JONES & BARTLETT LEARNING
CDX Automotive

Fundamentals of

Medium/Heavy Duty Commercial Vehicle Systems

Chapter 29
Braking Fundamentals

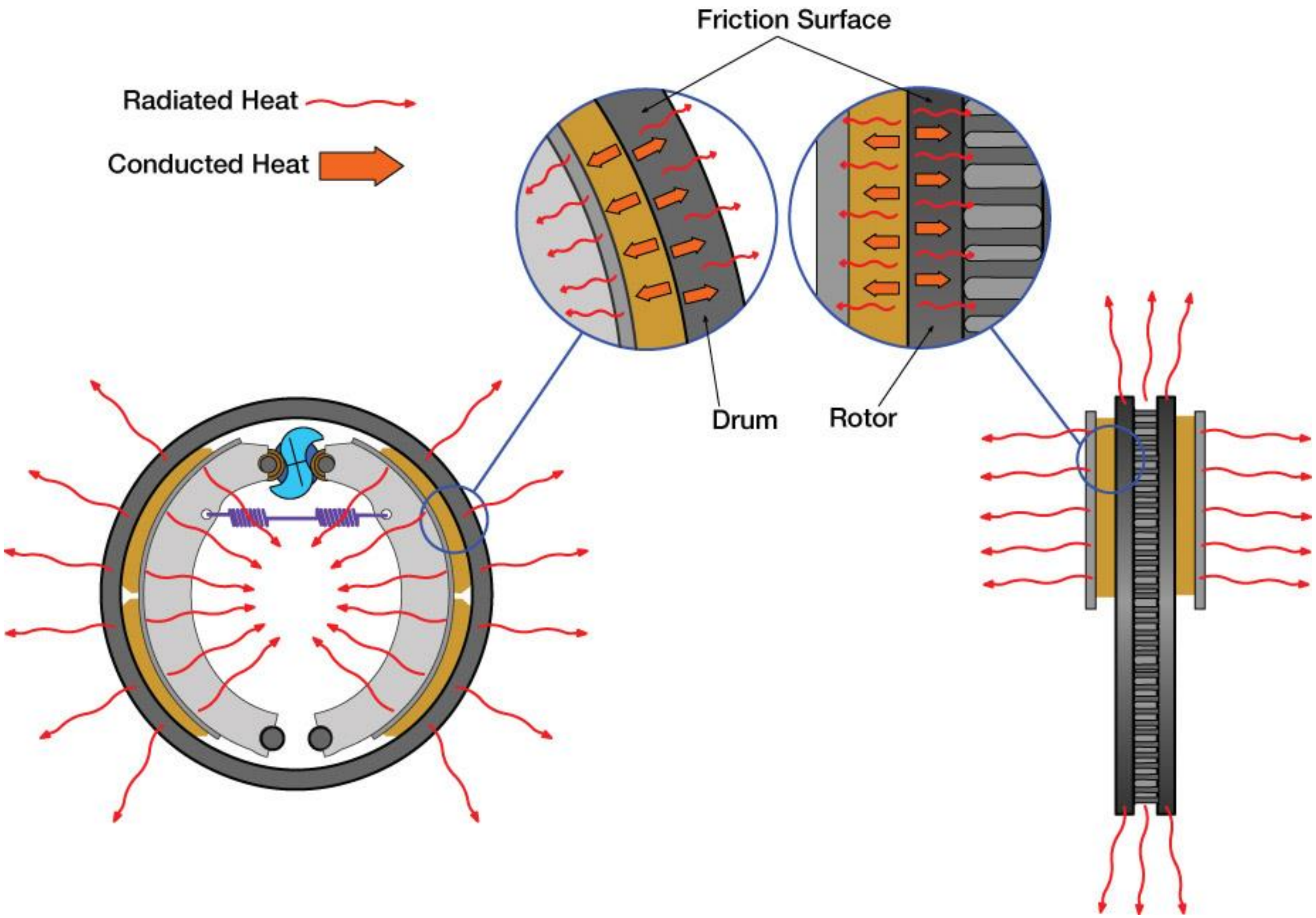
Introduction

- After vehicle has stopped, braking system of heavy trucks— not drive train—is used to keep vehicle parked.
- Braking systems integral to stability control, collision avoidance, rollover protection, traction control systems.
- Braking system has large element of electronic control operating braking system with virtually no driver input.

Introduction

- Brakes convert vehicle’s kinetic energy into heat energy using friction.
- Heat in brake components dissipated to atmosphere through brake design factors.
- Unless build-up of heat in brake parts is minimized, heat accumulations will lead to loss of braking efficiency and damage to brake components.

