MANITOBA PUBLIC INSURANCE

MANDATORY ENTRY-LEVEL TRAINING MANITOBA CLASS 1

Lesson 3

Instructor's Guide

Overview

Purpose/Objectives

This lesson provides information on the inspection and use of air brakes.

After completing this lesson, students should be able to:

- Inspect and operate a commercial vehicle with air brakes

How long should it take?

Classroom (hours)			In-Yard (hours)			In-Cab (hours)			Total Training Duration (hours)
Deliver	Apply	Assess	Deliver	Apply	Assess	Deliver	Apply	Assess	
5.0	1.5	0.5	0.5	1.0	0.5				9.0

Required materials

- Whiteboard or flipchart
- Markers
- Projector
- PPT presentation
- Printed and electronic quizzes
- Pens

Using this document

This document is intended to guide you through the session. It includes the following icons for reference:

▶ **Direction on what you need to <u>do</u>**

Sample language for what you need to <u>say</u>

? Sample wording for what you need to <u>ask</u>

ⓘ Extra information to consider

Reference material

Lesson Outline

Time (Approx. mins)	Topic	Materials	Slides
5	Introduction		1-2
25	Operating Principles		3-17
155	Components of Air Brakes		18-72
55	Variables that Affect Vehicle Braking		73-85
70	Foundation Brake Operation and Adjustment		86-103
5	Air Brake Inspections		104-109
20	Inspections: System Operations		110-126
20	Inspections: Air Brake Adjustment		127-144
5	Wrap Up		145
30	Knowledge Check		146
90	Practical In-Yard Training		147
30	Practical In-Yard Assessment		148

Total time = 9.0 hrs.

ⓘ Times are an approximation of what is expected in a 15-student class with active participation. Times also include in-yard demonstration, application, and assessments.

Student Materials

- Lesson 3: Exercise Book
- Textbook
- MPI Air Brake Manual
- Lesson 3 – Job Aid
- Lesson 3 – Practical Job Aid
- Lesson 3 – Air Brake Diagram Activity & Study Guide
- Lesson 3 – Retarders Job Aid
- Lesson 3 – Brake Drums Job Aid
- Lesson 3 – Air Dryers Job Aid
- Lesson 3 – Anti-Lock Brake System Job Aid

Introduction

Objectives: Introduce the lesson to students.

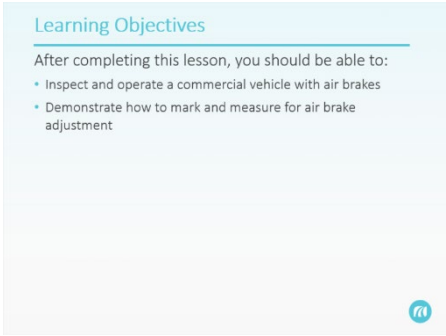
Time: 5 minutes

Slide: 1 Type: Presentation

- Welcome students and allow time to settle if this is a new day of classroom delivery.

Slide: 2 Type: Presentation

- After completing this lesson, you should be able to inspect and operate a commercial vehicle with air brakes.
- Demonstrate how to mark and measure for air brake adjustment



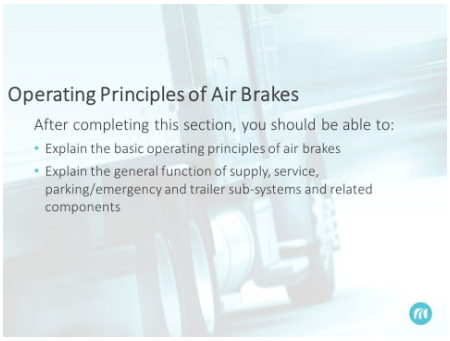
Operating Principles

Objectives: This section explains the basic operating principles of air brakes and the general function of supply, service, parking/emergency and trailer sub-systems and related components.

Time: 25 minutes

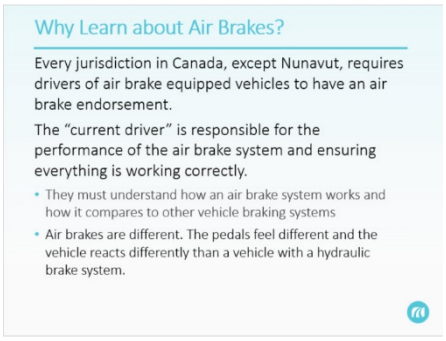
Slide: 3 Type: Presentation

- After completing this section, you should be able to:
  - Explain the basic operating principles of air brakes
  - Explain the general function of supply, service, parking/emergency and trailer sub-systems and related components



Slide: 4 Type: Presentation

It is important to learn about air brakes specifically because every jurisdiction in Canada, except Nunavut, requires drivers of air brake equipped vehicles to have an air brake endorsement.



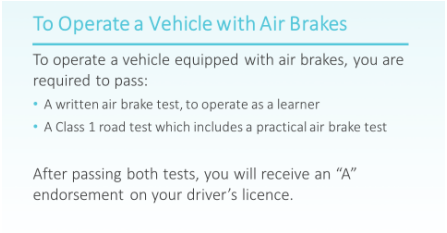
Air brakes are different from other brake systems. The pedals feel different and the vehicle reacts differently than a vehicle with a hydraulic brake system. There are more components in an air brake system, and they require more driver involvement to ensure the system is operating properly and safely.

The "current driver" is responsible for the performance of the air brake system and ensuring everything is working correctly. To do this, you must:

- Understand how the brake system works. Air brakes are different. The pedals feel different and the vehicle reacts differently than a vehicle with a hydraulic brake system.
- Perform effective air brake inspections
- Ensure the brakes are correctly adjusted
- Use the brakes properly

Slide: 5 Type: Presentation

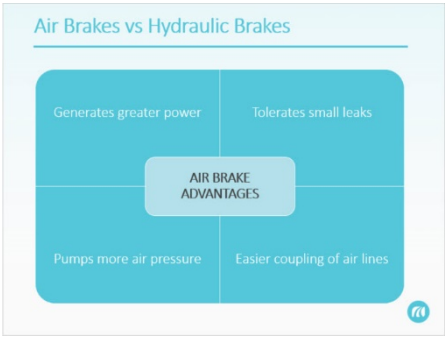
- The air brake “A” endorsement is independent of the class of licence held. The holder of a Class 1 licence must still pass the written and practical air brake test (which is part of the Class 1 road test) to operate a vehicle with air brakes.



Slide: 6 Type: Presentation

- Air brakes provide several advantages. Compressed air generates greater power than hydraulic brakes. A hydraulic brake leak can lead to brake failure, but air brake systems are tolerant of small leaks because they have compressors to provide more air pressure when required. Air line couplings are easier to attach than hydraulic lines and the systems have proven to be reliable.

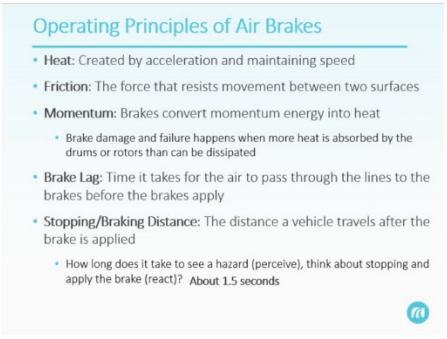
  However, the main disadvantage of air brakes is that there is a split second delay in brake reaction compared to hydraulic brakes.



Slide: 7 Type: Presentation

- Let’s review at a high level how air brakes work.

  Heat is created by accelerating and maintaining speed. Your vehicle requires traction to move, which is the amount of grip your tires have on the surface of the road. Gas and diesel engines use fuel to move a vehicle. A by-product of internal combustion is heat, which is dissipated by the cooling system. Stopping also creates heat.



  Friction is the resistance of motion between two objects or surfaces in contact with each other. Try rubbing your hands together quickly – you will feel them begin to heat as the friction builds.

