JONES & BARTLETT LEARNING
CDX Automotive

Fundamentals of
Medium/Heavy Duty Commercial Vehicle Systems

Chapter 33
Fundamentals of Hydraulic and Air-Over-Hydraulic Braking Systems

Introduction

- Vehicle's braking system must meet the following requirements:
  - To adequately and safely reduce a vehicle's speed, when required to do so
  - To maintain vehicle speed on downhill gradients
  - To be able to hold vehicle stationary, even when on gradient and driver is away from the vehicle

Fundamental Configurations for Hydraulic Braking Systems

- Hydraulic brake systems: same basic components augmented by one of two power assist or boost methods.
  - Vacuum booster: medium-duty commercial vehicles; lower cost factor for vehicle range; engine of choice is diesel engine.
  - Hydroboost: Class 4 to Class 6 commercial vehicles; uses pressurized hydraulic fluid to provide brake power assist.

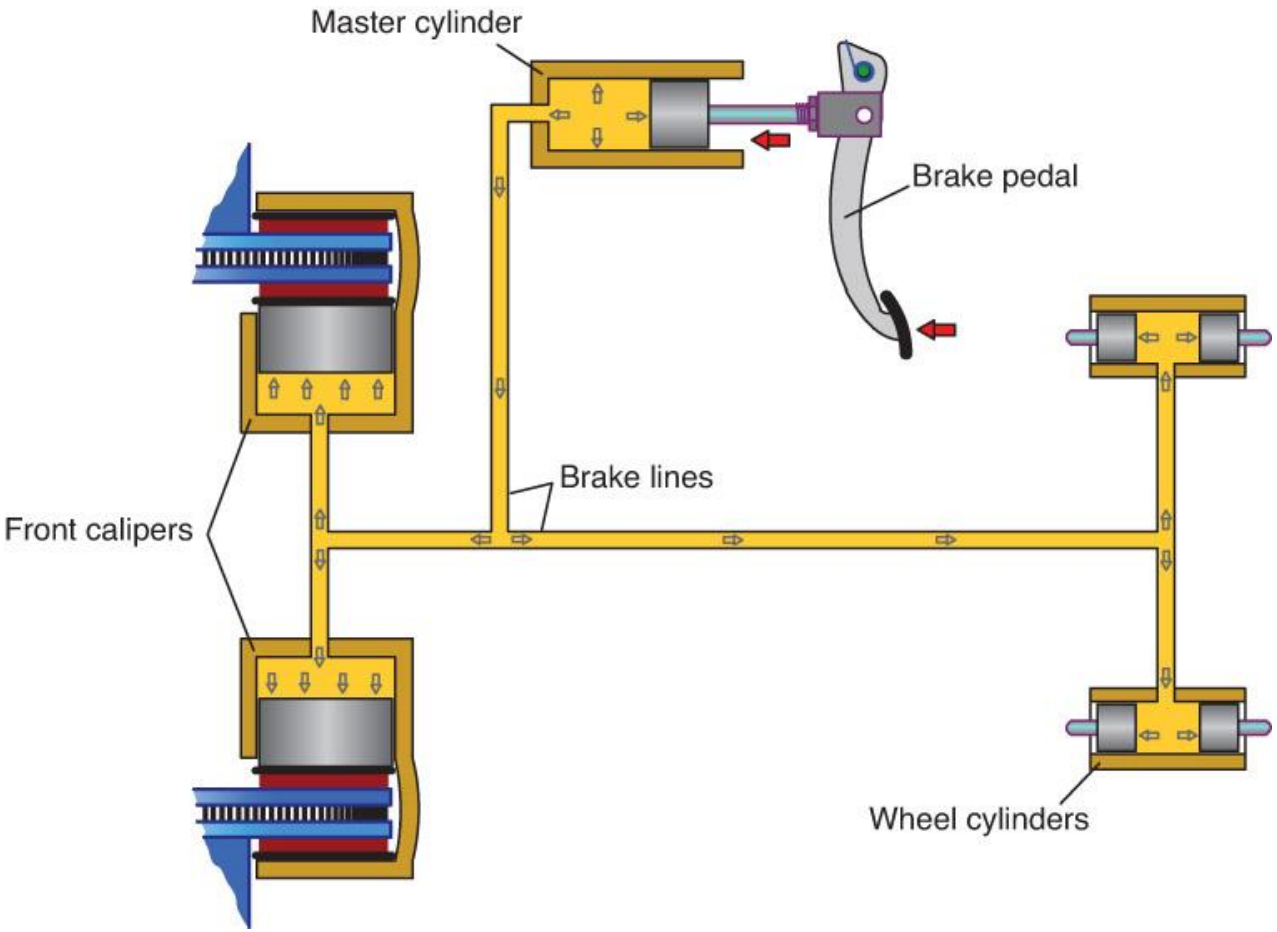
Fundamental Configurations for Hydraulic Braking Systems

- Air-Over-Hydraulic Braking Systems
  - Use air compressor to provide power assistance over hydraulic components to braking system
  - Hydraulically controlled system: compressor, air dryer reservoir tanks, lines
  - Air treadle (foot) valve: sends air pressure directly or indirectly to air boosters that actuate hydraulic master cylinders to apply the brakes

Fundamental Configurations for Hydraulic Braking Systems

- Hydraulic Braking Systems
  - Brake pedal or lever
  - Pushrod (actuating rod)
  - Master cylinder assembly containing piston assembly (one or two pistons, series of seals, O-rings, fluid reservoir)
  - Reinforced hydraulic lines
  - Disc brake assemblies
  - Filled with glycol-ether-based brake fluid

Fundamental Configurations for Hydraulic Braking Systems



Fundamental Configurations for Hydraulic Braking Systems

- Hydraulic Braking Systems
  - When brake pedal pressed, pushrod exerts force on piston(s) in master cylinder, causing fluid from brake fluid reservoir to flow into pressure chamber through compensating port.
  - Results in increase in pressure of entire system
  - Forces fluid through hydraulic lines toward disc brake calipers and drum brake wheel cylinders, where fluid force acts upon pistons

Fundamental Configurations for Hydraulic Braking Systems

- Hydraulic Braking Systems
  - Brake caliper pistons apply force to brake pads and brake shoes to push them against spinning rotor or drum.
  - Friction between pads/shoes and rotating surfaces generates braking torque to slow vehicle.
  - Release of brake pedal/lever allows spring(s) to return master piston(s) back into position.
  - Designed as closed system

Foundation Components of Hydraulic Braking Systems

- Drum Brakes
  - Drum arrangements used on rear wheels, with disc brakes on front in disc/drum configuration.
  - Drum brake has two brake shoes with attached lining made of friction material.
  - Main advantage: shoe mountings designed to assist their own operation (self-energizing)

Foundation Components of Hydraulic Braking Systems

- Drum Brakes
  - Main disadvantage: friction area almost entirely covered by lining; heat conducted through drum to reach outside air to cool.
  - Brake fade: gradual loss of brake stopping power during prolonged or strenuous use.
  - Very high temperatures occur at brake drum; causes deterioration in frictional value of lining or pad material.