Introduction



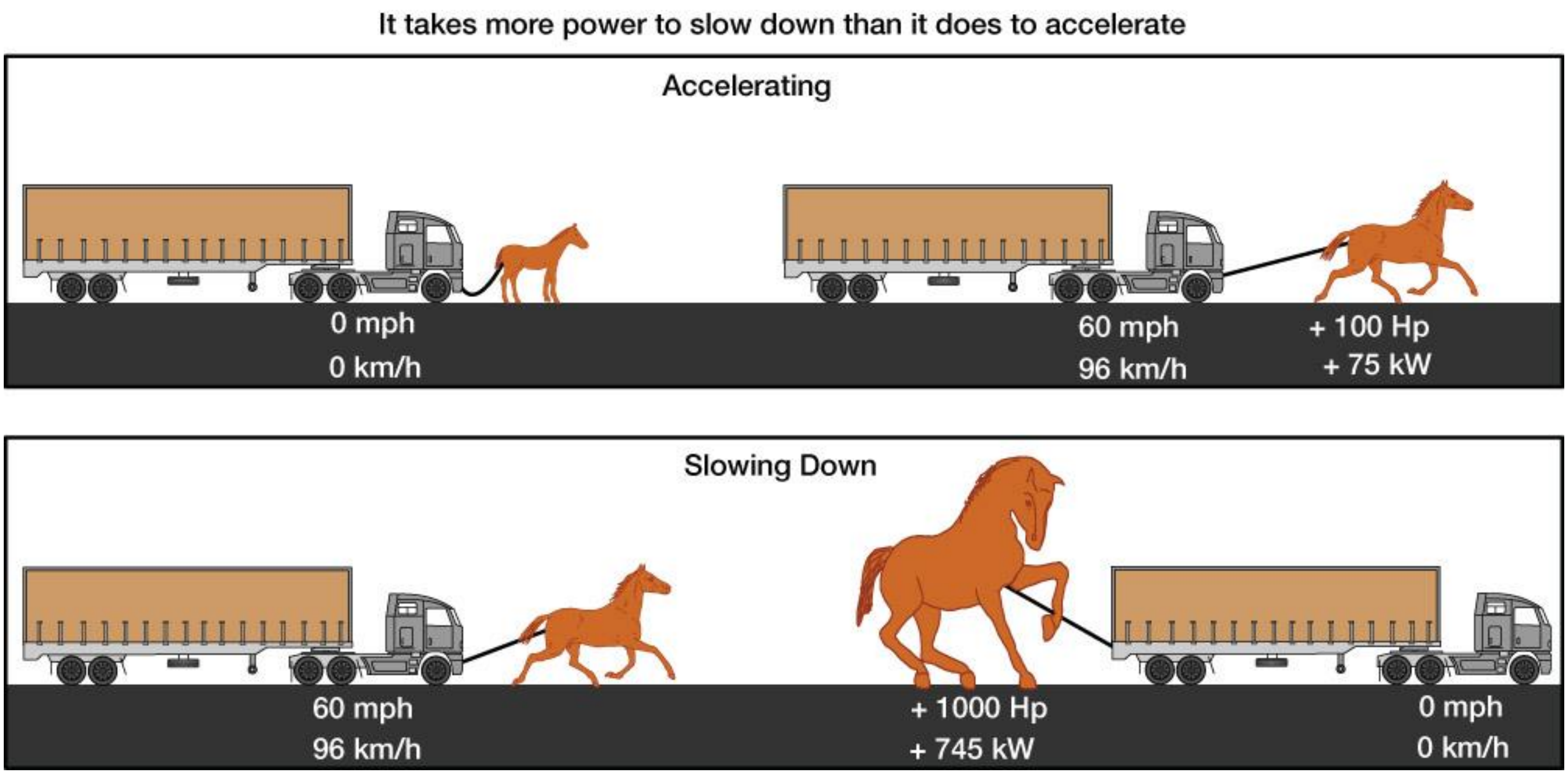
How Brakes Work

- Braking system takes vehicle power stored as kinetic energy (energy of body in motion) and converts it back into heat through friction.
- Using brake drums or discs attached to wheels, friction is produced by forcefully applying heat-resistant braking material against these rotating components.
- Friction's by-product—heat—is dissipated into the air.

How Brakes Work

- With the heavier weight and the speed commercial vehicles travel, power generated by brakes must be several times that of the engine.
- Many times more power is required to slow and stop a vehicle than required to accelerate a vehicle.

How Brakes Work



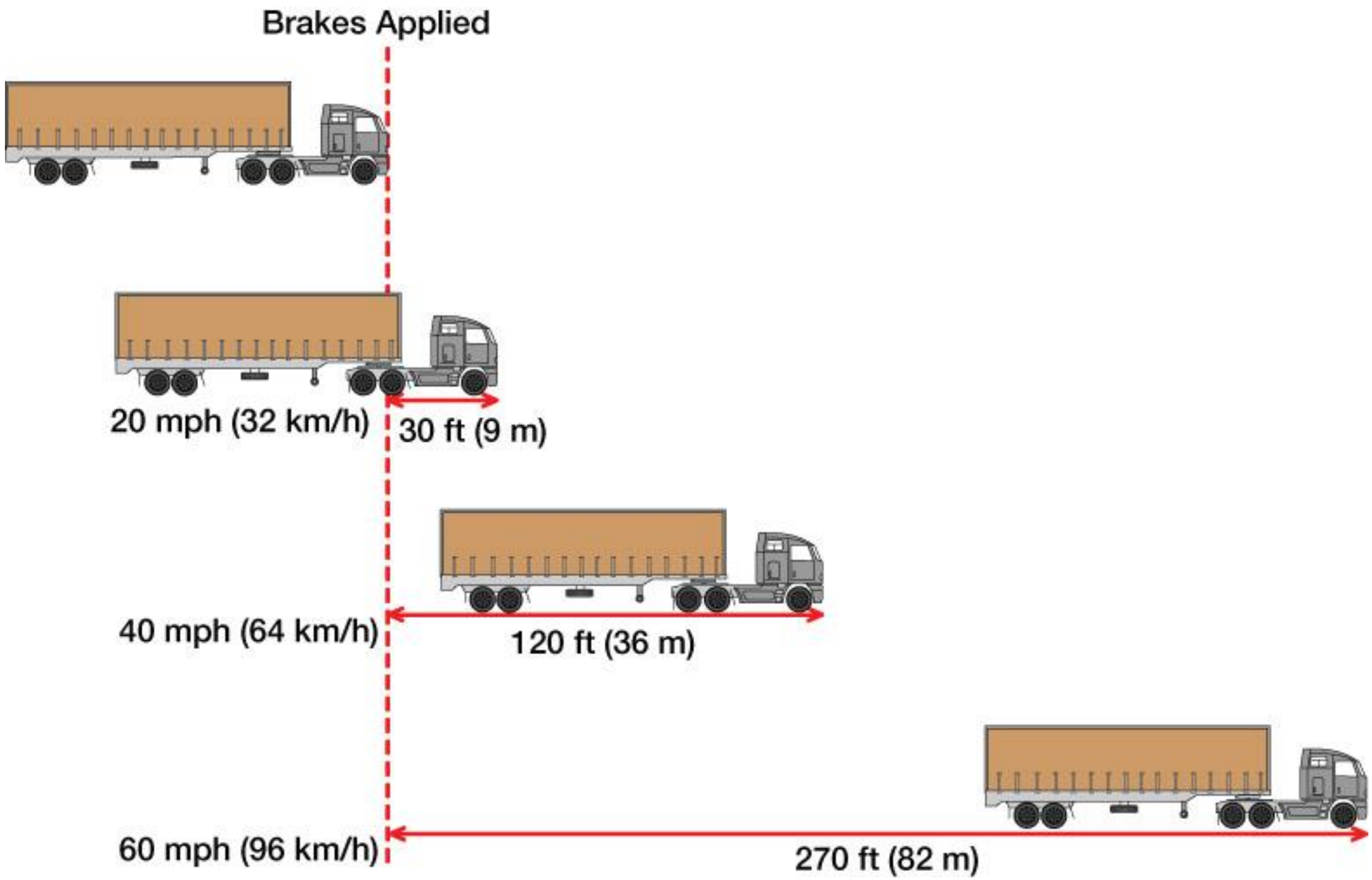
How Brakes Work

- Influence of Vehicle Weight and Speed
  - As the weight of vehicle is doubled, kinetic energy converted into heat energy is doubled.
  - Doubling vehicle weight or speed needs twice the braking power for same deceleration rate.
  - When weight and speed both doubled, braking force must increase by factor of eight.
  - Heavy-duty brakes specified not by type of vehicle but by weight carried by an axle and its location on the vehicle.