  Momentum - Brakes convert momentum energy into heat which is dissipated into the atmosphere by brake drums or disks. To stop a vehicle, brake shoe linings are forced against the machined surfaces of the brake drums. Brakes convert the energy of momentum into the energy of heat. This heat is then dissipated into the atmosphere by the brake drums or disc rotors. The amount of heat the brake drums can absorb depends on the thickness and type of metal. When enough friction is created between the brake linings and drums, the wheels stop turning. The final factor that stops the vehicle is the traction between the tires and the road surface.

- Brake failure happens when more heat is absorbed by the drums or rotors than can be dissipated. This can be caused by driving too fast for conditions. Most brake drums operate best around 115° C and should not exceed 215° C.

  Driver's perception and reaction time - It can take 3/4 of a second to 1 ½ seconds from the moment the hazard is identified to the time you apply the brake pedal.

  Brake Lag - is the time it takes for the air to pass through the lines to the brakes before the brakes apply. In a well maintained air brake system this can take about 4/10 of a second. Air lines to the service brakes are empty when the brakes are released. When the brakes are applied, air pressure must move through the air lines. This creates a delay before the service brakes apply. The longer a vehicle is, the greater the brake lag.

  Air line layout and types of fittings also affect air pressure flow. The vehicle least affected by brake lag will be a body job - everything is fairly close together. The greatest brake lag occurs when three trailers are coupled to a towing unit (Triple). With this configuration, control air to the last trailer brakes must pass through five pairs of gladhand couplers with two 90-degree bends in each coupler set and long distances - up to 35 metres (114.8 feet).

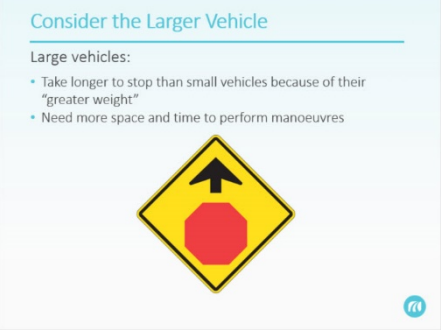
  Stopping/Braking Distance - Actual braking time and distance is the distance a vehicle travels after the brake is applied until the vehicle reaches a full stop. This distance depends on the ability of the lining to produce friction and the brake drums to dissipate the heat and then lastly for the tires to grip the road.

? How long does it take to see a hazard, think about stopping, and apply the brake?

- Wait for students to respond.
- CLICK to reveal.
- Answer: 1.5 seconds.

Slide: 8 Type: Presentation

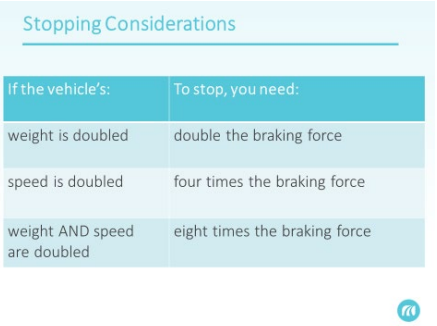
- Commercial trucks have larger brake components, and more wheels and brakes than passenger vehicles. Greater weight creates greater stopping distance. Large vehicles take longer to stop than small vehicles. While this may seem obvious, most people who begin their professional driving career need to learn how much more space and time is required to perform manoeuvres in larger vehicles.



Slide: 9 Type: Presentation

- Maintaining appropriate following distance and speeds to allow for stopping is a must. Increased vehicle mass means increased braking requirements. All vehicles must comply with standardized weight restrictions. This means all drivers are dealing with comparable weights for a given vehicle design.

  Increased speed also results in increased braking requirements.



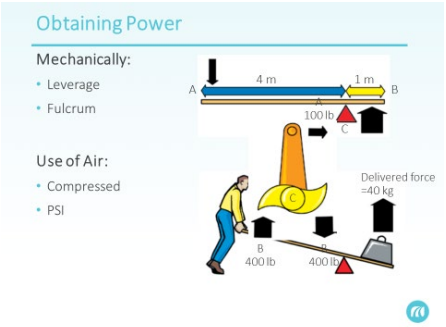
  Doubling both the weight and speed increases the complexity of the relationship between these factors and braking requirements.

ⓘ **Manual Reference:** Chapter 7: Demands on Brakes While Driving

Slide: 10 Type: Presentation

- Power is obtained mechanically and through the use of air.

  Braking systems use devices to gain a mechanical advantage. The most common device for this purpose is leverage. A lever is placed on a pivot called the fulcrum. If the distance from A to C is 4 metres, and from C to B is 1 metre, the ratio is four to one (4:1). Power is multiplied by the leverage principle. If a 10 kg downward force is applied at point A, then upward force at point B is 40 kg. This is the result of the mechanical advantage of leverage.

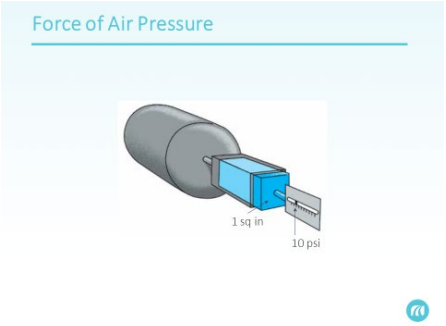


▶ CLICK to reveal.

- When the air brake system applies pressure to the S-cam (A), it uses the principle of leverage to multiply the pressure to the brake drums (B), which will stop the wheels from turning.

Slide: 11 Type: Presentation

- Force can also be multiplied by the use of air to gain a further mechanical advantage. Everyone has felt the power of air on a windy day. Air can be compressed into a much smaller space than it normally occupies. For instance, air is compressed in tires to support the weight of a vehicle. The smaller the space into which air is squeezed, the greater the air's resistance to being squeezed. This resistance creates pressure, which is used to gain mechanical advantage. If a constant supply of compressed air is directed through a pipe that is one-inch square, and if a one-square-inch plug was placed in the pipe, the compressed air would push against the plug. Holding a scale against the plug would register how many pounds of force were being exerted by the air against the plug.



If the scale registered 10 lb., for example, then it could be said the force was 10 lb. on the one-square-inch surface of the plug. This would be 10 lb. per square inch (psi).

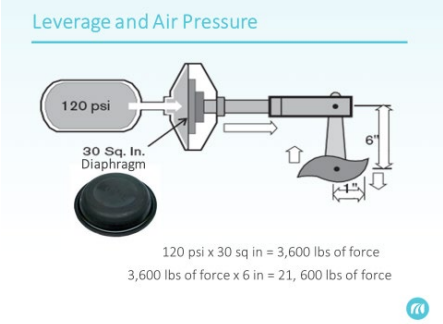
The more the air in the supply tank is compressed, the greater the force exerted on the face of the plug.

Slide: 12 Type: Presentation

- Let's discuss the relationship between leverage and air pressure.

  If compressed air of 120 psi acts on a 30 square inch diaphragm, 3,600 lbs. of force is produced (120 x 30).

  Apply this force to a push rod to move a six-inch slack adjuster operating a cam, and the total force equals 21,600 inch pounds torque (3,600 x 6) or 1,800 foot pounds torque (21,600 ÷ 12). In comparison, it requires 25 to 30 foot pounds of torque to tighten the wheel on a car.



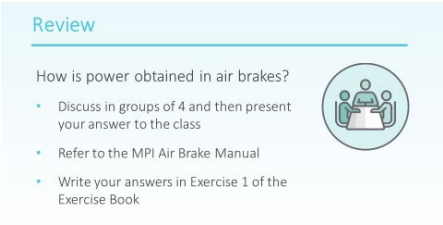
Slide: 13 Type: Group Activity

Time: 10 minutes

- Students should discuss in groups of 4 and then present answers to the class. Look for references to mechanics, including leverage, levers and fulcrum, as well as use of air, including compression and psi.

  Students should write answers in Exercise 1 of the Exercise Book.

- You may wish to show a video that explains how Air Brakes work, similar to this one by CrashForensics: https://www.youtube.com/watch?v=3mrUMTP4thI

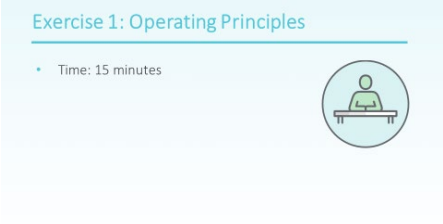


Slide: 14 Type: Self-paced Activity

Time: 15 minutes

- You have 15 minutes to complete Exercise 1 in the Exercise Book.

