Brake System

There will be three questions on the ASE P2 test that deal with brake systems, parts and products.

The brake system includes the master cylinder, power booster, disc brake calipers and rotors, wheel cylinders and brake drums, brake hardware, brake hoses and lines, various valves, disc brake pads and drum shoes, and brake fluid. On vehicles equipped with anti-lock brakes (ABS), additional parts include up to four-wheel speed sensors, the ABS hydraulic modulator and control module, and a pump motor and accumulator (not used on some systems).

- Automatic Transmission
- Braking System
- Cooling System
- Drivetrain
- Electrical System
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When the driver steps on the brake pedal, it moves a rod in the master cylinder forward to push a pair of pistons against fluid in the primary and secondary chambers. Brake systems are split into two separate hydraulic circuits. Each circuit operates two of the four brakes (both fronts, both rears or a diagonal pair). This is a safety requirement, so if one circuit fails, at least two brakes will continue to operate so the vehicle can still be stopped.

Brake fluid carries the hydraulic pressure created in the master cylinder through the brake lines to the front calipers and rear calipers or drums to apply the brakes. Most older vehicles have front disc brakes and drums in the rear, but many newer cars, SUVs and trucks have disc brakes in the front and rear. When pressure reaches the brakes, the pads are squeezed against the rotors, and if the vehicle has drums in the rear, the shoes are pushed out against the drums to generate friction and stop the vehicle.

On vehicles equipped with power brakes, a brake booster located behind the master cylinder on the firewall, multiplies the force of the brake pedal input using engine vacuum and a large diaphragm. This reduces the pedal effort needed to stop the vehicle. On some older vehicles with integral ABS systems, the ABS pump and accumulator provides power assist. The ABS pump and accumulator are also used to apply the brakes on vehicles equipped with traction control and/or stability control.

Additional parts involved in the braking process include a "pressure differential valve" (a safety switch that turns on the brake warning lamp if there's a loss of pressure in either brake circuit), a "proportioning valve" to reduce pressure to the rear brakes for more balanced braking (not used on all vehicles), and on some, a "load-sensing proportioning valve" to increase or decrease hydraulic pressure to the rear brakes based on vehicle loading.

The major wear components in the brake system are disc brake pads and drum shoes. Every time the brakes are applied these parts are subjected to friction and wear. Lining life depends on how the vehicle is driven. Stop-and-go city driving, mountain driving

and aggressive driving all involve more frequent braking, harder braking and higher brake temperatures — all of which add up to more wear and shorter lining life. Highway driving and gradual, light braking produce less lining wear and longer lining life.

On most vehicles, the front linings wear out twice as fast as the rear linings, so when the linings need to be replaced for the first time it's usually only the front pads that need to be changed. Replacement linings should be the same or better than the original linings. Semi-metallic linings are often used in high-heat applications because they can withstand high-operating temperatures without fading or wearing excessively. Other high-temperature friction materials include linings with ceramic content. Pads and shoes with non-asbestos organic (NAO) linings are typically used for lower heat applications such as rear brakes and front brakes on rear-wheel drive cars and trucks. Some aftermarket brake suppliers now use different friction materials for the inner and outer pads to optimize brake performance.

When linings are replaced, the rotors and drums may need to be resurfaced or replaced depending on their condition. If a rotor is worn to minimum thickness or a drum is worn to maximum diameter, replacement is necessary. Most rotors are made of cast iron, but "composite" rotors have a thin, stamped steel center hat attached to a cast iron rotor ring. Composite rotors are more difficult to resurface and more prone to pedal pulsation problems than one-piece cast rotors. They are also more expensive than cast. Composite rotors can be replaced with cast rotors as long as both rotors are replaced at the same time (don't intermix different kinds of rotors side-to-side).

Most front rotors are vented, while most rear rotors are not because more cooling is usually needed for the harder-working front brakes. Most rotors are interchangeable left to right, but some are directional, so pay close attention to the catalog listings when looking up part numbers. New rotors are ready to install and do not require additional resurfacing (turning rotors unnecessarily shortens the service life).