How Brakes Work

- Influence of Vehicle Weight and Speed
  - Increasing vehicle speed has greater effect than vehicle weight on braking system power.
  - Increased vehicle weight and speed need greater braking system pressure, larger friction surfaces, and greater capacity to absorb as well as dissipate heat.

How Brakes Work

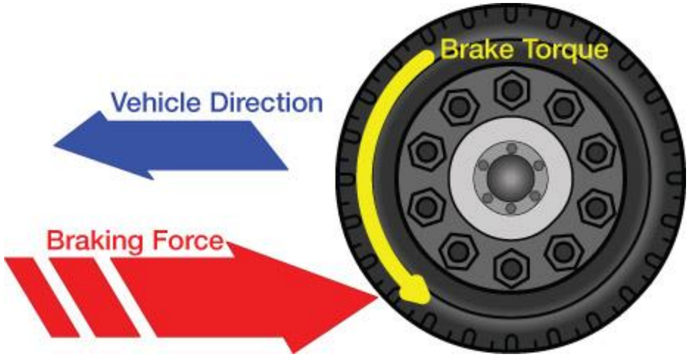


How Brakes Work

- Brake Torque and Inertia Shift
  - Components used to attach brake mechanism capable of repeated torque transfer from brake to axle.
  - Deceleration during braking produces shift in vehicle weight from rear to front of vehicle.
  - The effect (inertia shift) moves weight from rear axles and transfers it forward.

How Brakes Work

- Brake Torque and Inertia Shift
  - Wheel lock-up: tires skid; driver loses ability to steer vehicle
  - Too much braking by front axle can cause jackknifing.
  - Too much braking by rear axles can cause trailer or rear axles to swing out.



Types of Braking Systems

- Another term for brake application force is actuation pressure.
  - Force multiplication needed by braking system: multiply brake pedal input force enough to effectively apply brakes.
  - Hydraulic multiplication of driver input force: multiply brake pedal force and supply pressure to multiple wheel cylinders or brake caliper pistons.

Types of Braking Systems

- Air Systems
  - Best choice; large amount of air instead of liquid needed to actuate all brake chambers at each axle end.
  - Supply of air limitless; allows for minor leaks without loss of braking.
  - Connecting tractor and trailer braking systems easier using air lines than hydraulic hoses.
  - Not sensitive to altitude changes.

Types of Braking Systems

- Air Systems
  - Simpler foundation brakes (shoes, drums, components at wheel ends) simpler and fewer
  - Air can be compressed and store energy like coil.
  - Air must be pressurized, filtered, and stored in large, multiple reservoirs.
  - Speed of air pressure transmission much slower than hydraulic system.
  - Control of air pressure through brake circuits requires more valves and components.

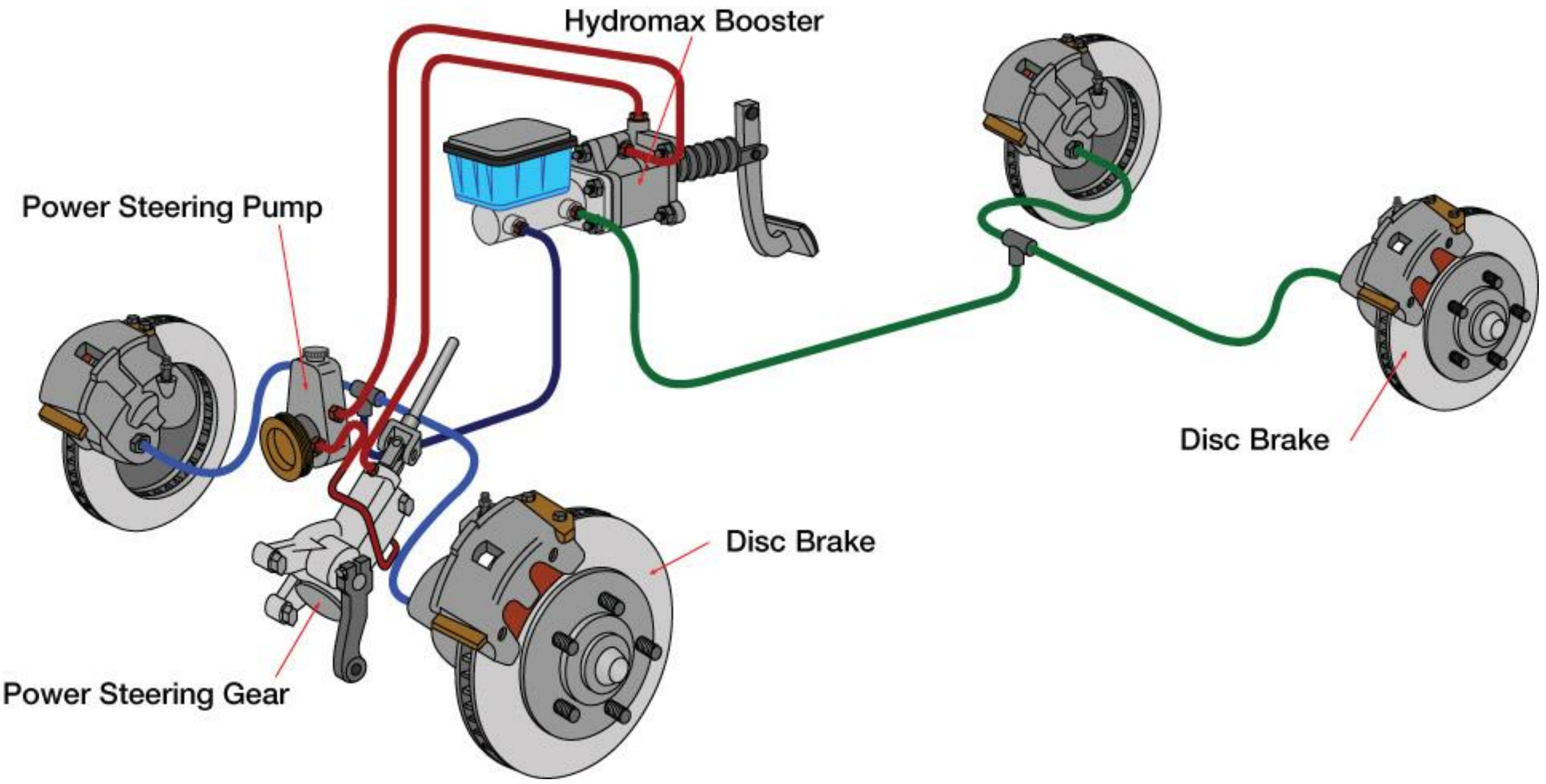
Types of Braking Systems

- Air Systems Disadvantages
  - Driver dissatisfaction with delay: air system empty and needs to build up pressure after engine started.
  - Little to no feedback from brake pedal about braking effort.
  - Larger brake system components and diameter lines required.
  - Air brake system complexity requires technicians have more knowledge and skill when servicing.