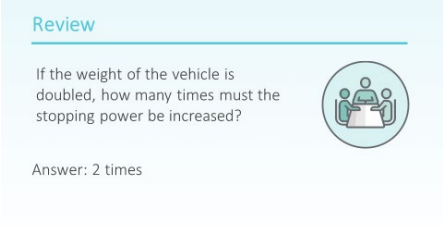
- Section 2 of Exercise 1 of the Exercise Book is a Fill in the Table exercise. This activity prepares the students for the review questions that follow.



Slide: 15 Type: Discussion

? If the weight of the vehicle is doubled, how many times must the stopping power be increased?

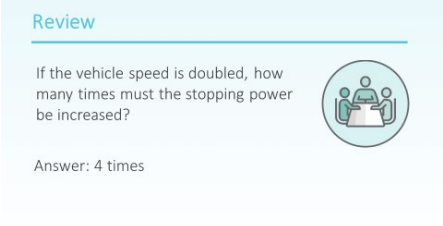
▶ Wait for students to respond, then click to reveal.



Slide: 16 Type: Discussion

? If the vehicle speed is doubled, how many times must the stopping power be increased?

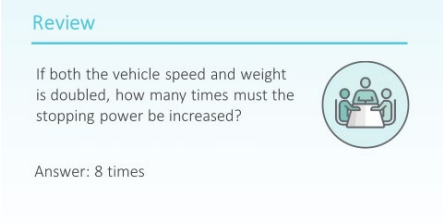
▶ Wait for students to respond, then click to reveal.



Slide: 17 Type: Discussion

? If both the vehicle speed and weight is doubled, how many times must the stopping power be increased?

▶ Wait for students to respond, then click to reveal.



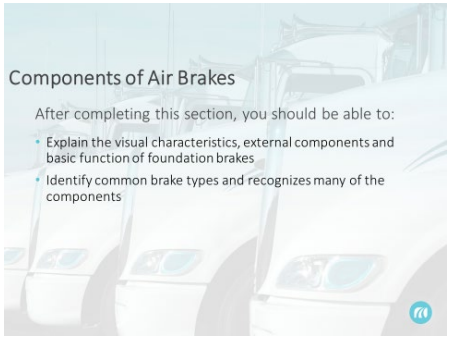
Components of Air Brakes

Objectives: This section of the lesson explains the visual characteristics, external components and basic function of foundation brakes and prepares students to identify common brake types and recognize many of the components.

Time: 155 minutes

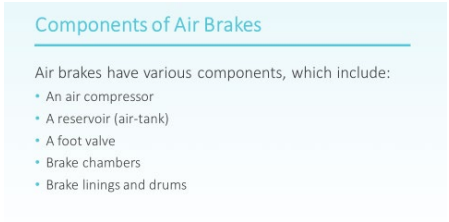
Slide: 18 Type: Presentation

- After completing this section, you should be able to:
  - Explain the visual characteristics, external components and basic function of foundation brakes
  - Identify common brake types and recognize many of the components



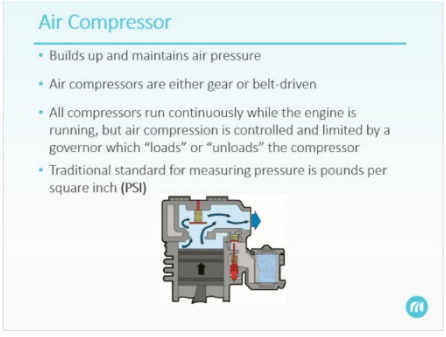
Slide: 19 Type: Presentation

- There are five main components of an air brake system. We'll review what they are and their purpose.



Slide: 20 Type: Presentation

- The function of the air compressor is to build up and maintain the air pressure required to operate air brakes and air-powered accessories. Air compressors are either gear-driven directly from the engine or belt-driven. All compressors run continuously while the engine is running, but air compression is controlled and limited by a governor which "loads" or "unloads" the compressor. In the loaded stage, air is pumped into reservoirs. In the unloaded stage, the compressor pumps air back and forth between the two cylinders without supplying the reservoirs.



ⓘ **Manual Reference:** Chapter 2: Air Supply Subsystem

- The traditional standard for measuring pressure has been pounds per square inch (psi) and many large vehicles still use this standard. An Original Equipment Manufacturer (OEM) may use kilopascals (kPa), a measurement that is becoming more common.

  European vehicles measure pressure in bars, which is about equal to the atmospheric pressure on earth at sea level. Although bars are never used on North American trucks, some may be familiar with this standard.

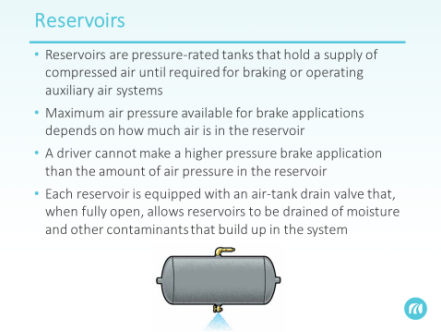
Slide: 21 Type: Presentation

- Reservoirs are pressure-rated tanks that hold a supply of compressed air until required for braking or operating auxiliary air systems.

  Maximum air pressure available for brake applications depends on how much air is in the reservoir.

  A driver cannot make a higher pressure brake application than the amount of air pressure in the reservoir.

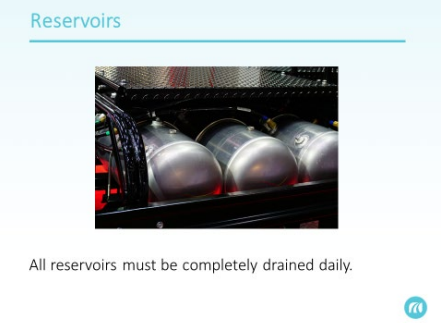
  Each reservoir is equipped with an air-tank drain valve that, when fully open, allows reservoirs to be drained of moisture and other contaminants that build up in the system.



ⓘ **Manual Reference:** Chapter 2: Air-Supply Subsystem.

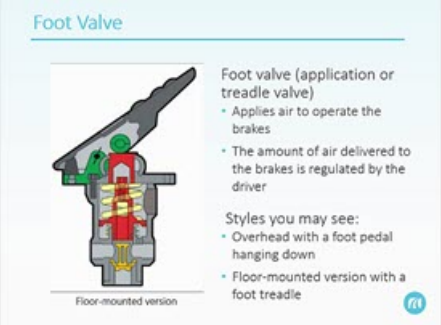
Slide: 22 Type: Presentation

- All reservoirs must be completely drained daily.



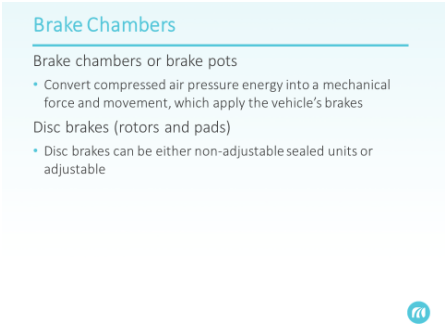
Slide: 23 Type: Presentation

- The foot valve (application or treadle valve) applies air to operate the brakes. You regulate the amount of air delivered to the brakes according to the distance the treadle or brake pedal is depressed. Releasing it exhausts air in the service brakes through its exhaust port. These valves are made in overhead styles with a foot pedal hanging down, or a floor-mounted version with a foot treadle.



Slide: 24 Type: Presentation

- Brake chambers or brake pots convert compressed air pressure energy into a mechanical force and movement, which applies the vehicle's brakes.



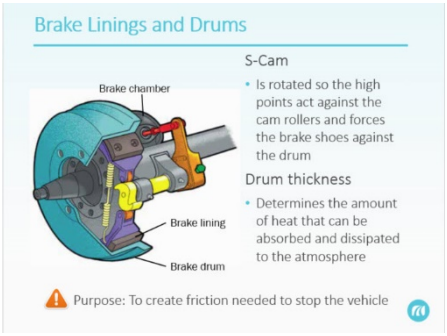
With service-brake chambers, when you apply pressure to the foot valve, air pressure enters the pressure side of the brake chamber through the inlet port and forces against the diaphragm which moves the pushrod assembly forward. When air pressure is released from the service-brake chamber, the return spring returns the diaphragm and pushrod to their released positions.

