Brake System Operation

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Brake System

- Master cylinder
- Brake lines
- Hydraulic valves
- Disc brakes
- Drum brakes
- Power assist unit
- Parking brake
- Antilock system

Brake System Functions

- Slow moving vehicle
- Bring vehicle to a stop
  - 30 mph – 57 feet
  - 60 mph – 216 feet
  - 95 mph – 607 feet
  - 100 mph – 673 feet
- Hold vehicle stationary

Vehicle Energy

- Vehicles operate by converting chemical energy into heat energy and then into kinetic energy
- Kinetic energy is the energy of mechanical work or motion
- Brakes stop the car using friction to convert kinetic energy into heat energy

Calculating Kinetic Energy

- What is the kinetic energy of a 4 kilogram ball moving at 10 meters per second?
  - KE = \( \frac{1}{2} m v^2 \)
  - KE = \(.5 \) (4) (10)^2
  - KE = (2) (100)
  - KE = 200 joules

Brake Lining Materials

- A brake’s linings coefficient of friction is affected by
  - Surface finish
  - Composition
  - Temperature
- Brake linings must resist fading as temperature increases
### Friction Lining Material Rating

<table>
<thead>
<tr>
<th>Edge Code</th>
<th>Coefficient of Friction</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Not over 0.15</td>
</tr>
<tr>
<td>D</td>
<td>Over 0.15 but not over 0.25</td>
</tr>
<tr>
<td>E</td>
<td>Over 0.25 but not over 0.35</td>
</tr>
<tr>
<td>F</td>
<td>Over 0.35 but not over 0.45</td>
</tr>
<tr>
<td>G</td>
<td>Over 0.45 but not over 0.55</td>
</tr>
<tr>
<td>H</td>
<td>Over 0.55</td>
</tr>
</tbody>
</table>

### Pascal’s Law

- Pressure on a confined fluid is transmitted equally in all directions and acts with equal force on all parts.
- Force = pressure x area
- Pressure applied to a piston with a larger surface area will generate a greater output force with less travel.

### Brake Hydraulics

- Increasing the size of the output piston
- Increases output force
- Decreases output travel
- Disc brakes require more output force than drum brakes

### Brake Fluid

- Brake fluid properties
  - High boiling point
  - Low freezing point
  - Non-corrosive to rubber and metal brake parts
  - Ability to lubricate rubber and metal brake system parts
- Most brake fluid is poly glycol or silicone based although a few European manufacturers have used a mineral oil based brake fluid

### Brake Fluid Characteristics

<table>
<thead>
<tr>
<th>Fluid Grade</th>
<th>DOT 3</th>
<th>DOT 4</th>
<th>DOT 5</th>
<th>DOT 5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Type</td>
<td>Poly Glycol</td>
<td>Poly Glycol</td>
<td>Silicone</td>
<td>Poly Glycol</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>401°F</td>
<td>446°F</td>
<td>500°F</td>
<td>518°F</td>
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</tbody>
</table>

### Brake Hydraulic System

- Master cylinder
- Lines and hoses
- Calipers
- Wheel cylinders
- Hydraulic valves
  - Metering
  - Proportioning
  - Pressure differential
  - Residual pressure check valve
Master Cylinder

- Brake fluid reservoir
  - Plastic
  - Cast iron
- Master cylinder body
  - contains piston assemblies used to generate hydraulic pressure

Master Cylinder Operation

- In 1967 DOT required dual-brake systems
- Dual-brake systems utilize two master cylinder pistons
- Brake hydraulic systems are normally split
  - front-rear
  - diagonally

Fill Port

Compensating Port

Combination Valve

- Replaces
  - Metering valve
  - Proportioning valve
  - Pressure differential switch
- Some manufacturers have used a two function combination valve that combines only a pressure differential switch and a proportioning or metering valve
Automotive Brake Systems

Disc Brakes
- Fade resistant design
- Heat
- Water
- Self adjusting
- Brake noise during normal operation
  - Increased with the use of semi-metallic pads

Disc Brake Parts
- Rotor
  - Solid or ventilated
- Caliper assembly
  - Caliper housing
  - Piston
  - Square cut piston seal
  - Dust boot
  - Bleeder screw
- Brake pads

Disc brake Operation
- Hydraulic pressure moves the caliper piston and inner brake pad outward
- The floating caliper assembly then moves inward applying the outer pad and balancing the apply force

Floating or Sliding Caliper
- The caliper floats on pins or V shaped surfaces allowing the outboard fixed pad to move toward the rotor as the inboard pad is applied

Fixed Caliper
- One or more pistons on each side of the caliper apply the brake pads
- Multiple pistons
  - Increase clamping force
  - Decrease brake pad deflection

Drum Brakes
- Backing plate
- Wheel cylinder
- Brake shoes
  - Primary and secondary
- Hold down springs
- Brake shoe return springs
- Self-adjuster
- Brake drum
**Wheel Cylinders**

- Brake system pressure from the master cylinder expands the wheel cylinder's cup seals and forces the pistons outward.
- Most wheel cylinders also utilize cup seal expanders to improve sealing when the brake system pressure is not present.

**Drum Brake Operation**

- Master cylinder pressure moves the wheel cylinder pistons and brake shoes outward.
- When the pressure is released the brake return springs move the brake shoes back to their original position.

**Drum Brake Operation**

- Drum brakes are mechanically self-energizing when applied.
- Two drum brake designs are common:
  - Duo Servo
  - Balanced or leading-trailing

**Duo Servo Drum Brakes**

- Duo servo drum brakes require the least apply pressure.
- Hydraulic pressure moves the wheel cylinder pistons and brake shoes outward.
- The shoes contact the rotating drum and the primary shoe forces the secondary shoe into the drum.

**Duo Servo Operation**

- Hydraulic pressure moves the wheel cylinder pistons and brake shoes outward.
- The rotating drum forces the primary shoe into the anchor pin and the secondary shoe is forced into the wheel cylinder apply pin.
Leading Trailing Operation

The power assist unit decreases the necessary pedal effort to apply the brakes.

Three types of power assist units are common:
- Vacuum
- Hydro-boost
- Electro-hydraulic

Vacuum Power Assist Unit

- Brakes not applied
- Moderate brake application
- Brakes holding
- Full brake application
- Brakes being released

Antilock Brakes

- The electronic control unit monitors brake pedal application and wheel speed
- Solenoids are used to limit and/or reduce brake apply pressure

Antilock Brake Components

- Computer monitors input from wheel speed sensors
- Solenoids limit or reduce hydraulic pressure to slipping wheel(s)
  - Inlet solenoid
  - Outlet solenoid