Types of Braking Systems

- Hydraulic Systems
  - Higher line pressures; use of smaller components
  - Faster force transmission through smaller lines
  - Improved feedback during braking application
  - Lower initial cost due to fewer and smaller components

Types of Braking Systems



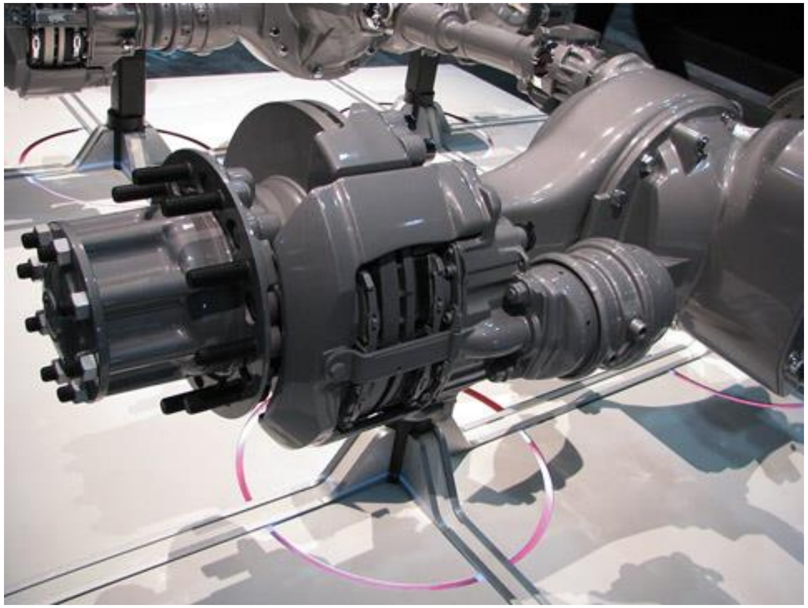
Types of Braking Systems

- Brake System Components
  - Brake foundations: braking components found at wheel ends.
  - Dual brake circuits: two separate brake circuits control front and rear axle braking systems.
  - Parking brakes: with exception of trucks using drive line park brake, all vehicles use foundation brakes for keeping vehicle stationary when parked.

Air Brake Foundation Systems

- Types of Brake Foundation Configurations
  - Cam brakes: most common foundation brake found on heavy trucks today.
  - Air disc systems squeeze brake pads against rotor attached to wheel to produce braking action.
  - Wedge brakes use leverage to multiply braking force.
  - Air pressure proportional to brake pedal travel supplied primary and secondary air systems.

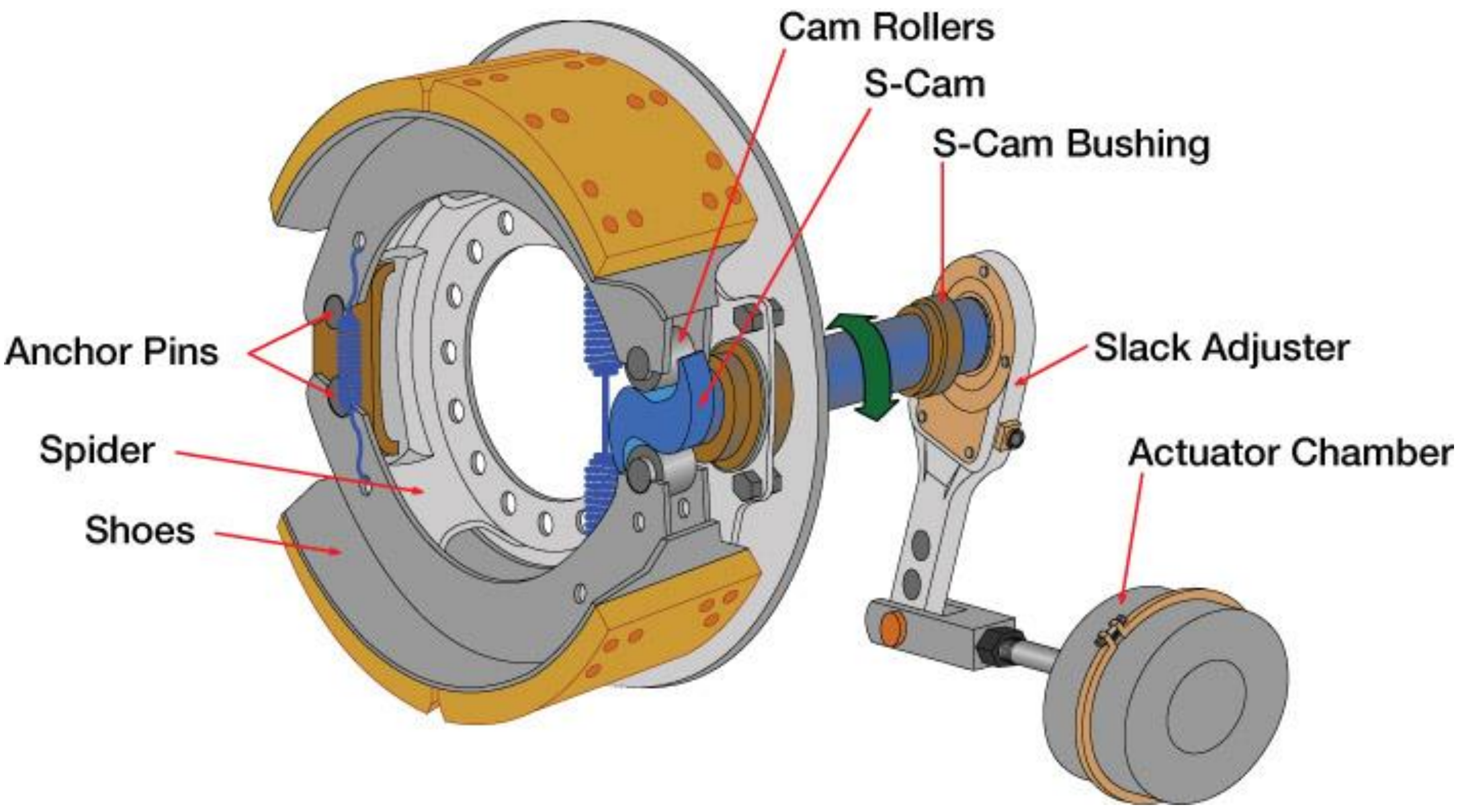
Air Brake Foundation Systems



Air Brake Foundation Systems

- Cam Brake System
  - Air brake chamber, automatic slack adjuster, S-camshaft, brake hardware, shoes and linings, spider, brake drum
  - Cam brake: “S”-shaped camshaft, or S-cam, used to force brake shoes onto brake drum.
  - When torque applied to camshaft through S-shaped cam ramps, rollers on brake shoes ride up cam, causing shoes to contact brake drum.
  - Shoe-to-drum friction slows and stops vehicle.