Some trucks are now equipped with disc brakes (rotors and pads). Disc brakes can be either non-adjustable sealed units or adjustable. If your truck is so equipped, consult the manufacturer's manual for information on how to keep the brakes properly adjusted.

ⓘ **Manual Reference:** Chapter 3: Service Brake Subsystem.

Slide: 25 Type: Presentation

- The purpose of brake linings and drums is to create the friction needed to stop the vehicle.



The "S" cam brake is rotated so the high points act against the cam rollers and force the brake shoes against the drum. When the brakes are released, the brake cam shaft returns the brake cam to its normal position. The cam rollers roll down into the crook of the S-cam as the brake shoe return spring pulls the shoes away from the drum. Brake shoes generate heat through friction with the brake drum surface.

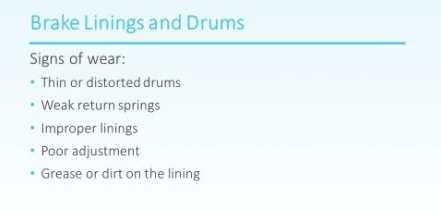
Drum thickness determines the amount of heat that can be absorbed and dissipated to the atmosphere. Thin or distorted drums, weak return springs, improper linings, poor adjustment, or grease or dirt on the lining results in erratic, unpredictable and potentially dangerous brake performance.

ⓘ **Manual Reference:** Chapter 6: Foundation Brakes

Slide: 26 Type: Presentation

- Signs of wear are thin or distorted drums, weak return springs, improper linings, poor adjustment, or grease or dirt on the lining.

  This type of wear can result in brake malfunction including erratic, unpredictable and potentially dangerous brake performance.

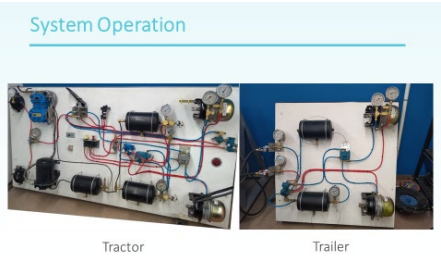


ⓘ **Manual Reference:** Chapter 9: Inspecting Air Brake Components

Slide: 27 Type: Presentation

- Air is pumped by the compressor to the reservoir. When air pressure reaches 120 psi to 145 psi, the governor places the compressor into its unloaded stage. At this stage the air system is fully charged.

  When the brakes are applied, air is delivered through the foot valve to the service-brake chambers. Air pushes against each service-brake diaphragm causing the pushrod to move the slack adjuster. The slack adjuster rotates the brake cam, which forces the shoes against the brake drum. When you release the foot valve, air in the brake chambers is exhausted through the foot valve, which releases the brakes. When reservoir air pressure drops, the governor puts the compressor back into the pumping stage to keep adequate air pressure available for future brake applications.

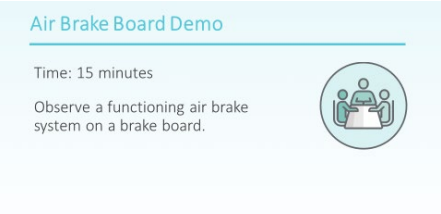


Slide: 28 Type: Presentation

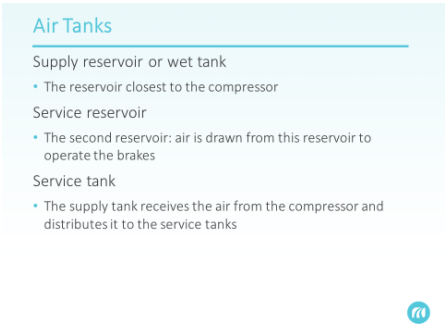
- Have students watch while you explain how air brakes work using the board or the app. Then have students come up one by one to explain it to the class. Field any questions that come up during this process.

  Provide students with Air Brake Diagram Activity & Study Guide. This can be used before they work on the board or the app.

Air Brake Diagram Activity & Study Guide



Slide: 29 Type: Presentation



- The reservoir closest to the compressor is called the supply reservoir. It's also known as the wet tank because most of the water and oil from the compressor gathers here.

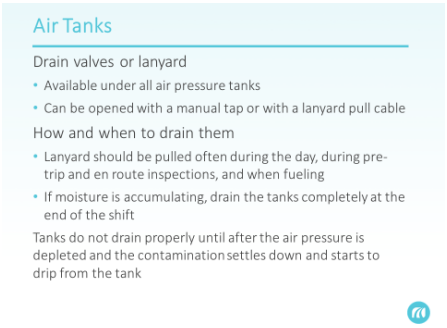
  The second reservoir is called the service reservoir. Air is drawn from this reservoir to operate the brakes.

  The terms supply, wet, and purge are all used interchangeably to describe the first tank that receives the flow of air pressure. Supply is the formal term. Wet tank is a more common term because this is the tank that captures the bulk of contamination. Most air dryers store their own air pressure to purge (back-flush) the desiccant, which is similar to the dry silica packets that is found at the bottom of your box of new shoes. Others allow some air pressure from the supply tank, while others use a separate independent tank for purge air. The supply tank is often called the purge tank, when in fact it rarely is. Other than the Air Dryer Integrated Solution system, most dryers manage their own purge air rather than relying on the supply tank.

- The supply tank receives the air from the compressor and distributes it to the service tanks. Compressed air heats when compressed and cools in the tanks. Humidity condenses and accumulates. Other contaminates such as compressor lube oil may also migrate through the system.

ⓘ **Manual Reference:** Chapter 2: Air Supply Subsystem

Slide: 30 Type: Presentation

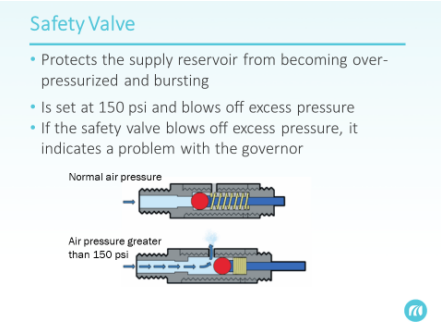


- There is a drain valve under all air pressure tanks. It can be opened with a manual tap or with a lanyard pull cable. Most supply tanks have lanyard pulls and either lanyards or manual drain valves on the service tanks.

  The supply tank lanyard should be pulled often during the day, during pre-trip and en route inspections, and when fueling. Although this does not drain contamination properly, it will ensure contamination does not accumulate. If moisture is accumulating, drain the tanks completely at the end of the shift. If necessary, hold the lanyard pulls open with tarp straps following a work shift.

  Tanks do not drain properly until after the air pressure is depleted and the contamination settles down and starts to drip from the tank. Stand clear of discharging air pressure.

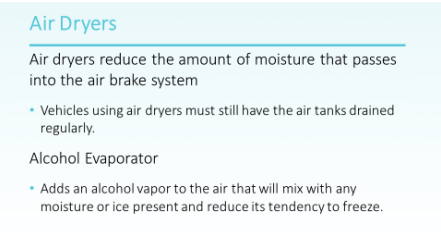
Slide: 31 Type: Presentation



- The safety valve protects the supply reservoir from becoming over-pressurized and bursting. This valve is set at 150 psi and blows off excess pressure. If the safety valve blows off excess pressure, it indicates a problem with the governor.

  Safety valves are located in the supply circuit so components downstream are protected. Some are external and others thread in so that the top is flush with the bung, and the pressure spring and seat is in the tank. Most air brake equipped vehicles have safety valves in both the air dryer and the supply tank. Some only have a safety valve in the air dryer.