Other parts that wear out over time include hydraulic components such as the calipers, wheel cylinders and master cylinder. Most calipers have one or two pistons, but some have up to four mounted in a rigid housing. Most calipers are cast iron (though some are aluminum) with steel or molded phenolic (plastic) pistons. Most calipers are a "floating" design with slides or bushings that allow the caliper to move sideways and center itself over the rotor when the brakes are applied.

Others are a "fixed" design with rigid mounts and do not move. If the slides or bushings on a floating caliper become badly corroded or worn, it may prevent the caliper from sliding, causing uneven pad wear. The inside pad will wear faster than the outside pad. If a piston in either type of caliper sticks, the caliper may not release. This causes the brake to drag, puts rapid pad wear on one side, and an uneven braking and a pull to one side when the brakes are applied.

Leaky piston seals will allow brake fluid to contaminate the brake linings. Leaky calipers must be rebuilt or replaced.

Loaded calipers come ready to install with new pads. Bare calipers do not include pads. On vehicles with four-wheel disc brakes, the rear calipers may also include some type of parking brake mechanism. This makes the calipers more complicated and expensive to replace.

The wheel cylinders inside drum brakes have two opposing pistons that move outward when pressure is applied. The wheel cylinder is mounted on the brake backing plate and has dust seals over the pistons to keep out dust and water. Each piston has a cup-shaped seal for the fluid inside. Common problems with wheel cylinders include fluid leaks and sticking. Wheel cylinders can be rebuilt or replaced. Leaking fluid can contaminate the brake shoes, requiring their replacement as well.

Wear in the master cylinder may allow fluid to leak past the piston or shaft seals. One symptom that might indicate a bad master cylinder is a brake pedal that slowly sinks to the floor when holding the brakes at a stop light. Leaks or failure to hold pressure require rebuilding or replacing the master cylinder. Rebuilding aluminum master cylinders is not recommended. On some older vehicles with ABS, the master cylinder is part of the ABS modulator and is very expensive to replace.

Rubber brake hoses can also deteriorate with age and leak. Any hose that is cracked, bulging, leaking or damaged should be replaced without delay because of the danger of brake failure should the hose leak. Steel brake lines can corrode internally or externally. Replacement brake lines must be steel with double-flared or ISO end fittings.

Brake fluid also wears out over time and should be replaced when the brakes are serviced. The main issue here is moisture contamination that causes a breakdown of corrosion inhibitors in the fluid and lowers the fluid's boiling temperature (which increases the risk of fluid boil and pedal fade under hard use). DOT 3 and DOT 4 brake fluid are the two main types, and both are glycol-based hydraulic fluids. DOT 5 fluid is a silicone-based fluid and is used only for special applications (like older vehicles that sit for long periods of time or are operated in extremely wet environments). DOT 4 has a higher temperature rating than DOT 3 and is used in many European vehicles. Use the type of fluid specified by the vehicle manufacturer. DOT 5 brake fluid is not recommended for vehicles with antilock brakes.

Related items that may also need to be replaced when servicing the brakes include the wheel bearings and seals. On older vehicles with serviceable wheel bearings, the grease seals should always be replaced when the bearings are cleaned and repacked with grease. Special high-temperature wheel bearing grease is required (never ordinary chassis grease).

Disc and drum brake hardware should also be replaced when the brakes are serviced. Drum hardware includes the return springs, hold-down springs, self-adjusters and other cables, clips or springs used in the brake assembly. Return springs that pull the shoes away from the drum when the brakes are released may become weak with age, allowing the brakes to drag. Self-adjusters can become corroded and stick, which can cause increased pedal travel as the shoes wear. On disc brakes, the hardware includes slides and bushings that can become worn and corroded, and anti-rattle clips and springs that reduce noise. A high-temperature, moly-based brake grease should be used to lubricate slides, bushings and shoe pads on drum-brake backing plates.

Other replacement parts related to the brake system include the wheel speed sensors used by the antilock brake, traction control and/or stability control system. These are magnetic sensors that may be mounted on the brake hub or backing plate, or built into the sealed wheel bearing and hub assembly. A defective sensor will turn on the ABS, TRAC or stability control warning lights and disable these systems. ◉