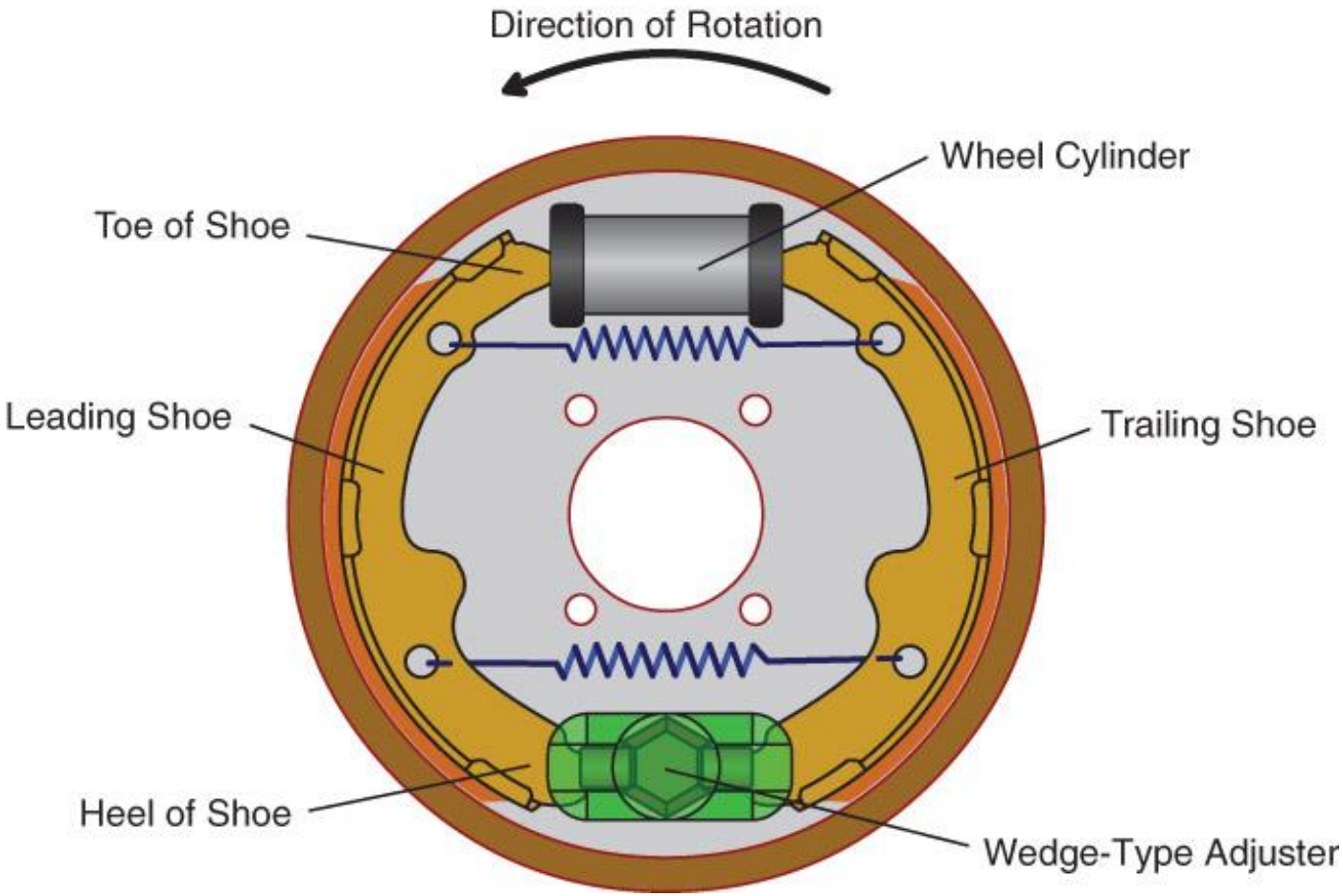
Foundation Components of Hydraulic Braking Systems

- Brake Shoe Configurations and Actuation Mechanisms
  - Single-leading-shoe drum brake (SLS): leading/trailing shoe drum brake arrangement; basic drum brake design
  - Found on rear wheels of vehicles
  - Term “leading/trailing”: one shoe “leading,” that is, moving with direction of drum’s rotation and exhibiting self-applying, or self-servo, effect.

Foundation Components of Hydraulic Braking Systems

- Brake Shoe Configurations and Actuation Mechanisms
  - Other shoe is “trailing”: moving against direction of rotation, and being thrown off drum’s friction surface and not retarding drum effectively.
  - Self-servo effect arises in two-leading-shoe arrangement because leading shoes are dragged into brake drum’s friction surface and achieve maximum braking force.

Foundation Components of Hydraulic Braking Systems

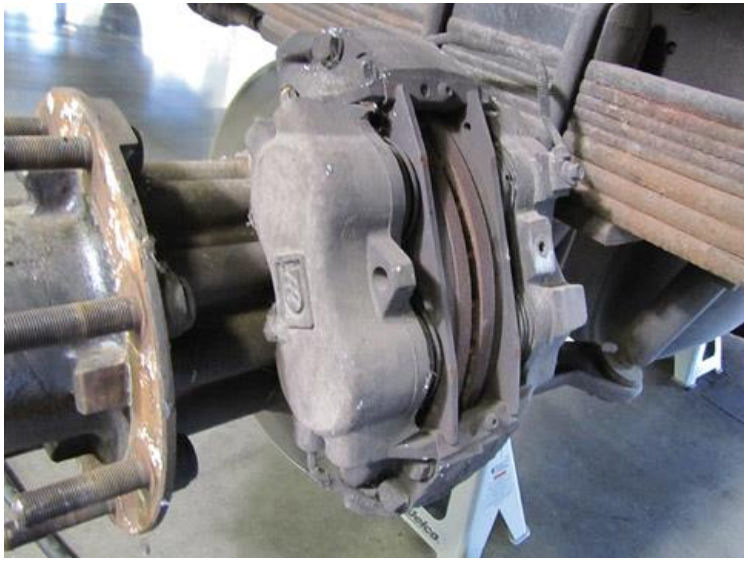


Foundation Components of Hydraulic Braking Systems

- Types of Adjusters Used with Drum Brakes
  - Important to maintain specified drum-to-lining clearance at all times.
  - Star adjusting screw: threaded bolt and two nuts; each end of adjusting in contact with a brake shoe, clearance decreases as screws are turned.
  - Wedge-type adjuster: conical wedge screwed in or out from back of backing plate between tappets that adjust brake lining to brake drum clearance.