Slide: 32 Type: Presentation



- Air dryers remove contamination from the air pressure being delivered by the compressor. Older air dryers were an after-cooler type arrangement where the air passed through a canister that cooled the warm air from the compressor very quickly. Contamination from the cooled air would collect in the sump of the air dryer which was then purged at the end of the pumping cycle. These older air dryers have cooling fins on their sides.

  Modern dryers use desiccant which absorbs moisture as it passes by. This absorbed moisture is blown off of the desiccant as it is purged (back-flushed). Most air dryers manage their own purge air, but some have a separate air tank strictly for purge purposes that is not part of the air brake system. Other dryers use a bit of the supply tank air pressure to purge the desiccant.

  The air dryer integrated system, or AD-IS, combines the governor, air dryer, safety valve and supply tank into one system. It uses a combination of pressure protection valves to protect the service circuits. This system collects and removes contaminants in solid, liquid and vapour form before they enter the brake system.

  It eliminates the need for daily manual draining of air tanks. It is still recommended to pull drain lanyards regularly to confirm the dryer is working properly.

  Air brake antifreeze is methyl alcohol with a lubricant added to prevent rubber components in the valves from drying out. Some vehicles depend on air brake antifreeze to keep them running in the winter.

  Some manufacturers do not recommend using air brake antifreeze, while others outfit their vehicles with inline alcohol injector kits at the factory. Pure alcohol can damage the air dryer desiccant, so avoid adding alcohol ahead of that component. For example, do not add alcohol into the pressure line from the air compressor because that alcohol will go directly into the dryer.

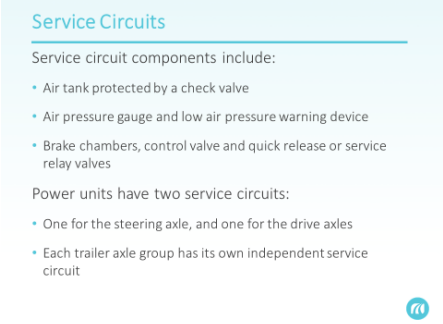
Some trailers flow the emergency and service air lines through small desiccant dryers. Alcohol would damage these dryers. These trailers typically have a decal fitted to the front of the trailer warning against alcohol use.

- Alternative delivery method: Provide a job aid about air dryers as alternative to reading the notes. If providing the job aid, ensure "How do they apply to my driving?" section is covered at minimum.

Lesson 3 – Air Dryers Job Aid

Slide: 33 Type: Presentation

Each axle group has an independent service brake circuit. Power units have two service circuits; one for the steering axle, and one for the drive axles. Each trailer axle group will have its own independent service circuit.



Every axle group will have an independent service brake circuit. Sometimes a trailer Original Equipment Manufacturer (OEM) fits one circuit per axle; others outfit one circuit for the complete axle group.

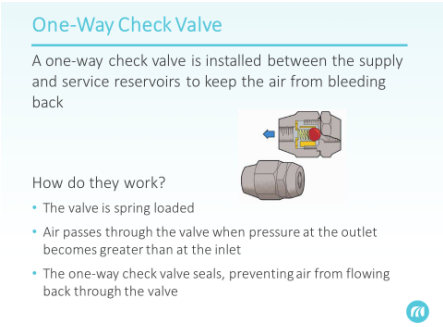
The service circuit components include:

- Air tank protected by a check valve, air pressure gauge and low air pressure warning device
- Brake chambers, control valve and quick release or service relay valves
- The service tank holds the pressurized air used for service brake applications. The capacity is set to the size and number of brakes installed in the axle group. The air tank stores air pressure for the simplified service circuit and is sized according to the air volume required for the brake chambers.

The tanks are hydrostatically tested to handle at least five times the compressor cut-out pressure or 500 psi (3,448 kPa), whichever is greater. Air tank volume capacity must be capable of providing for a minimum of 12 full-service brake applications for power units and 8 full-service applications for trailers.

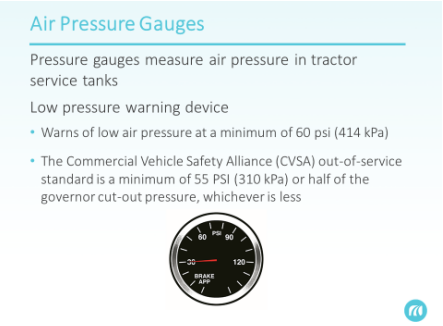
Slide: 34 Type: Presentation

If the air compressor fails or a leak develops in the supply reservoir, a one-way check valve between the supply and service reservoirs keeps the air from bleeding back. The valve is spring-loaded. Air passes through the valve when pressure at the outlet becomes greater than at the inlet. The one-way check valve seals, preventing air from flowing back through the valve.



ⓘ **Manual Reference:** Chapter 2: Air Supply Subsystem

Slide: 35 Type: Presentation



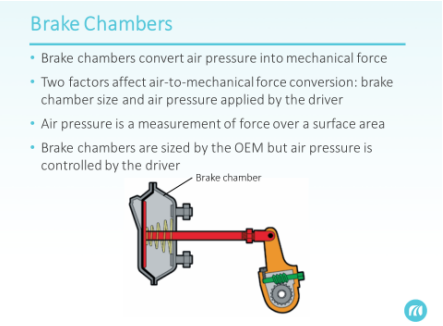
- The air pressure gauges measure air pressure in the two tractor service tanks. Trailer service tanks receive air pressure from the tractor service tank with the highest pressure and do not have an air pressure gauge. The maximum brake application depends on the amount of air pressure available in the reservoirs.

  A low pressure warning device warns of low air pressure at a minimum of 60 psi (414 kPa). It's manufactured with both a visual indicator and audible alarm to warn you that the pressure has become too low. The Original Equipment Manufacturer (OEM) tends to activate the alarm sound around 70 psi (483 kPa).

  The Commercial Vehicle Safety Alliance (CVSA), an organization that all enforcement agencies belong to, standardizes commercial vehicle inspections so that defects are applied equally throughout North America.

  The CVSA out-of-service standard is a minimum of 55 psi (310 kPa) or half of the governor cut-out pressure, whichever is less. Additionally, if either the audible or visual warning device is working, the vehicle will not be placed out-of-service.

Slide: 36 Type: Presentation



- Brake chambers convert air pressure into mechanical force. This is the end of the air system and the beginning of the mechanical linkages, which apply the foundation brakes. The two factors that affect this air-to-mechanical force conversion are the brake chamber size and the air pressure you apply. Air pressure is a measurement of force over a surface area. For example, 10 psi (69 kPa) applies 10 pounds (4.5 kg) of force onto a single square inch of surface area. A surface area of 20 square inches (129 square cm) will multiply the force by the overall surface area, which in this example is 20 square inches (129 square cm). The pressure being applied would be the equivalent of 200 pounds (91 kg) of force on the push plate and on through to the pushrod.

- Brake chambers are sized by the Original Equipment Manufacturer (OEM), but you control the air pressure. The typical size for steering axles is Type 20, meaning 20 square inches of diaphragm surface area (129 square cm). The typical size for load-bearing axles is Type 30, meaning 30 square inches of diaphragm surface area (194 square cm).

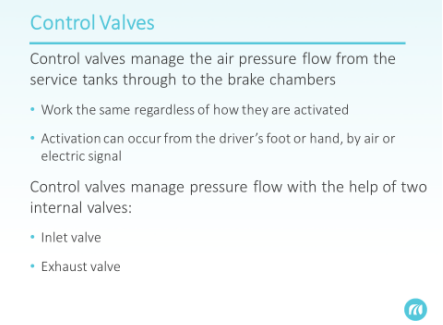
  Long stroke chambers have more total stroke before the push plate bottoms in the chamber. A standard Type 30 brake chamber has a total stroke of 2½ inches (64 mm), whereas a long stroke chamber has a total stroke of 3 inches (77 mm). Long stroke chambers have square inlet ports.

  These components are not interchangeable with regular chambers.

▶ Refer back to previous slides for the graphics that provide an explanation of power and force.