Air Brake Foundation Systems



Air Brake Foundation Systems

- Cam Brake System
  - Primary-secondary shoe design with fixed anchor points for each shoe opposite camshaft end of shoe.
  - Self-energizing causes shoe-drum friction to rotate brake shoe into drum with more force.
  - Effect is brake will apply “harder” or “bite” into drum with greater force increasing friction.
  - Self-energization can cause uneven brake shoe wear.

Air Brake Foundation Systems

- Cam Brake System
  - Depending on direction camshaft rotates to force primary shoe against drum, cam referred to as left- or right-hand camshaft.
  - Left-hand cams rotate counterclockwise; right-hand cams turn clockwise.
  - Cam-same camshaft rotates in same direction as drum to energize brakes.
  - Cam-opposite camshaft rotates opposite drum’s rotation to energize brakes.

Air Brake Foundation Systems

- Cam Brake System
  - To support camshaft between brake chamber and brake spider at wheel end, a support bracket is used to enclose camshaft.
  - S-cams shimmed with washers to prevent any excessive end play in cam bracket.

Air Brake Foundation Systems

- Cam Brake System
  - Cam brakes use brake shoes made in different sizes to match an axle weight rating.
  - One or two pieces of friction material attached to brake shoe table (brake block/brake lining)
  - Coefficient of friction (CoF): amount of force required to move an object while in contact with another.
  - Two categories for friction material: non-asbestos organic (NAO) lining and semi-metallic linings

Air Brake Foundation Systems

- Cam Brake System
  - Selection of brake block material: taking in axle weight, service condition—severe, heavy, and moderate
  - AL factor: size or surface area of brake chamber multiplied by length of slack adjuster in inches.
  - All brake block friction material identified by a stencil on its edge called an edge code.

Air Brake Foundation Systems

- Cam Brake System
  - Brake fade: inability of brakes to maintain their effectiveness
  - Types of brake fade: heat, water, mechanical, and chemical fade; glazing of lining
  - Heat fade: loss or reduction in coefficient of friction as brake temperature increases
  - Anti-fade: opposite condition of heat fade, where coefficient of friction increases as brakes get hotter

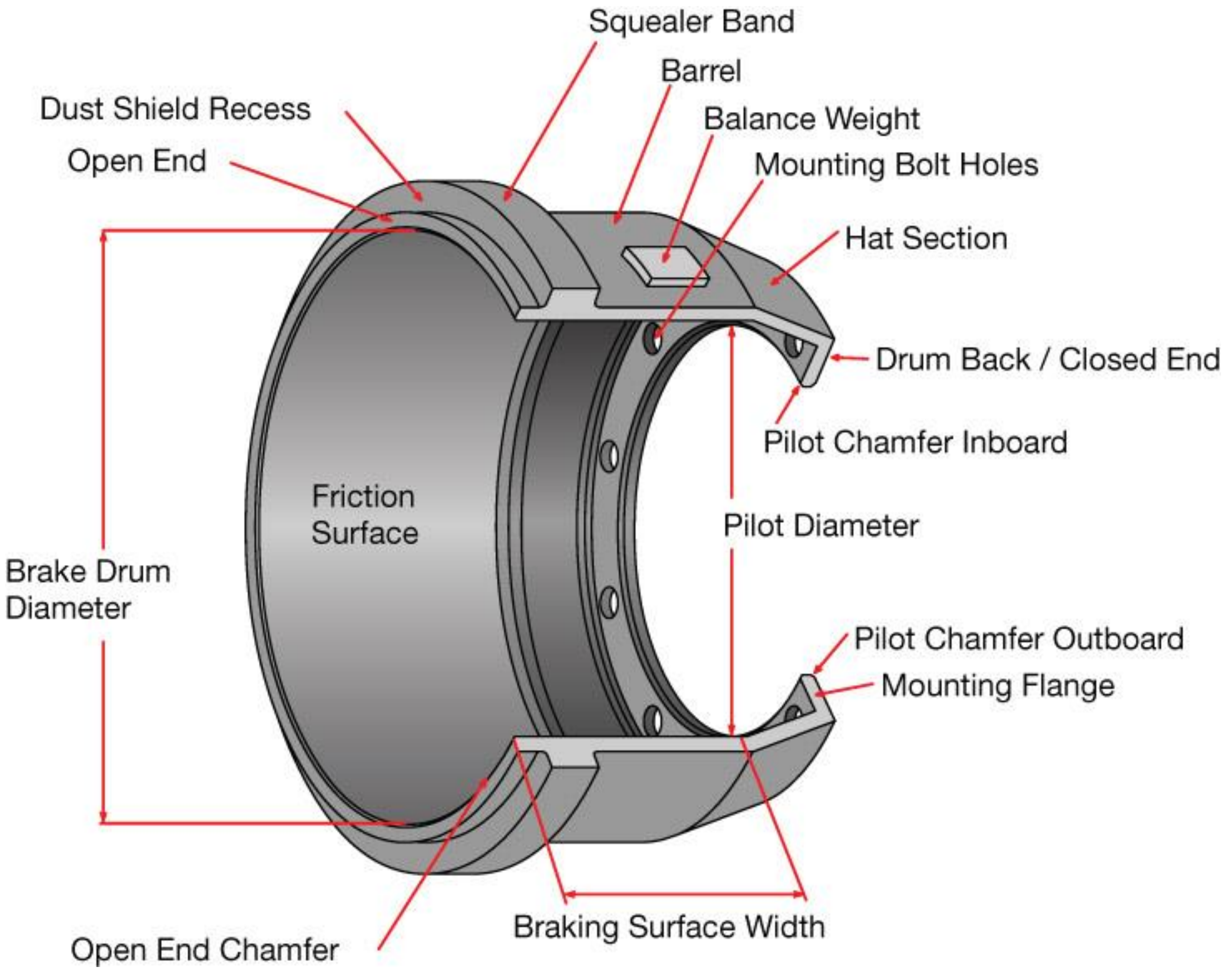
Air Brake Foundation Systems

- Cam Brake System
  - Water fade: water gets between friction surfaces and drum and acts act as lubricant, reducing braking efficiency.
  - Mechanical fade: drums expand due to heat.
  - Chemical fade: steam or gases from vaporized lining materials form between hot lining and drum, reducing coefficient of friction.
  - Glazing: characterized by hard, glassy burnt appearance to lining surface.