Foundation Components of Hydraulic Braking Systems

- Disc Brakes
  - Slows rotation of wheel by friction caused by pushing brake pads against brake disc with set of calipers.
  - Made of cast iron or composites
  - Disc connected to wheel and/or axle.



Foundation Components of Hydraulic Braking Systems

- Disc Brakes
  - To stop wheel, friction material (brake pads mounted on device called brake caliper) forced mechanically, hydraulically, pneumatically, or electromagnetically against both sides of disc.
  - Friction causes disc and attached wheel to slow or stop.
  - Compared with drum brakes, disc brakes offer better stopping performance because disc more readily cooled.

Foundation Components of Hydraulic Braking Systems

- Disc Brakes
  - Less prone to brake fade and recover more quickly from immersion.
  - Has no self-servo effect.
  - Disc brake performance improves as components heat up; drum brake performance deteriorates.
  - Disc brakes can be retrofitted.

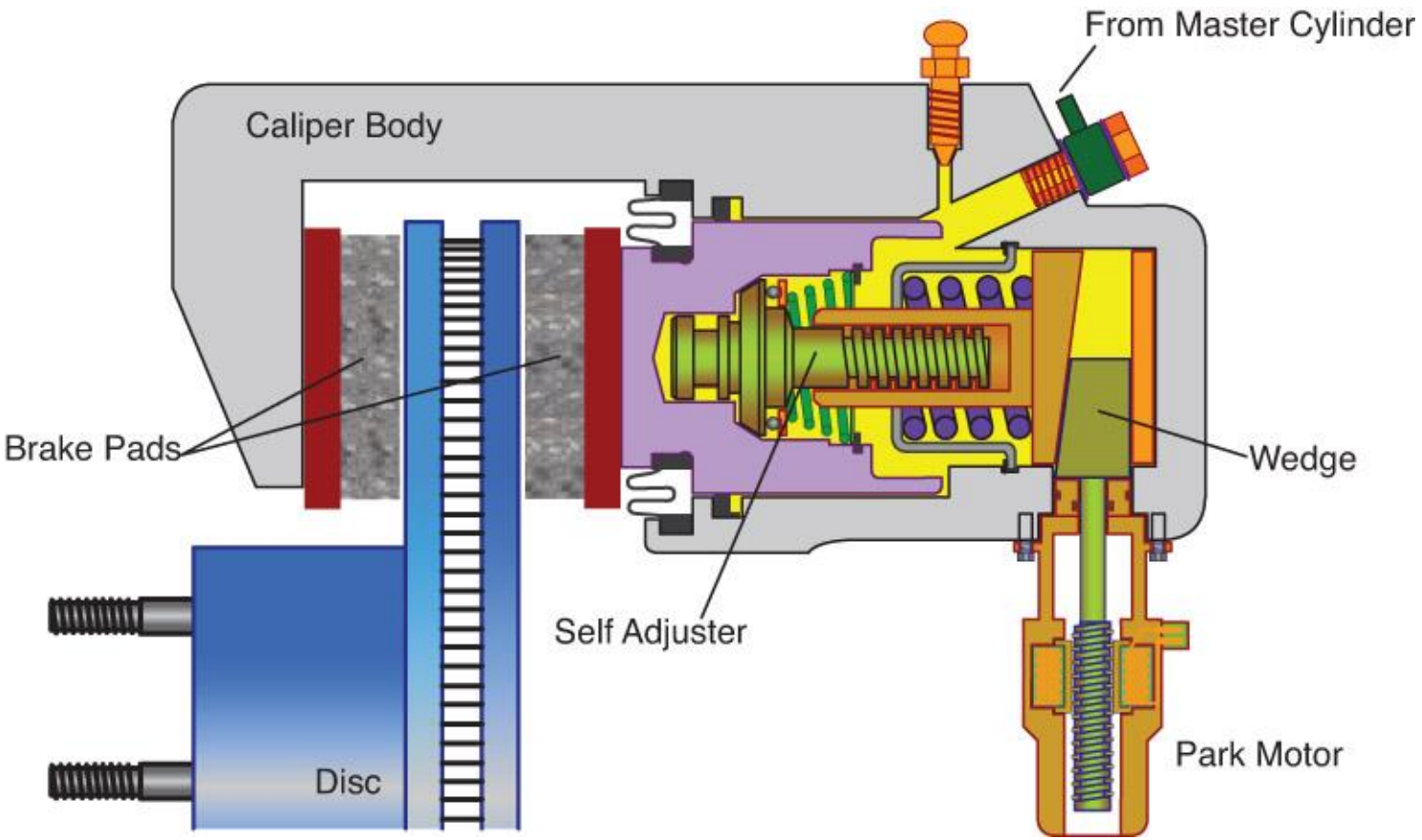
Emergency/Hand Brakes

- Mechanical Hand Brake
  - Primary function: hold vehicle in stationary position when parked.
  - Secondary function: act as emergency stopping brake if primary brake malfunctions.
  - Drive shaft brakes not designed to act as emergency brake.

Emergency/Hand Brakes

- Electrically Activated Hand Brake
  - Found in light-duty commercial vehicles.
  - Cable-pulling type: electric motor pulls emergency brake cable rather than mechanical handle in cabin.
  - More complex unit uses two computer-controlled motors attached to rear brake calipers to activate it.

Emergency/Hand Brakes



Emergency/Hand Brakes

- Spring Brake Park Brake
  - Air-over-hydraulic systems use vehicle's air system to hold brake off when vehicle moving.
  - When actuation valve moved to apply brakes, air pressure is exhausted from spring brake chamber.
  - Power spring in unit mechanically moves brake components to apply brake.

Hydraulic Components of Hydraulic Brake Systems

- Master Cylinder
  - Primary function is that of a pump.
  - When activated by foot brake pedal, it forces hydraulic brake fluid through brake lines under pressure to activate wheel cylinders.
  - Develops pressure necessary to force wheels to expand and apply brakes
  - Maintains equal pressure on brake shoes/ disc pads