ⓘ **Manual Reference:** Chapter 3: Service Brake Subsystem

Slide: 37 Type: Presentation



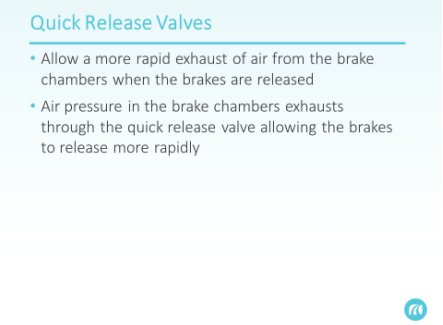
Control valves manage the air pressure flow from the service tanks through to the brake chambers. All control valves work the same regardless of how they are activated. Activation can occur by a linkage from your foot or hand, by air or electric signal.

Control valves manage pressure flow with the help of two internal valves: an inlet valve that allows air pressure to flow from the service tank to the brake chambers, and an exhaust valve that allows air pressure in the chambers to escape into the atmosphere. When the brake is released, the inlet is closed, holding the air in the tank and the exhaust open. This leaves the chambers open.

When the control is applied, the exhaust closes and the inlet opens. Air pressure travels through to the diaphragms in the chambers and the service brakes are applied. When the control valve is in the hold/balance position, both the inlet and exhaust are closed. This captures the application air in the brake chambers. When the brakes are released, the inlet remains closed and the exhaust opens, allowing the application air pressure to exhaust to the atmosphere.

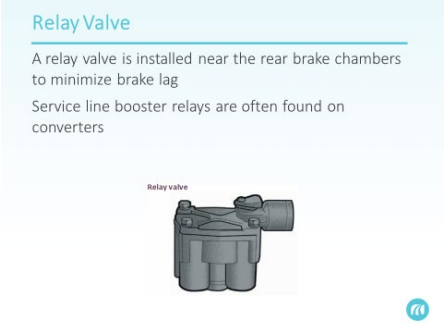
ⓘ **Manual Reference:** Chapter 4: Spring Brake Subsystem

Slide: 38 Type: Presentation



Quick release valves allow a more rapid exhaust of air from the brake chambers when the brakes are released. The valve is mounted under the front cross member area or incorporated into the ABS system. Brakes are applied normally through the foot valve. The brake chambers are close to the foot pedal, so brake lag is minimal. When the brake application is released, air pressure in the brake chambers exhausts through the quick release valve allowing the brakes to release more rapidly. Air exhausts through the quick release valve, but may also exhaust through the ABS modulators, if equipped.

Slide: 39 Type: Presentation



- On long wheelbase trucks and tractors and on trailers, the distance from the brake chambers to the foot valve is too far to cause immediate application of the brake when the foot valve is depressed. This is called brake lag.

  To correct this situation, a relay valve is installed near the rear brake chambers.

  The air line from the foot valve to the relay valve now becomes a control line that signals to the relay valve the amount of air to be drawn from the service reservoir for faster application of the brakes. A quick release valve is built in for faster release of the brakes.

  Relays can be mounted directly into the service tank (typical of trailers) or mounted on the frame (typical of drive axles). You send a control signal to the top of the relay to trigger the application. Today's air brake equipped vehicles may have brake management systems that use electronics to pilot the relays; all vehicles must maintain air pressure control signals.

  The large volumes of air pressure from the tank to the relays are moved through larger air hoses, typically 5/8 to 3/4 inch (16 to 19 mm) in diameter. Air pressure signals tend to flow through smaller diameter lines, which provides faster delivery. Brake signals are typically moved through 3/8 inch (10 mm) lines, governor signal pressures through 1/4 inch (7 mm) lines, and transmission signals through 1/8 inch (4 mm) lines.

  Crack pressure is the amount of control air pressure from the foot valve that must be initially delivered to the top of the relay before the valve starts to open to deliver air pressure from the service tank to the brake chambers.

- Different cracking pressures are used to regulate the timing of the service brakes down the length of the vehicle. Since the control (pilot) air comes from the cab, the relay valves further down the length of the vehicle will take longer to receive the control signals. Crack pressures are used to time the actual application of air to the chambers. Relay valves closer to the cab will have higher crack pressures - this allows more time for the control air to make its way to the back before the power unit brakes apply.

  The exception to relay crack pressures is when a relay is used in a service line booster situation. Long trailer service lines tend to cause service signal to diminish (transmission loss). A special relay (booster) is used to recharge the service signal. These booster relays have zero crack pressures, otherwise the signal air coming from the booster relay would be reduced from what was originally sent from the tractor's foot valve.

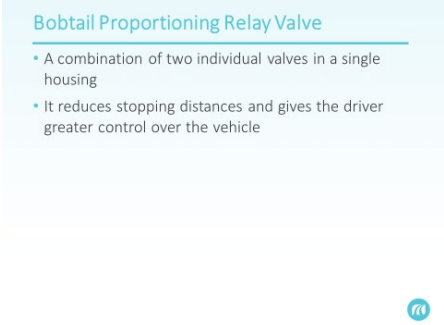
  Service line booster relays are often found on converters. It is important that valves are replaced with the proper components. When service brakes are released, the air pressure in the chambers exhausts directly from under the relay, and the smaller volume in the longer control line exhausts back out of the foot valve.

Slide: 40 Type: Presentation

- Some trucks are equipped with a bobtail proportioning relay valve, which is a combination of two individual valves in a single housing.

  The lower portion contains a standard service-brake relay valve, which functions as a relay station to speed up brake application and release.

  The upper portion houses a brake proportioning valve that reduces normal service brake application pressure when the tractor is not towing a trailer.



  During bobtail operation, this valve reduces stopping distances and gives you greater control over the vehicle.

  The brake pedal has to be pushed farther to apply sufficient air to stop.

Slide: 41 Type: Discussion

? What pre-set psi is a safety valve set for to blow off excess pressure?

▶ Wait for students to answer, then click to reveal.

? What does blowing off excess pressure indicate?

▶ Wait for students to answer, then click to reveal.

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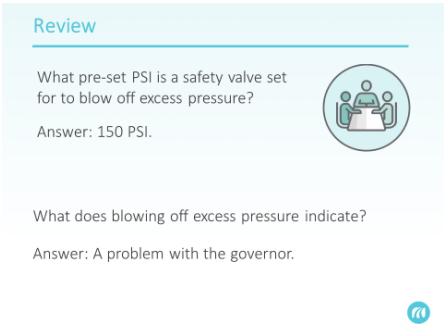
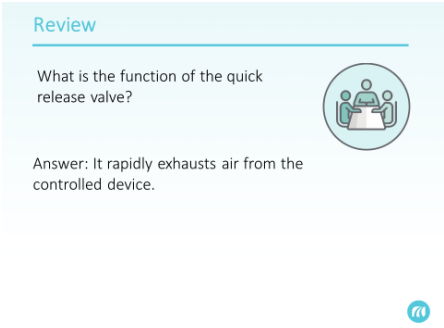


Slide: 42 Type: Discussion

? What is the function of the quick release valve?

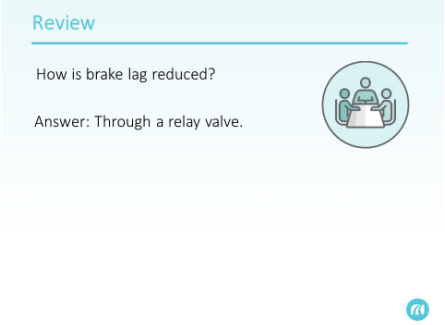
▶ Wait for students to answer, then click to reveal.



Slide: 43 Type: Discussion

? How is brake lag reduced?

▶ Wait for students to answer, then click to reveal.



Slide: 44 Type: Group Activity

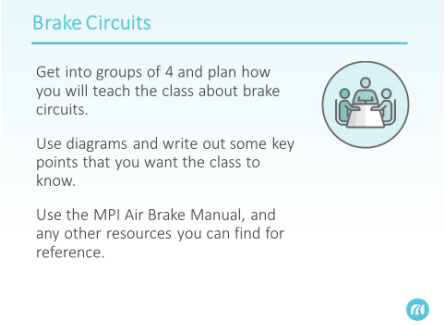
Time: 30 minutes

▶ Have students get into groups of 4 to prepare a lesson on brake circuits.

- Get into groups of 4 and plan how you will teach the class about brake circuits.