Air Brake Foundation Systems

- Cam Brake System
  - Brake torque: force applied to foundation brakes during braking
  - Brake drums must:
    - Resist distortion and brake fade
    - Resist wear, scoring, and heat damage
    - Absorb heat and transfer it to outer surface
  - Two types of brake drums:
    - Cast drums made from cast iron
    - Centrifuge drums made with cast iron core surrounded by steel band

Air Brake Foundation Systems



Air Brake Foundation Systems

- Cam Brake System
  - Two types of brake drums: inboard or outboard—mounted on disc type wheels.
  - Type of wheel end a drum is mounted to will change the features of a drum.

Air Brake Foundation Systems

- Cam Brake System
  - Applying the brakes supplies air pressure to actuator chambers proportional to brake pedal travel.
  - Brake chambers then take air pressure and convert it to mechanical force to apply brakes.
  - Actuators are like brake chambers except they have additional components such as power springs used to apply park brakes or internal pushrod lock mechanisms.

Air Brake Foundation Systems

- Cam Brake System
  - Standard brake chamber: 2.5" stroke travel
  - Some 3" stroke chambers called long stroke chambers.
  - Service chamber: when brake chamber uses only a single chamber.
  - Dual brake chambers contain spring brake actuator and two separate air and mechanical actuators in a single housing.

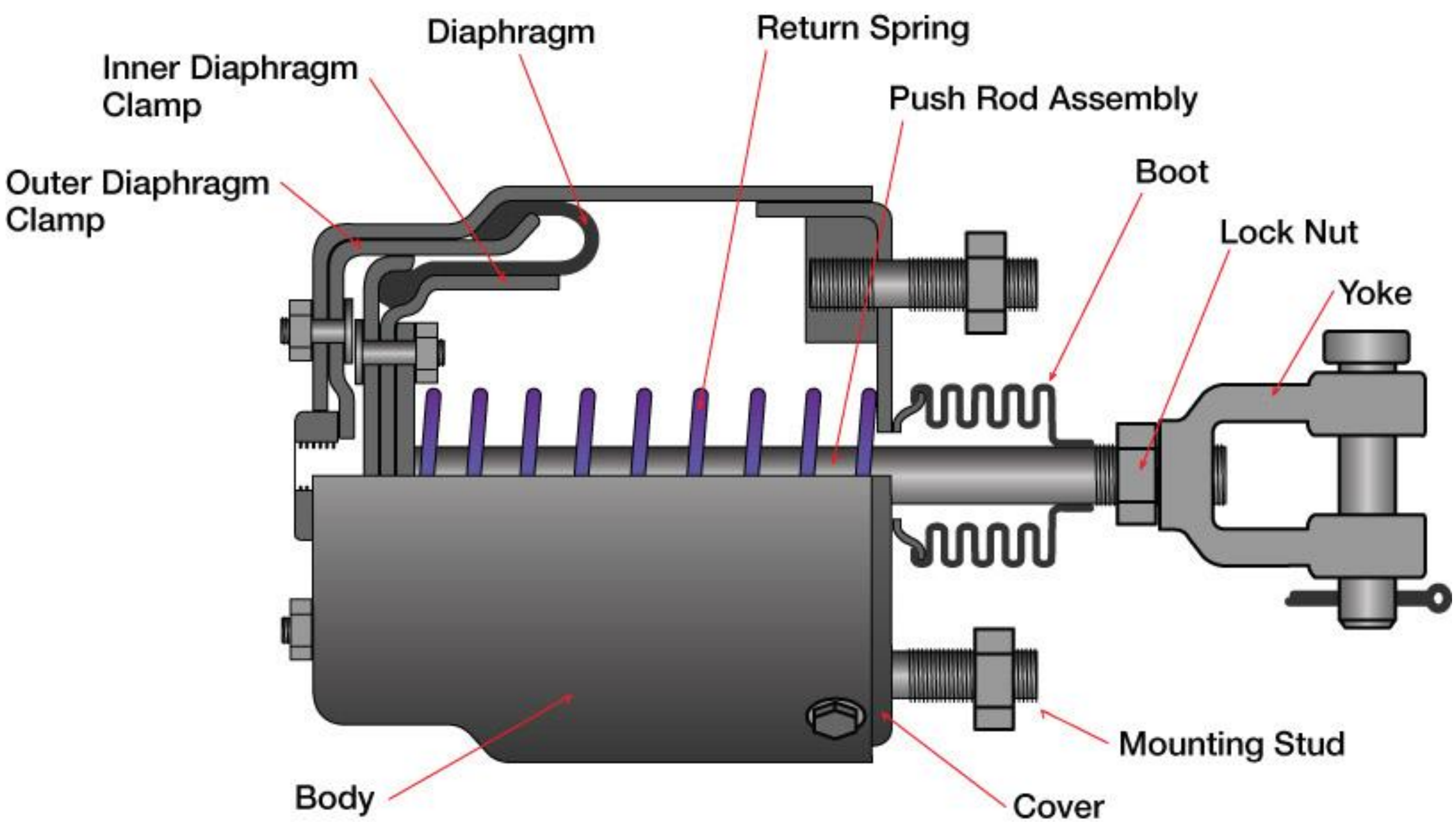
Air Brake Foundation Systems

- Cam Brake System
  - Service chamber requires air pressure to apply brakes.
  - Park/emergency spring brake needs air pressure to release brakes.
  - In event of a loss of vehicle air pressure and ability of air system to build pressure, power spring will apply brakes.

Air Brake Foundation Systems

- Cam Brake System
  - Power spring can be released by inserting a release bolt into spring and tightening the bolt.
  - Release or caging bolt attached to every dual chamber brake actuator.
  - Roto-chambers: actuators with unique diaphragm construction; delivers consistent output force regardless of pushrod position.