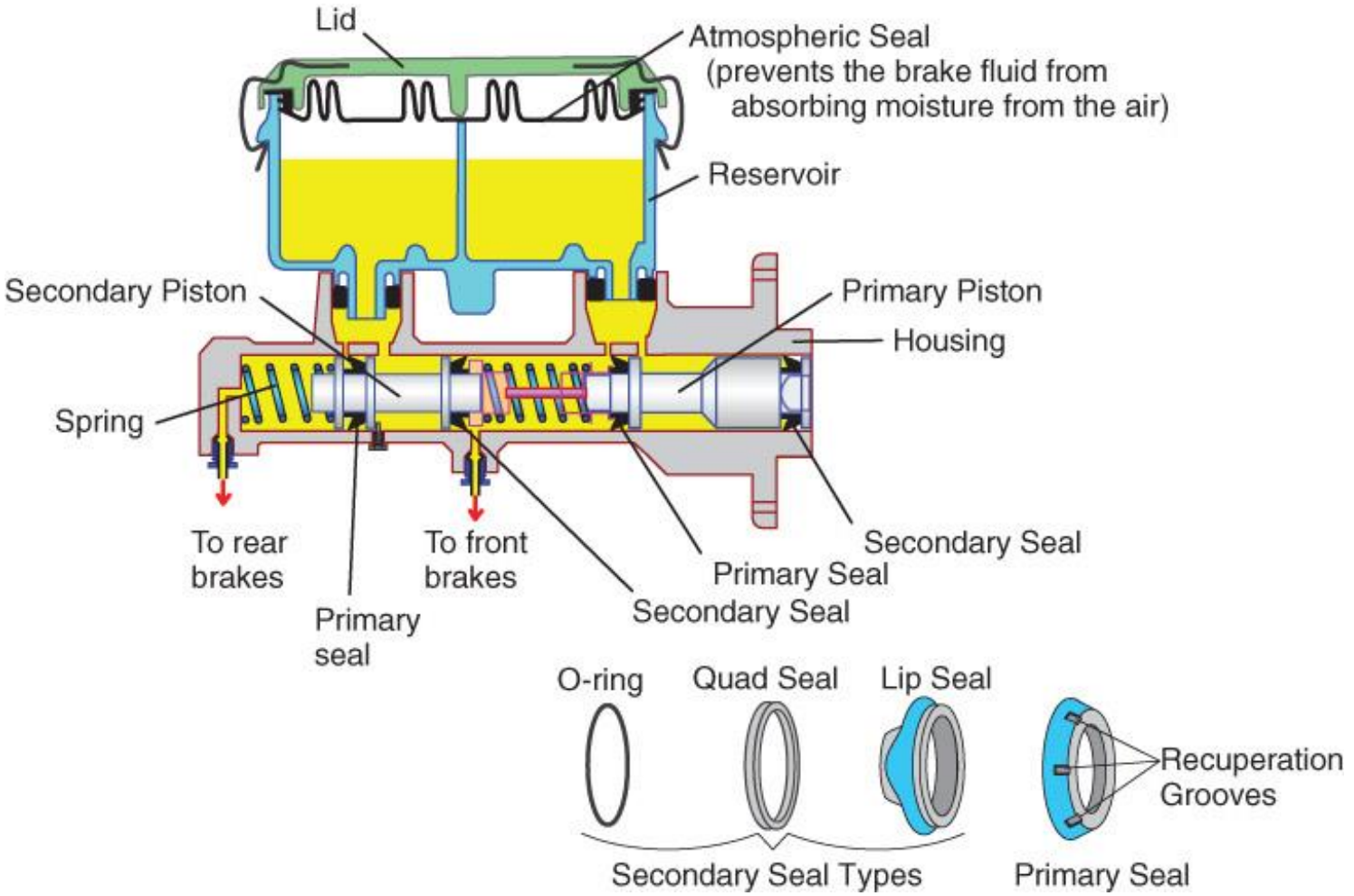
Hydraulic Components of Hydraulic Brake Systems

- Master Cylinder
  - Keeps braking system full of fluid to reduce risk of possible air induction into system as well as keep other contaminants from entering system.
  - Compensates for wear in brake linings/pads as well as maintain a slight residual pressure in braking system
  - Converts non-hydraulic pressure from driver's application of brake pedal into hydraulic pressure.

Hydraulic Components of Hydraulic Brake Systems

- Master Cylinder
  - Primary piston moved directly by pushrod or power booster; generates hydraulic pressure to move secondary piston.
  - Single bore
  - Separated into two chambers by primary and secondary piston.
  - Could contain residual pressure valve for drum-type brakes (not fitted to disc brakes).

Hydraulic Components of Hydraulic Brake Systems



Hydraulic Components of Hydraulic Brake Systems

- Master Cylinder
  - Reservoir above each master cylinder supplies master cylinder with enough brake fluid to avoid air from entering.
  - Medium-duty vehicles with hydraulic brakes will have one master cylinder for the brakes.
  - Actuating rod from brake pedal linked directly to primary piston (pushrod).

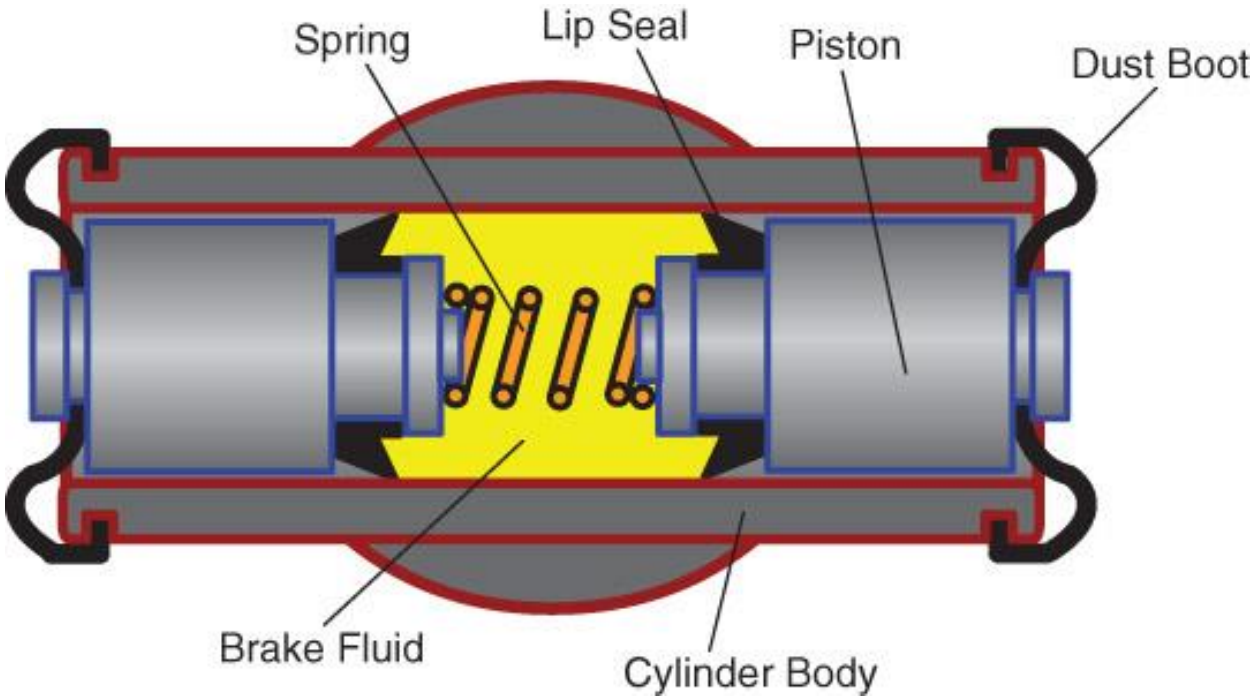
Hydraulic Components of Hydraulic Brake Systems

- Split Braking Systems
  - Divided system safer in event of partial failure.
  - Longitudinal split: brake system has one piston in master cylinder operating front braking circuit and other piston to operate rear braking circuit.
  - Diagonal split: brake system has each master cylinder piston controlling and operating braking system diagonally.