  Use diagrams and write out some key points that you want the class to know.

  Use the MPI Air Brake Manual, and any other resources you can find for reference.

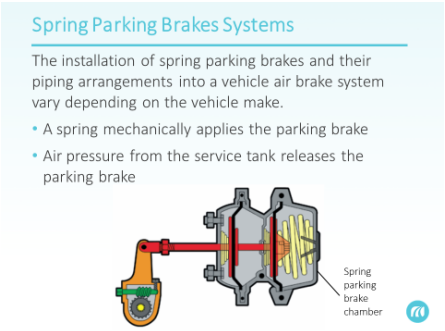


Slide: 45 Type: Presentation

- Air pressure is not reliable for parking brakes. Service brakes require air pressure to apply. Without air pressure the vehicle will not be secured.

  The installation of spring parking brakes and their piping arrangements into a vehicle air brake system vary depending on the vehicle make.

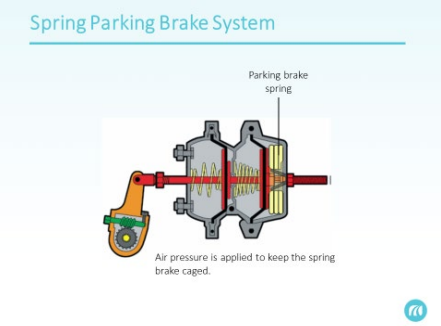
  A spring mechanically applies the parking brake. This is typically installed on all loaded-axle service chambers. The parking brake is firmly held without depending on air pressure to secure the vehicle. Air pressure from the service tank is used to release the parking brake, which begins to release at 60 psi (414 kPa).



ⓘ **Manual Reference:** Chapter 4: Spring Brake Subsystem

Slide: 46 Type: Presentation

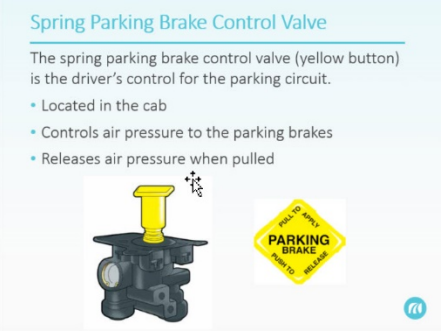
- It takes approximately 90 psi of air pressure to keep the spring brakes caged. If reservoir air pressure is allowed to drop below 90 psi, the springs will start to move. At approximately 70 psi the brakes will be partially applied making it difficult to continue driving. If the air pressure drops below 60 psi the brakes will be fully applied making it impossible to move the vehicle until enough air pressure is built up to cage the springs, or until they are manually caged.



Spring parking brakes are under extreme pressure and could cause serious injury or death. DO NOT take brake chambers apart. There are no repairable parts inside!

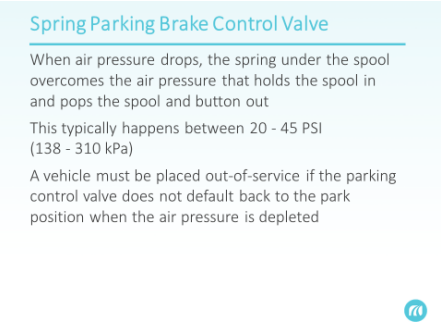
Slide: 47 Type: Presentation

- The spring parking brake control valve controls air pressure to the parking brakes and is located in the cab. Air pressure is released when the valve is pulled. The parking control valve (yellow button) is your control for the parking circuit.



Slide: 48 Type: Presentation

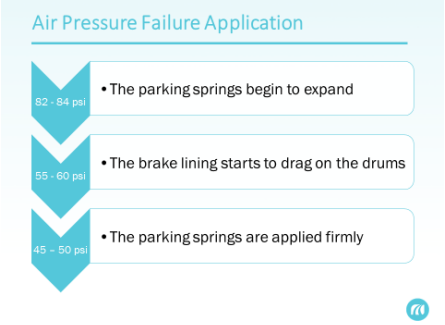
- The yellow button sits on top of a spring-loaded spool in the housing. Air pressure holds it in (open). When air pressure drops, the spring under the spool overcomes the air pressure, holds it in, and pops the spool and button out. This typically happens between 20 - 45 psi (138 - 310 kPa), although in new trucks it can happen as low as 10 psi (69 kPa). A vehicle must be placed out-of-service if the parking control does not default back to the park position when the air pressure is depleted.



When the parking control valve (yellow button) is pulled, air is exhausted and the parking spring expands and applies the foundation brake.

Slide: 49 Type: Presentation

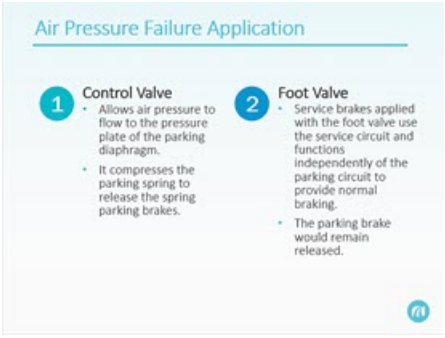
- When air pressure drops to 82 - 84 psi (566 - 580 kPa), the parking springs begin to expand. By the time the springs expand enough to take up the free-play, air pressure is down to 55 - 60 psi (380 - 414 kPa). At this point, the brake lining starts to drag on the drums. The parking springs are applied firmly by 45 - 50 psi (310 - 345 kPa) air pressure. Spring parking brakes begin to apply if system air pressure drops below 60 psi (414 kPa). An automatic application of the spring parking brakes provides minimum reaction time and can reduce vehicle control.



Slide: 50 Type: Presentation

- Opening the parking control valve (by pushing the yellow button) allows air pressure to flow to the pressure plate of the parking diaphragm. It compresses the parking spring to release the spring parking brakes.

  Applying the service brakes with the foot valve uses the service circuit and functions independently of the parking circuit to provide normal braking. The parking brake remains released.



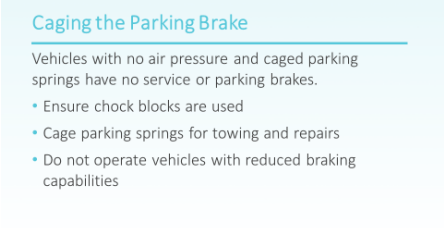
Slide: 51 Type: Presentation

- Spring brakes can be manually released (caged) with a release bolt. The release bolt is often found in a side pocket on the chamber. Some spring brake chambers incorporate the release tool into the body of the chamber.

  Caging bolts (release tools) are used to pull the parking spring off the application so the vehicle can be **towed or repaired.** They are not to be used as a method of taking the parking chambers apart. If all of the parking brakes are to be caged, ensure chock blocks are placed on both sides of the wheels.

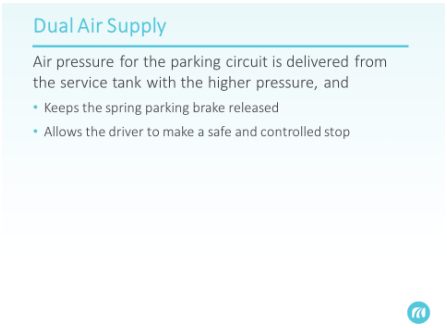
Slide: 52 Type: Presentation

- Vehicles with no air pressure and caged parking springs have no service or parking brakes. Ensure that chock blocks are in place before caging the parking springs. Caging parking springs is a procedure used for towing vehicles and mechanical repairs only. Do not operate vehicles with reduced braking capabilities.



Slide: 53 Type: Presentation

- Air pressure for the parking circuit is delivered from the service tank with the higher pressure. This keeps the spring parking brake released if there is a system failure in either service circuit and allows you to make a safe and controlled stop.

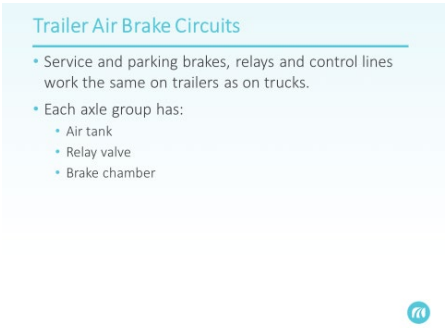


Slide: 54 Type: Presentation

- Service and park brakes operate the same on trailers as they do on power units (i.e., the truck or tractor). Relays and control lines also work the same.

