel cylinder is fitted with push rods that extend from the outer side of each piston through a rubber boot, where they bear against the brake shoes. In disc brakes, the wheel cylinder is built into the caliper. All wheel cylinders have bleeder screws (or bleeder valves) to allow the system to be purged of air bubbles.

As the brake pedal is depressed, it moves pistons within the master cylinder, pressurizing the brake fluid in the brake lines and slave cylinders at each wheel. The fluid pressure causes the wheel cylinders' pistons to move, which forces the shoes or pads against the brake drums or rotors. Drum brakes use return springs to pull the pistons back away from the drum when the pressure is released. On disc brakes, the

calipers' piston seals are designed to retract the piston slightly, thus allowing the pads to clear the rotor and thereby reduce rolling friction.

Parking (Emergency) Brakes

The parking brake (sometimes called the emergency brake) is a cable-activated system used to hold the brakes continuously in the applied position. The parking brake activates the brakes on the rear wheels. Instead of hydraulic pressure, a cable (mechanical) linkage is used to engage the brake shoes or discs. When the parking-brake pedal is pressed (or, in many cars, a hand lever is pulled), a steel cable draws the brake shoes or pads firmly against the drums or rotors. The release lever or button slackens the cables and disengages the brake shoes. The parking brake is self adjusting on most systems. An automatic adjuster compensates for lining (brake shoe) wear. On many cars, the parking brake is used to re-adjust the brake shoes as they wear in, or when the shoes are replaced. In these systems, the adjustment is made by repeatedly applying the parking brake while backing up.

The parking brake can be useful while driving up hills: If you're driving a manual transmission car, and you pull up to a stop on an incline, you might notice that you don't have enough feet to operate the clutch, brake, and gas at the same time. In other words, you will likely roll backwards slightly while getting started again. If a someone pulls up right behind you, this can be a problem. Your parking brake is useful in this situation: Apply the parking brake after you stop. When you want to go, release the clutch while pressing the gas, and release the parking brake. This keeps you from having to quickly switch your left foot from the brake to the clutch, or your right foot from the brake to the gas pedal. A little practice, and you'll be able to do it smoothly. Also, remember if you pull up behind someone who is stopped on a hill, give them extra room to roll back a little. Especially if it's a truck.

Some cars have no parking brake release! They automatically release the parking brake when the car is placed in drive or reverse.

Remember, it's a good idea to test the parking brake periodically and keep it in good condition. It may save your life if the main braking system fails!