Hydraulic Components of Hydraulic Brake Systems

- Wheel Cylinders
  - Component in drum brake system
  - Located in each wheel at top, above shoes
  - Responsibility: exert force onto shoes so they can contact drum and stop vehicle with friction.
  - Single piston/single action
  - Dual action/double cylinder with piston at each end

Hydraulic Components of Hydraulic Brake Systems

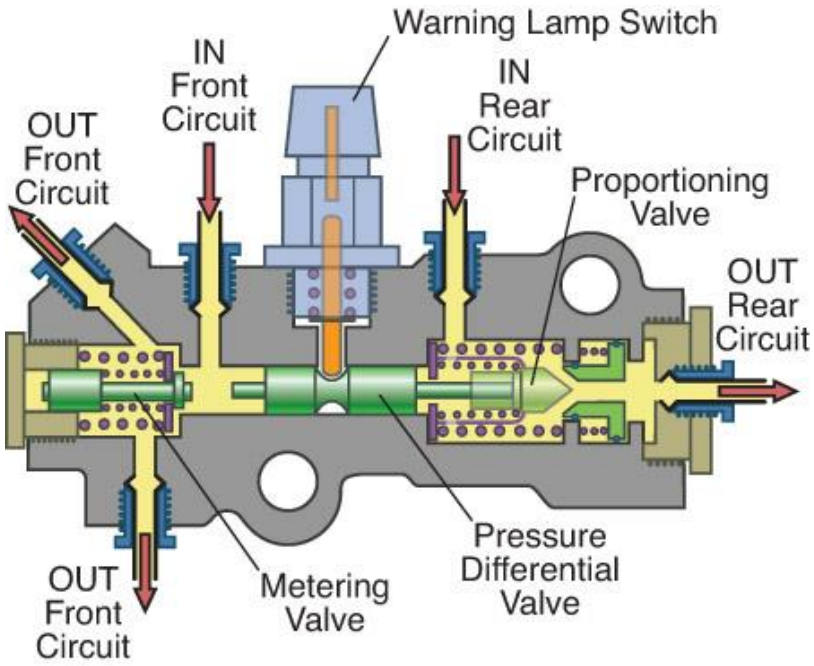


Hydraulic Components of Hydraulic Brake Systems

- Hydraulic Brake Valves
  - Proportioning valves: reduce brake pressure to rear wheels when their load is reduced during moderate to severe braking.
  - Metering valves: hold off application of front brakes on vehicles with disc brakes on front wheels and drum brakes on rear wheels.
  - Pressure differential valve: monitors pressure difference between two separate hydraulic brake circuits.

Hydraulic Components of Hydraulic Brake Systems

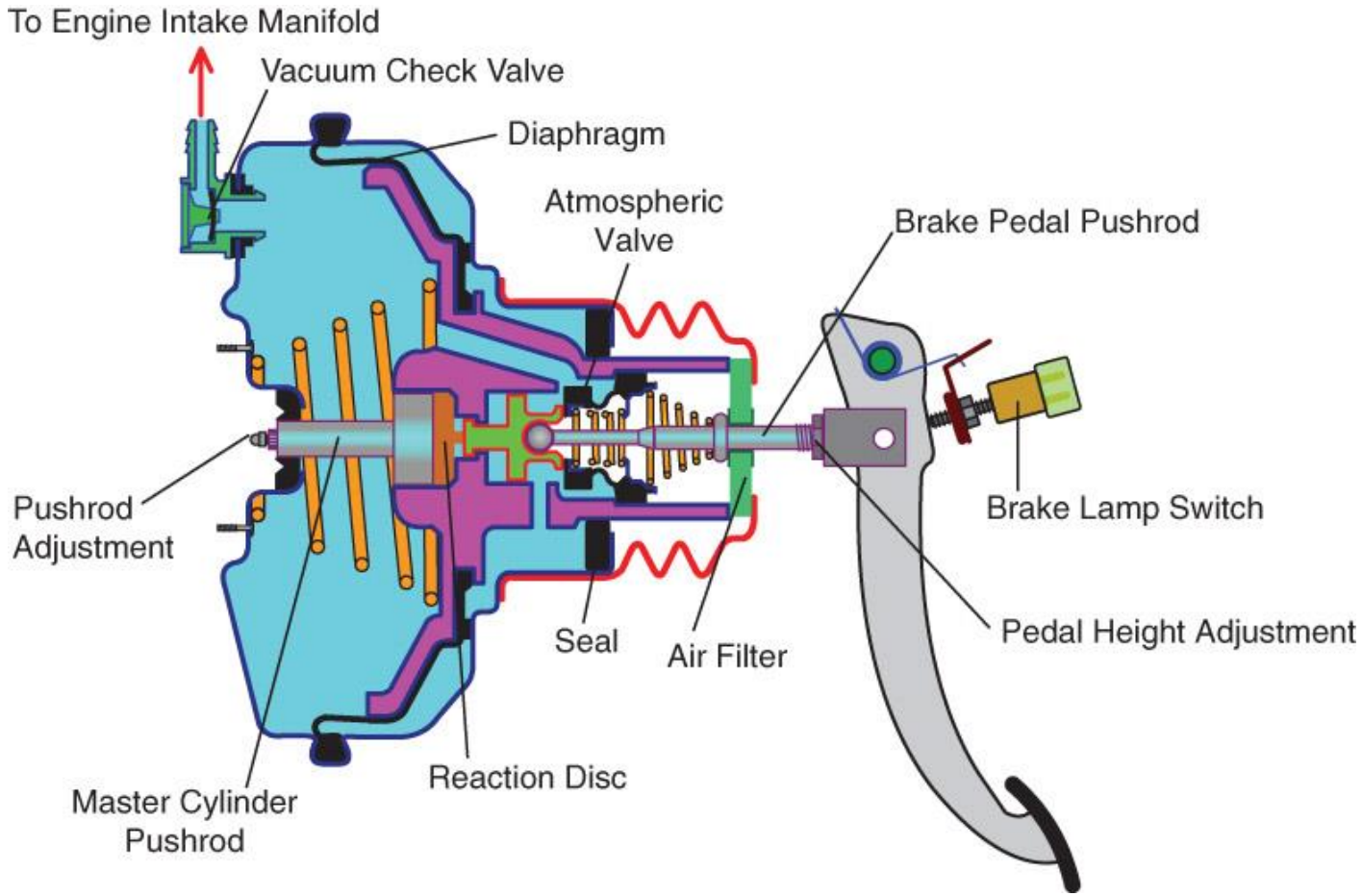
- Hydraulic Brake Valves
  - Combination valve: can combine pressure differential valve, metering valve, and proportioning valve(s) in one unit.
  - Not serviceable; if they become faulty, they must be replaced.



