UNIT 1: INTRODUCTION TO BRAKE SYSTEMS

LESSON 1: FUNDAMENTAL PRINCIPLES OF BRAKE SYSTEMS

I. Terms and definitions

A. **Brake fading —** Loss of brakes, usually due to heat.

B. **Brake lining —** Material mounted on the surface of a brake shoe or pad. Brake lining produces a great deal of friction when brought together with another friction surface.

C. **Brake pads —** Replaceable friction surfaces that are forced against the rotor by the caliper piston.

D. **Brake shoe —** Drum brake component that is forced against a brake drum in order to create friction.

E. **Caliper —** A nonrotating disc brake component that forms the cylinder and contains the piston(s) and brake pads. The caliper produces braking action by using hydraulic pressure to cause a clamping action on a rotating disc.

F. **Coefficient of friction —** The amount of friction produced by two objects rubbing against each other.

G. **Disc brakes —** Brake system that creates friction by forcing brake pads against a rotating disc.

H. **Drum brakes —** Brake system that creates friction by forcing brake shoes against brake drums.

I. **Kinetic energy —** A type of energy that moves objects.

J. **Kinetic friction —** A type of friction occurring between two objects, one of which is moving.

K. **Static friction —** A type of friction occurring between two objects, both of which are stationary.

II. Effect of kinetic energy on the movement of a vehicle

A. The energy that moves a vehicle is called kinetic energy. A moving vehicle encounters resistance that depletes (takes away) its kinetic energy. Such resistance includes friction created by the vehicle's tires rolling against the pavement and by the vehicle's body moving through the atmosphere (wind resistance).

B. However, wind resistance and tire friction only slow a vehicle gradually. A modern brake system can bring a vehicle to an abrupt stop by rapidly converting a vehicle's kinetic energy into heat through the use of friction and then dissipating it.

III. The principles of friction involved in brake action

A. Friction is the resistance to movement that results from two objects moving or rubbing against each other. There are two types of friction: kinetic and static.

1. Kinetic friction occurs between two objects, one of which is moving. Kinetic friction always produces heat. The more kinetic friction produced, the more heat produced. Automotive braking systems use kinetic friction to convert the energy of a moving vehicle into heat.

2. Static friction occurs between two objects that are stationary. Automotive braking systems use static friction to hold a vehicle while it is parked. Static friction produces no heat.

B. Various factors that affect the amount of friction produced between two objects

1. The rougher the surfaces of two objects, the more friction they produce.

a. Extremely rough surfaces create the most friction, but rough surfaces also wear down quickly. Therefore, automotive brakes use relatively smooth surfaces to avoid rapid wear.

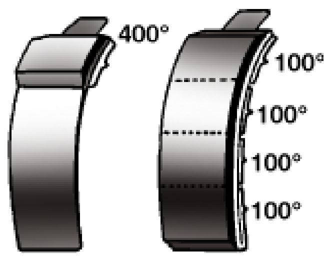
b. In order to compensate for their smooth surfaces, automotive brakes are applied with a great amount of pressure over a relatively large contact area.

2. The greater the pressure bringing the objects together, the more friction they produce. Therefore, the greater the pressure applied to the brakes, with all other factors equal, the greater their stopping power.

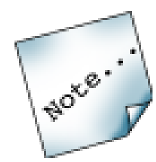
3. The greater the amount of shared contact area between two objects, the greater the amount of friction the objects produce.

   a. Automotive braking systems use the largest contact area possible.

   b. The greater the contact area of a brake shoe or pad, the less heat the shoe or pad generates. Less heat allows for more friction, which makes the brakes more efficient.



NOTE: On drum brake systems, a brake shoe is applied to a brake drum to create friction. On disc brake systems, a brake pad is applied to a disc to create friction. Both of these systems are discussed later in this module.



4. The hotter the friction surface of two objects, the less friction produced. (Rub your hands together and feel the heat!)

   a. All heat that the brake system creates must dissipate as rapidly as it is created. The brake system can store little or no heat.

   b. Brake friction surfaces are made of a material that can conduct heat easily.

   c. Braking system components that produce friction (brake shoes or brake pads) are positioned so that air cools them. In some braking systems, forced air cools the components.

C. The amount of friction that two objects produce when rubbing against each other is called the coefficient of friction.

D. An important brake friction surface is the brake lining that is mounted on either a brake shoe or brake pad. The brake lining produces friction by directly contacting another friction surface, either a brake drum or disc. The brake lining and the material that it touches must have the following special characteristics.

1. The brake drum or disc must conduct heat easily, hold its shape under extremely high heat, withstand rapid temperature changes, resist warping and distortion, and wear well in general. Therefore, brake drums and discs are typically constructed of iron or steel combined with aluminum.

2. The brake lining must be somewhat softer than the brake drum or disc. At present, most brake linings are made of organic materials, metallic particles, and other minerals held together by a bonding agent.

   NOTE: For years, asbestos was commonly used in brake linings. Because asbestos is a cancer-causing substance, federal law prohibits its use in brake systems.

3. When the brake lining is applied to a drum or disc, it is important that the proper coefficient of friction is produced in order to ensure that the brakes are effective.

   a. If the friction coefficient is too great, the brakes may be "grabby" or overly sensitive. Overly sensitive brakes may cause the vehicle to skid too easily.

   b. If the friction coefficient is too low, brake application requires excessive pressure. Applying the brakes with excessive pressure creates excessive heat that could result in brake failure.