Air Brake Foundation Systems



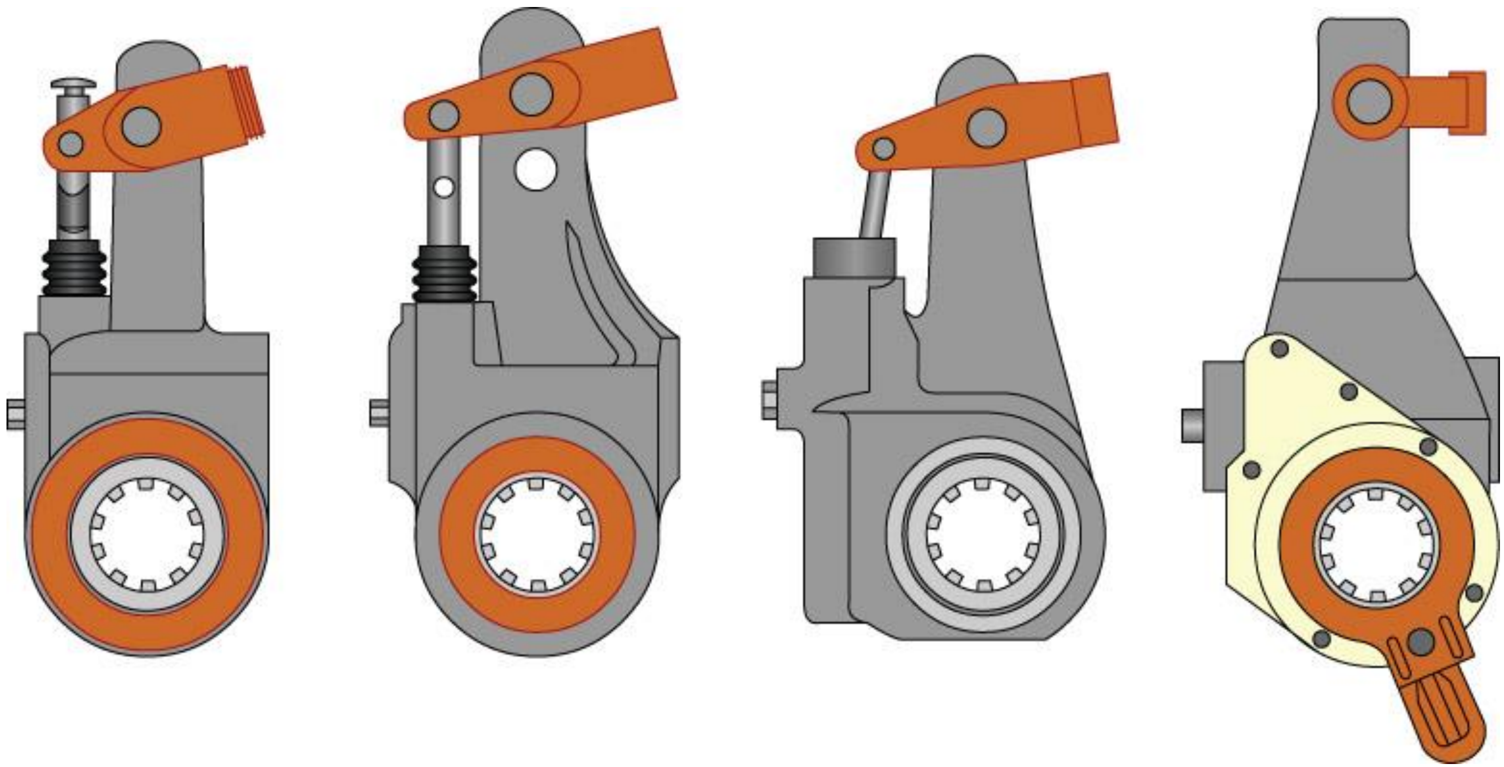
Air Brake Foundation Systems

- Cam Brake System
  - Slack Adjuster
    - Mechanical lever between brake chamber and foundation brake assembly
    - Multiply force from brake chamber to camshaft of foundation brakes.
    - Remove excessive chamber pushrod travel to maintain minimal clearance between brake shoe and drum on a cam brake system.
    - Two types: manual and automatic.

Air Brake Foundation Systems

- Cam Brake System
  - Automatic Slack Adjusters (ASA)
    - Stroke sensing ASAs: makes adjustments to slack based on measured rotation between a brake application and release.
    - Clearance sensing ASAs: reduce pushrod travel based on torque input to ASA.

Air Brake Foundation Systems



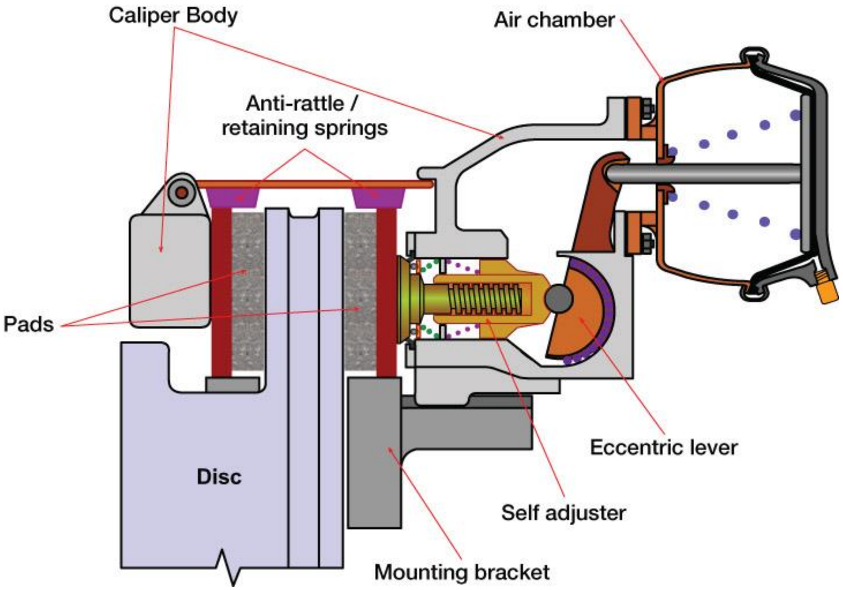
Air Brake Foundation Systems

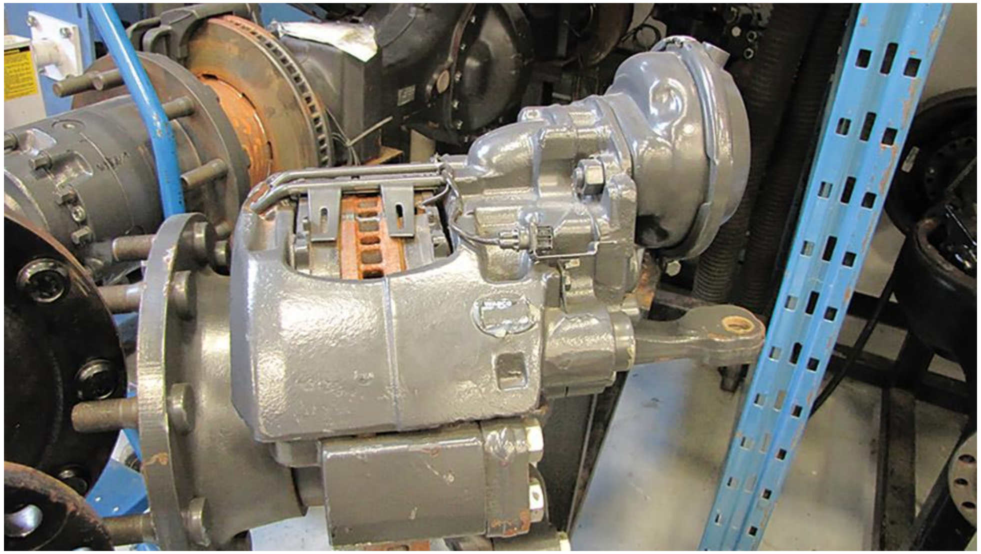
- Air Disc Brakes (ADB) Advantages
  - Lower side-to-side consistency in braking torque
  - Lower potential for heat- and mechanical-related brake fade
  - Better cooling with air disc brakes
  - Consistent actuation force
  - Shorter service time