Hydraulic Brake Power-Assist Systems

- Vacuum Brake Booster or Servo
  - Vacuum power-assist system: uses vacuum booster to provide assistance to driver by increasing braking force created by brake pedal effort.
  - Vacuum boosters or servos use differential in pressure principle to increase braking force applied to brake master cylinder.

Hydraulic Brake Power-Assist Systems



Hydraulic Brake Power-Assist Systems

- Vacuum Brake Booster or Servo
  - Booster between brake and master cylinder
  - Stage 1: driver's foot off pedal; vacuum valve open to both sides of diaphragm; equalizes pressure so there is no power assist, and system is released.
  - Stage 2: driver pushes foot on pedal. Atmospheric pressure enters rear side of diaphragm and starts to push towards master cylinder creating power assist.

Hydraulic Brake Power-Assist Systems

- Vacuum Brake Booster or Servo
  - Stage 3: driver holds pedal at a certain point. Allows vacuum valve to move to position that maintains pressure differential between two sides; assist pressure holds at steady level.
  - Boosters designed with reserve capacity to allow two to three full brake applications before entire vacuum is lost.

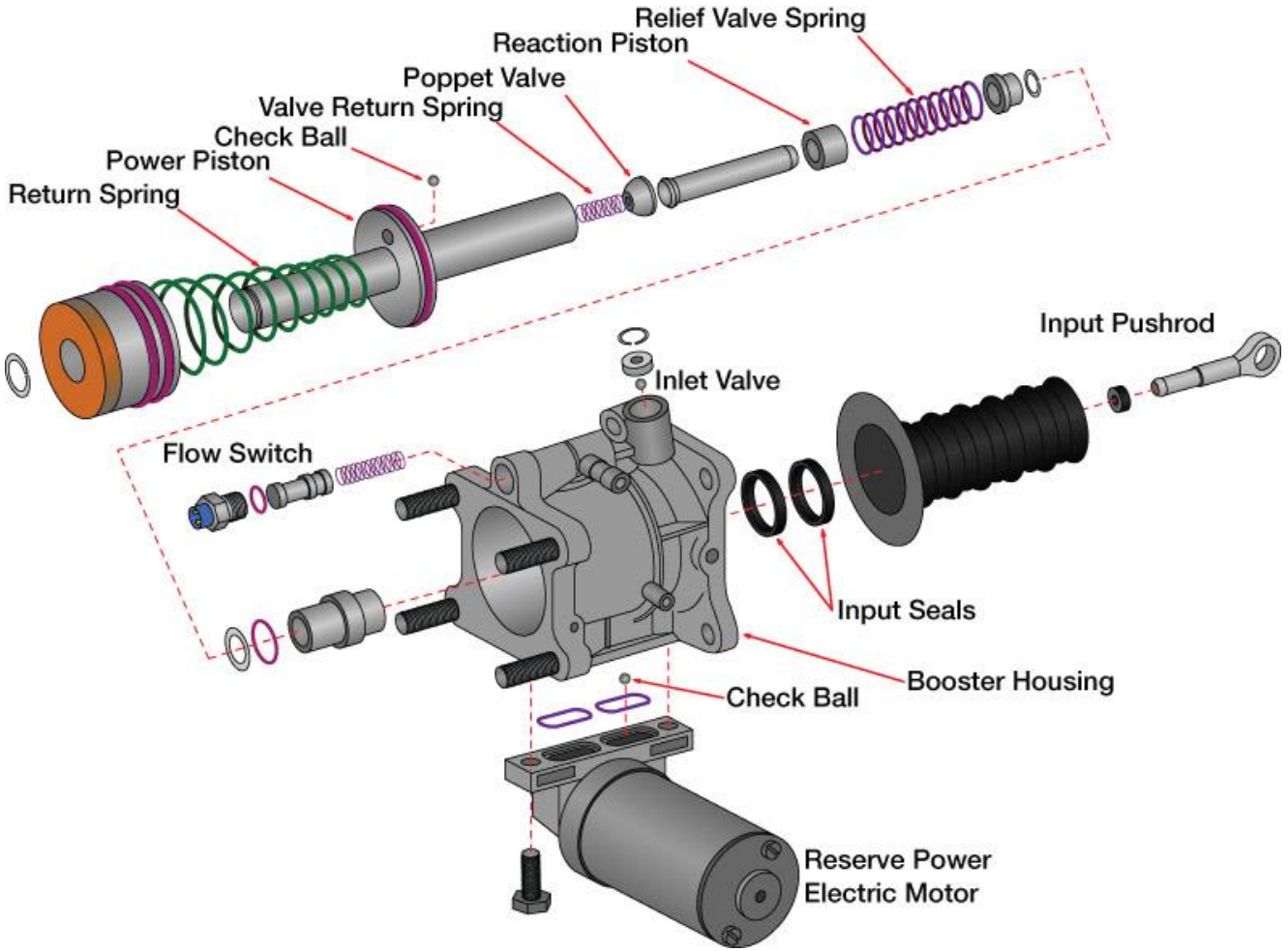
Hydraulic Brake Power-Assist Systems

- Hydroboost Systems
  - Use pressurized hydraulic fluid to provide brake power assist.
  - Booster unit bolted to flywheel; master cylinder bolted to booster.
  - Hydraulic pressure used for power assist supplied by vehicle's power steering pump.
  - Equipped with electrical back-up motor