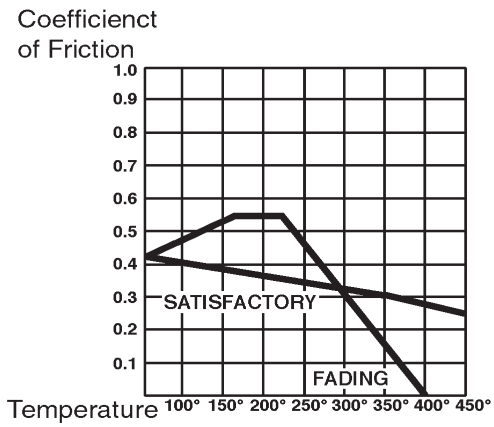
      NOTE: Heat always reduces the coefficient of friction between two objects. Hence, high temperatures may cause brakes to fail.

   c. If the brakes create more heat than they can dissipate, the friction coefficient reduces, which causes the brakes to fade.

      • Excessive heat also causes bonding agents in the lining to melt and flow to the surface, which produces a glaze on the shoe lining.

• This glaze reduces the brake's friction coefficient and causes more brake fading.

• Brake application then requires more pressure, thus creating more heat and more glazing.



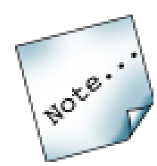
IV. How brakes are applied and how the hydraulic system functions

A. Automotive brake systems fall into two major categories: service brakes (hydraulic brakes) and parking brakes.

1. Service brakes stop the vehicle when it is in motion.

2. A parking brake holds the vehicle while it is parked. A parking brake is not designed to stop a moving vehicle.

NOTE: Parking brakes often use the same friction surfaces as service brakes.



B. Hydraulic brake systems

1. In modern vehicles, hydraulic systems transfer pressure (which the driver applies) from the brake pedal to the brake shoes or pads. In some brake systems, servo action and/or power boosters enhance pressure from the driver's pedal.

2. Most vehicles use two separate hydraulic systems to activate the brakes; therefore, failure of one hydraulic system does not result in complete brake loss.

a. On some vehicles, one hydraulic system activates the front-wheel brakes while the other hydraulic system activates the rear-wheel brakes.

b. On other types of vehicles, one hydraulic system activates the brakes on one front wheel and one rear wheel while another hydraulic system activates the brakes on the other front wheel and rear wheel. In this design, the brakes on one hydraulic system are always at opposite corners of the vehicle.

3. How the hydraulic braking system functions

a. When the driver presses the brake pedal, hydraulic pressure builds in the master cylinder.

b. Hydraulic pressure travels through the brake lines and valves to various brake activators — either the wheel cylinders or calipers.

c. The wheel cylinders or calipers convert the hydraulic pressure into mechanical force.

d. In drum brake systems, hydraulic pressure causes a wheel cylinder to press the brake shoe against the brake drum.

e. In disc brake systems, hydraulic pressure causes a caliper to press a brake pad against a rotating disc. Therefore, in both systems, the action of one component pressing against another creates friction and slows the vehicle.

NOTE: Wheel cylinders and calipers are discussed in more detail later in this module.

f. When the brake releases, various devices move the brake shoes or brake pads away from the drums or discs.

NOTE: A cable or some other mechanical linkage — not the hydraulic system — activates the parking brake.

V. Factors associated with controlled stopping of the vehicle

A. Vehicle weight

1. The more weight a moving vehicle has, the more kinetic energy it possesses. Brake systems must convert kinetic energy into heat; therefore, any increase in vehicle weight puts more demand on the brakes.

2. If a vehicle's weight doubles, the amount of kinetic energy that the brakes must convert into heat doubles. The amount of heat energy resulting from the conversion also doubles. Brakes on an overloaded vehicle may therefore become ineffective due to overheating.

B. Vehicle speed

1. When the speed of a vehicle doubles, the brakes must convert four times the amount of kinetic energy into heat. Speed greatly increases the demand on a vehicle's brakes.

2. A combination of high speed and excessive weight may push a vehicle's brakes beyond their performance limit, resulting in a serious loss of stopping power.

C. Friction between tire and road

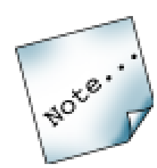
1. The point where a vehicle's tire contacts the road is called the tire footprint. Changes in the tire footprint affect a vehicle's ability to stop. Below is a discussion of the factors affecting the tire footprint.

a. The larger a tire's diameter is, the larger its footprint is.

• The larger the tire footprint is, the more stopping power can be applied at the tire's contact point with the road.

• However, it is important to realize that the greater a tire's diameter is, the more braking power is needed to stop the vehicle.

NOTE: A general rule is that the larger a tire's diameter is, the more braking power is required.



b. The greater the width of a tire is, the larger the tire footprint is.

• The larger the tire footprint is, the more stopping power can be applied at the tire's contact point with the road.

• However, it is important to realize that the greater a tire's width is, the more braking power is needed to stop the vehicle.

NOTE: A general rule is that wide tires require large brakes.

c. Excessive vehicle weight can distort tire tread and thereby reduce the tire's hold on the road. Tires that cannot hold the road reduce the vehicle's ability to stop.

d. High vehicle speed can aerodynamically lift a vehicle as it moves. This lifting reduces the tire's hold on the road and reduces the vehicle's ability to stop.

NOTE: Aerodynamic lift merely adds to the stopping problems that high speed creates. Remember that every time a vehicle's speed doubles, the vehicle's required stopping power quadruples, even if there is no aerodynamic lift.

NOTE: To control the vehicle, friction must occur at the tire footprint. If this friction is lost, the vehicle is out of control.

e. Tires grip the road more securely and can stop better if the wheels are moving. Therefore, the stopping power decreases if the brakes lock up the wheels.

- Automotive engineers carefully avoid designing brake systems that are too powerful for the cars in which they are installed.

- If a brake system locks up the wheels too easily, this significantly reduces stopping power and vehicle control.