Air Brake Foundation Systems

- Air Disc Brakes (ADB)
  - Disc brakes use rotors instead of drums.
  - Floating caliper design (caliper floats on two pins); two major parts: caliper and carrier
  - Bendix ADB system: air chamber as actuator
  - When brake actuation has finished, brake caliper will return to its initial position.
  - Internal automatic clearance sensing adjusting mechanism is used.

Air Brake Foundation Systems

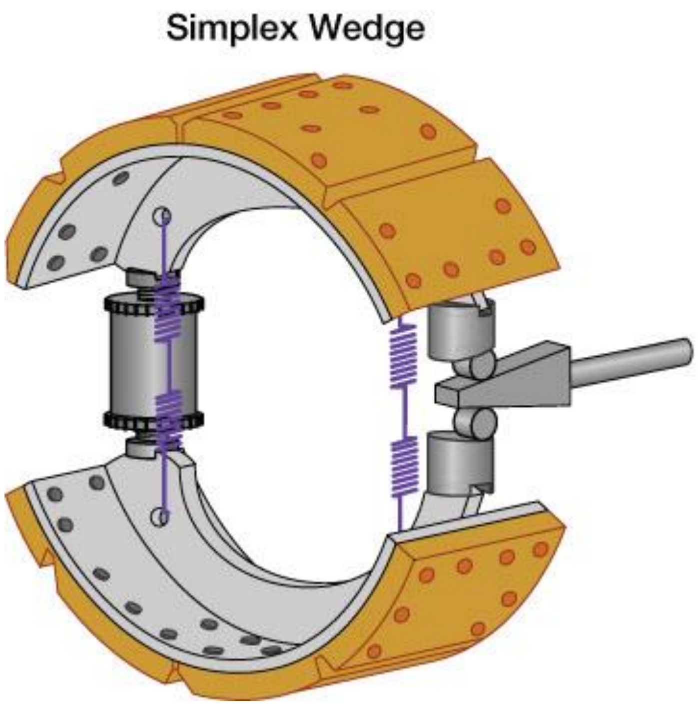


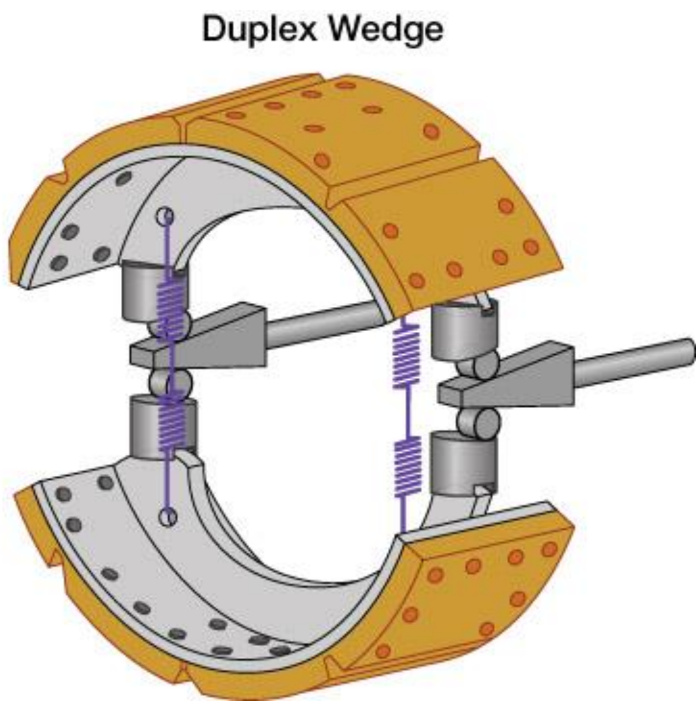


Air Brake Foundation Systems

- Wedge Brakes
  - Ramp-and-roller design inside wheel cylinder to multiply force supplied by an air chamber.
  - Simplex system: single actuator
  - Duplex systems: dual actuators
  - Due to greater complexity, cost, unpredictable release, wedge brakes not popular.
  - Adjusting mechanism incorporated into housing of brake itself

Air Brake Foundation Systems





Summary

- Moving vehicle has tremendous amount of kinetic energy.
- To stop vehicle, kinetic energy must be converted into heat energy through braking system.
- Weight and speed have different effects on braking requirements.
- Doubling the weight requires double the braking force, but doubling the weight and the speed requires eight times the braking force.

Summary

- To operate, brakes must turn kinetic energy into heat and be capable of dissipating heat quickly, or they will lose their effectiveness.
- As a vehicle brakes, its weight shifts from back to front. Brakes must be designed to be able to handle this inertia shift.
- All brake systems use some force to multiply braking effort applied to brake pedal by driver.
- This force can be compressed air, hydraulic pressure, or a combination of the two.

Summary

- Compressed air is primary method of choice to multiply brake force for on highway trucks.
- Air brake systems are very versatile and can be easily hooked up and disconnected; there is no worry of leaks or spills, as in hydraulic systems.
- Air brake systems can handle small system leaks without adverse effects.
- All brake systems are dual brake systems; if one system fails the other can still stop the vehicle.

Summary

- Because of their simplicity, cam brakes most popular air brake foundation brake system in on-highway trucks.
- Air brake systems are subject to federal regulation under Federal Motor Vehicle Safety Standard (FMVSS) 121.
- S-cam used in cam brakes can be left- or right-handed.
- Brake friction material is edge coded to ensure material used is matched to vehicle.

Summary

- Brake chamber size and slack adjuster lever length combine to deliver a twisting force to the brake camshafts.
- Brake chambers are air operated diaphragm chambers used to apply pressure to the brakes.
- Actuators have dual chambers with one containing a power spring to operate emergency or parking brake system.

Summary

- Spring brake chambers must be disarmed before they are discarded by cutting the power spring with an acetylene torch.
- Slack adjusters used to keep brake chamber stroke adjusted.
- All modern vehicles are equipped with automatic slack adjusters.