Hydraulic Brake Power-Assist Systems

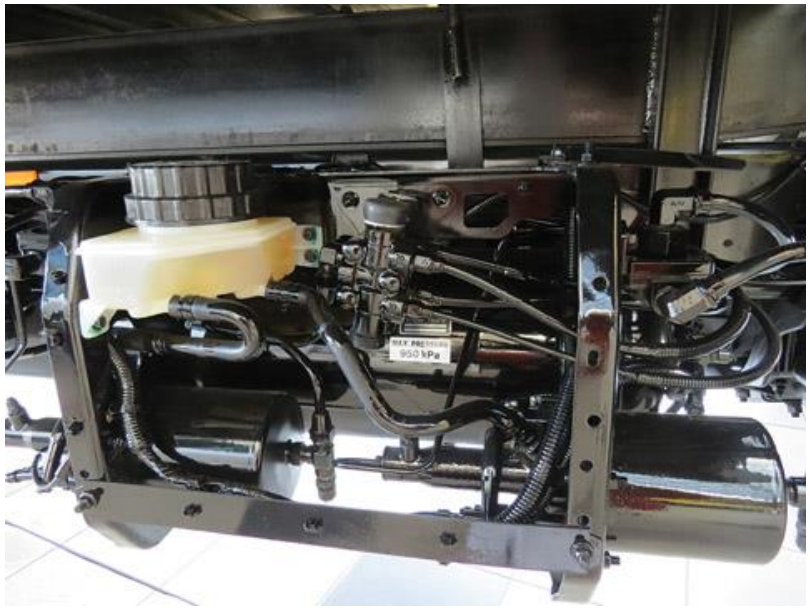
- Hydroboost Systems
  - First mode: engine running and no brake application, hydraulic pressure delivered to inlet of booster and travels through unit unrestricted.
  - Second mode (braking mode): driver pushes brake pedal.
  - Third mode: driver holds brake pedal depressed at any point.
  - Fourth mode: electrical backup motor.

Hydraulic Brake Power-Assist Systems



Air-Over-Hydraulic Braking Systems

- Air Booster Units
  - Convert control line air pressure from foot brake valve into hydraulic pressure to operate wheel cylinders or calipers and apply brakes.
  - Indirect-acting type and direct-acting type.



Air-Over-Hydraulic Braking Systems

- Indirect Air Booster Operation
  - Pneumatic [air] section and hydraulic section [master cylinder] separated by seals.
  - Relay valve part of the assembly.
- Direct Air Booster/Stroke Detector Operation
  - Foot brake valve supplies control line pressure directly to pneumatic piston.
  - Atmospheric pressure on non-pressure side of pneumatic piston exhausts through breathe.

Air-Over-Hydraulic Braking Systems

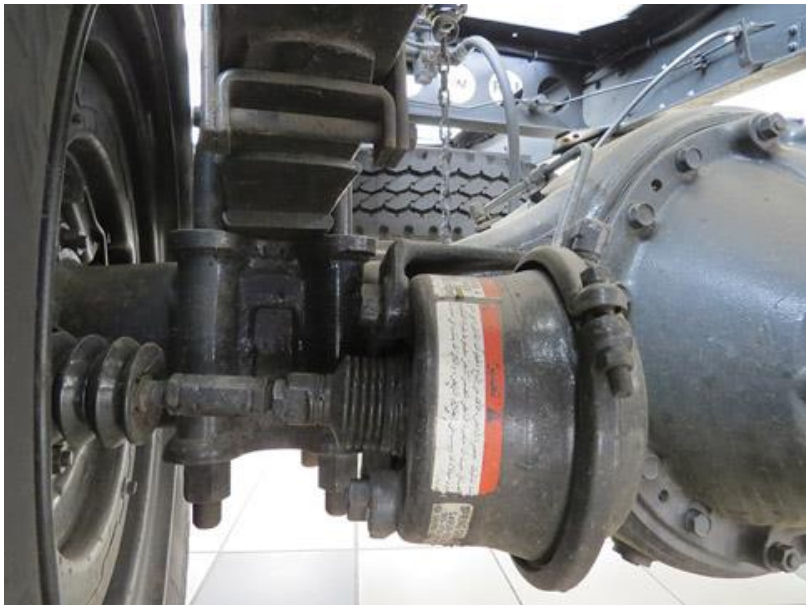
- Piston Stroke Detector
  - If brakes too far out of adjustment or fault occurs in hydraulic circuit, pneumatic piston will have to stroke excessively to operate wheel cylinders.
  - All types of boosters have a piston stroke detector to warn of this condition.

Park Brake and Emergency Circuits

- All vehicles required to have park brake system that can act as emergency brake should there be failure of service brakes.
  - Tandem arrangements: either one or the other part of tandem system designated as emergency brake, depending on which service system fails.
  - Hydraulic braking systems: park or emergency brake mechanically operated hand brake
  - Air-over-hydraulic systems: spring brakes often used as parking brakes.

Park Brake and Emergency Circuits

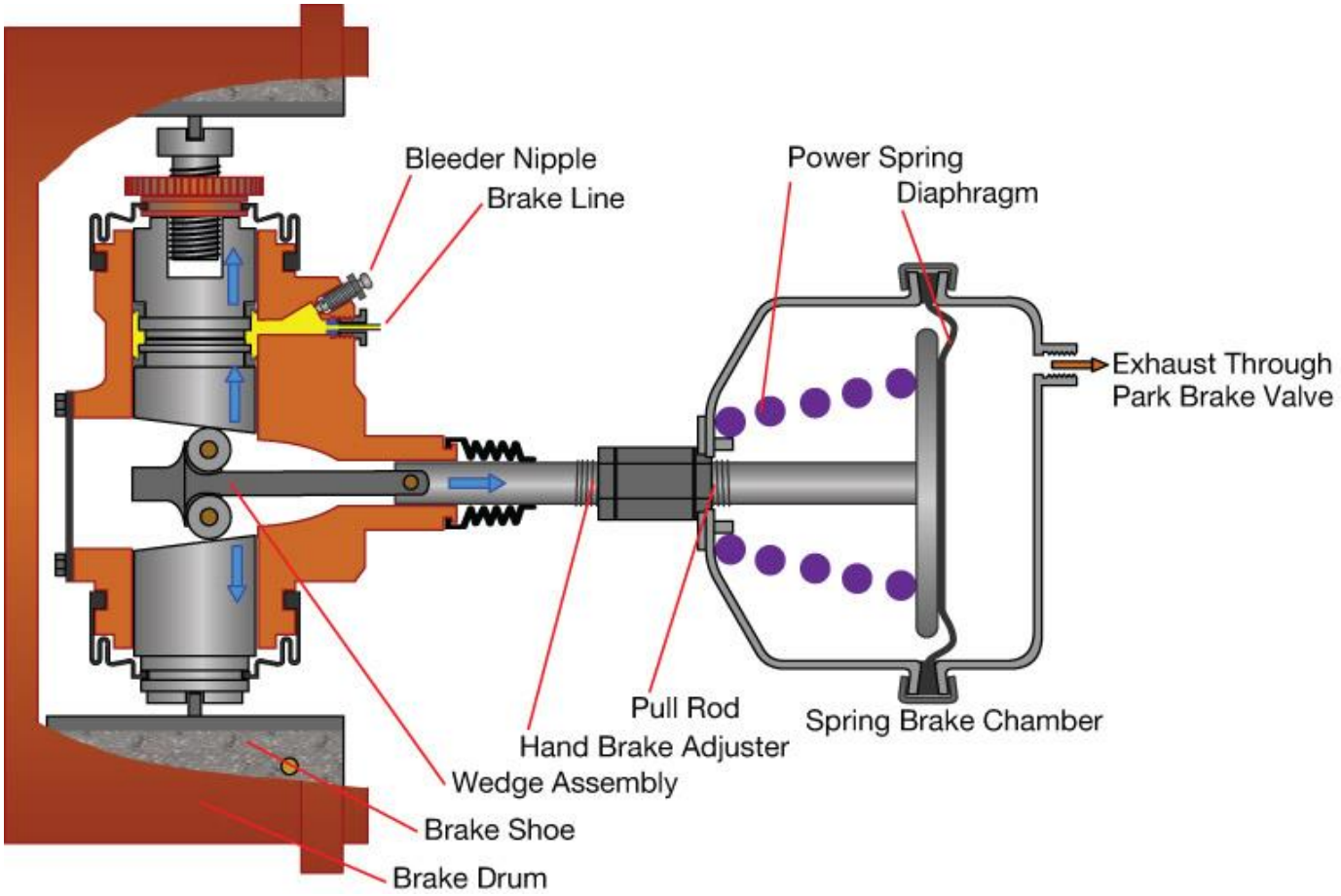
- Spring Brake Chamber/Wheel Cylinder
  - In brake-type wheel cylinder, design enables it to actuate brakes when activated by spring brake chamber providing a parking brake.



Park Brake and Emergency Circuits

- Park Brake Off and Applied
  - When park brake and service brake at rest, spring brake chamber charged with air pressure from hand brake valve.
  - When park brake applied, air pressure exhausted from spring brake chamber.
  - When park brake is released while service brake is applied, air pressure from park brake valve holds park brake off.

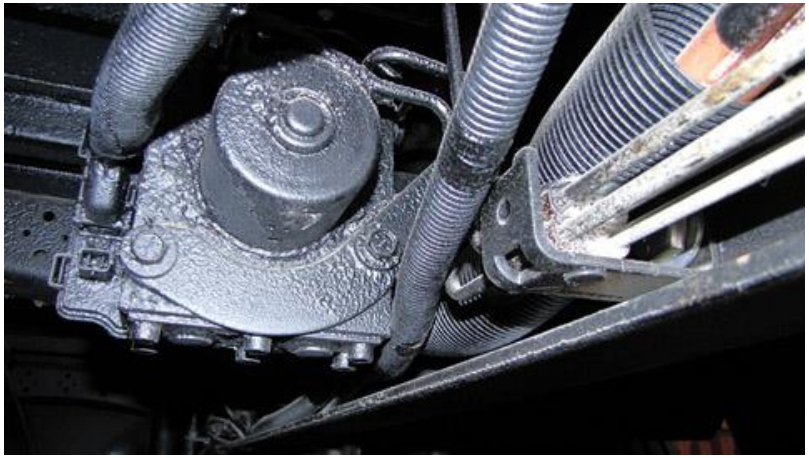
Park Brake and Emergency Circuits



Hydraulic Brake Anti-lock Braking System (ABS)

- Configurations of Hydraulic ABS
  - Single-channel ABS
  - Two-channel ABS
  - Three-channel ABS
  - Four-channel ABS
  - Four-channel ABS most commonly found today.

Hydraulic Brake Anti-lock Braking System (ABS)



- ABS Module
  - ABS electronic control module is brain behind ABS system.
  - Contains powerful computer that controls all functions of ABS system
  - ABS system can be designed to provide stability control for vehicle.

Maintenance of Hydraulic Brake Systems

- Hydraulic brake systems components: brake master cylinder, wheel cylinders, brake shoes, drums/discs.
  - System inspected in two ways: foot-pressure applied and conduct a system test.
  - Whenever hydraulic brake circuits are opened to replace components, air can enter the system.
  - Air must be removed because, unlike hydraulic fluid, air is compressible.
  - If it remains in system, brake operation will be poor or non-existent.

Summary

- Medium- to heavy-duty vehicle hydraulic braking systems need power assist to operate satisfactorily.
- The power assist can be supplied by vacuum, hydraulic pressure, or air pressure.
- Hydraulic braking with vacuum assist typical for lighter-duty vehicles.
- Hydroboost systems and air-over-hydraulic systems used on medium- and heavy-duty vehicles.

Summary

- In all hydraulic braking systems, pushrod exerts force on piston(s) in master cylinder, causing increase in fluid pressure that results in force being applied to brake pads and shoes.
- Vacuum-assisted braking systems use atmospheric pressure to intensify braking effort.
- Hydroboost systems use hydraulic pressure supplied by power steering pump or a dedicated pump to intensify braking effort.

Summary

- Air-over-hydraulic brake systems use conventional hydraulic brake system.
- Drum brakes most common; some vehicles may have disc brakes on the front axle.
- Air-over-hydraulic systems use compressed air to intensify braking effort.
- Braking systems complex; components depend on whether system uses drum or disc brakes.
- Drum brakes use brake shoes in various configurations and adjusters; disc brakes use pads.

Summary

- Today, drum brakes generally found only on vehicle's rear wheels.
- Drum brake has two brake shoes, with a friction material called a lining attached.
- These shoes expand against brake drum's inside surface and slow wheel down.
- Even though drum brakes self-energizing, they commonly overheat and cause brake fade.
- Disc brakes slow rotation of wheels by friction caused by pushing brake pads against a brake disc with a set of calipers.

Summary

- Disc brakes offer better stopping performance than drum brakes and provide much higher braking force per lb (kg) of brake weight.
- Disc brake performance improves as components heat up.
- Drum brake performance deteriorates as components heat up.
- In addition to foot brakes, vehicles use hand brakes mechanical or electrically activated.

Summary

- Common components in hydraulic braking and air-over-hydraulic brake systems: master cylinder, wheel cylinder, and brake booster.
- Hydraulic brake systems use variety of valves to control system operation.
- These include proportioning valves, metering valves, pressure differential valves, and/or combination valves.
- Air-over-hydraulic systems include systems for air supply, foot brake valve, air booster units, and fail safe systems.

Summary

- Air boosters can be indirect or direct.
- Indirect are found on heavier trucks; direct found on lighter trucks.
- Boosters positions: released, applied, balanced
- As a fail safe, air-over-hydraulic braking systems required by regulation to use tandem system design so that one system can compensate if the other fails.
- All vehicles are required to have park brake system that can act as emergency brake should there be a failure of the service brakes.

Summary

- Spring brake actuators critical components of park and service brake operation.
- Most hydraulic brake systems equipped with four-channel ABS; each of four wheel brakes controlled individually.
- Vehicles with ABS system can use ABS system to operate electronic stability system to enhance vehicle safety.
- ABS components can be used to provide traction control on lighter vehicles.