  Air pressure is provided by the tow vehicle, so there is no supply circuit on the trailer. Each axle group has an air tank, relay valve, and brake chamber.

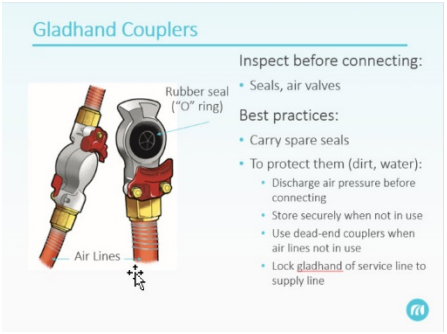
  The two air lines that connect to the trailer carry the air supply and the brake signal to the trailer's service and parking circuits.



Slide: 55 Type: Presentation

- Advise students to carry a supply of spare seals and demonstrate how to replace them. Remember that the thick side goes into the gladhand coupler. It may be helpful to display a sample of red and blue gladhand couplers with a variety of seals.

  - Gladhand couplers should be completely inspected before being connected. If the seals are soft or degraded, they will leak. If the gladhand couplers are damaged they may not press together properly and leak.



  Gladhands connect the two air lines to the trailer. They are friction locked and rubber sealed, usually "polarized" to prevent cross-connection. Trailer air valves are expensive, so keep them clean. Dirt in the air lines from bobtails will migrate into and contaminate trailer valves resulting in expensive repairs.

  Some best practices include:

  - Carrying spare seals
  - Protecting them from dirt and water by:
  - A quick discharge of air pressure before connecting the gladhand couplers will help contamination blow out rather than sending it into the trailer. Leave the gladhand couplers lying open on the tractor deck. Pull the hand valve, and hold the red dash valve in

for a few seconds. Release both the dash valve and the hand valve and then connect the air lines.

- Storing them securely when not in use
- Use dead-end couplers when the air lines are not in use.
- If the unit is not equipped with dead-end couplers, the gladhand of the service line can be locked to the gladhand of the supply line to keep water and dirt from entering the unused lines.

Gladhands and lines should also be secured to prevent the line from bouncing off the vehicle, which could seriously damage the couplers.

There are different types of air lines. Plastic coiled air lines work well, but can become brittle over time. Rubber air lines are also available.

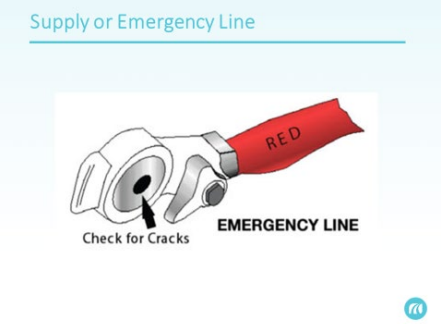
Flat deck haulers may run the trailer air lines from the back of the frame to the landing leg area of the trailer, rather than from the back of the cab to the nose of the trailer. This causes less interference from loads that overhang the front of the deck.

Slide: 56 Type: Presentation

All supply couplers have the word “Emergency” or a large “E” on them. Typically, they couple to the left (driver) side of the two couplers on the trailer. This is a convention rather than a requirement.

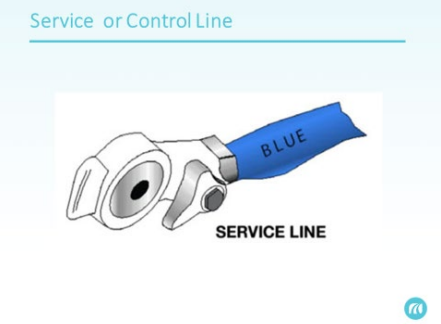
The air pressure used to supply the trailer tanks will come from the higher of the two tractor service tanks.

The two functions of this supply line are to fill trailer tanks, and release trailer parking brakes. It is usually colour-coded red.



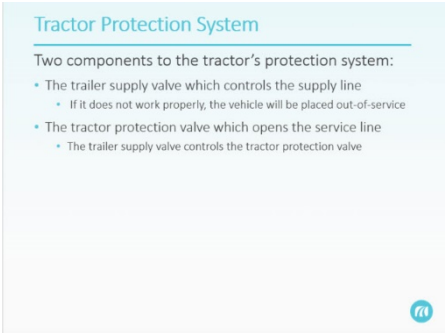
Slide: 57 Type: Presentation

The service or control line carries the control signal from the foot valve to the trailer circuit relays. It is usually colour-coded blue and generally mounted on the passenger side of the gladhand couplers. Service couplers will say “Service” or have a large “S” on them.



Slide: 58 Type: Presentation

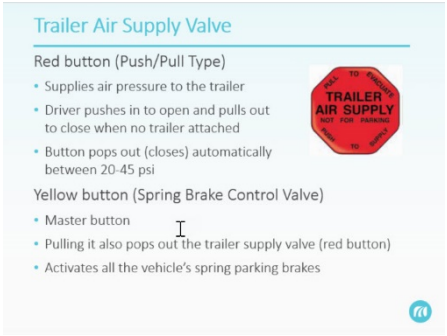
- There are two components to the tractor's protection system: the trailer supply valve and the tractor protection valve. The trailer air supply valve (red button) controls the supply line, and the tractor protection valve uses supply line pressure to open the service line. The trailer supply valve is an item checked by enforcement officers during roadside vehicle inspections. If it does not work properly, the vehicle will be placed out-of-service.



Enforcement officers during Level 1 Commercial Vehicle Safety Alliance (CVSA) inspection will check both parts of the tractor's protection system. Both lines will be removed from the trailer and when the red button trips, you will be asked to apply the service brake. The service line should not leak. This procedure is a part of the air system pre-trip inspection.

Slide: 59 Type: Presentation

- Push the red button to open and supply air pressure to the trailer. Pull to close and stop the air pressure supply. If the supply line separates, the button pops out at 20 psi or greater.

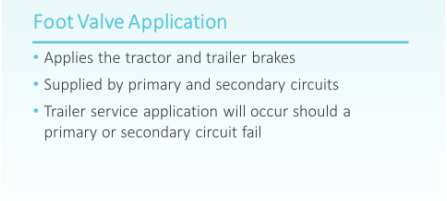


The trailer air supply valve is also controlled by the spring brake (parking and emergency) control valve (yellow button, see **Spring Parking Brake Control Valve** slide). This is the master button. Pulling it also pops out the trailer supply valve (red button) and activates all of the vehicle's spring parking brakes.

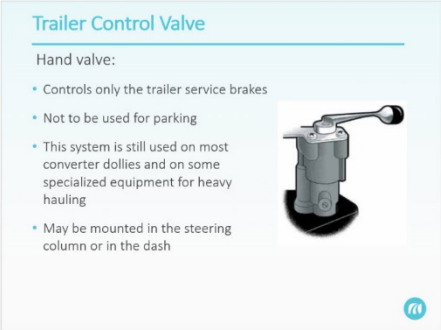
In the two-button system, the trailer air supply valve (red button) automatically applies or pops out when the spring brake control valve is pulled. Most drivers get into the habit of holding a thumb on the trailer air supply valve (red button) while pulling the spring brake control valve (yellow button). This applies the tractor spring parking brakes while keeping the trailer spring parking brakes released, which prevents the trailer brake linings from freezing onto the drums in cold weather.

Slide: 60 Type: Presentation

- When the foot valve application treadle is depressed, air is delivered to the tractor and trailer brakes. The air is supplied by the service circuits. There will be a trailer service application if a circuit fails.



Slide: 61 Type: Presentation



- The hand valve controls only the trailer service brakes, independently of the tractor service brakes. Hand valves send controlled air pressure through the trailer service (blue) line to the top of the trailer relays. These valves may be mounted on the steering column or in the dash. Some are spring-loaded, returning to the released position unless held by the driver, while others stay applied and must be manually released.

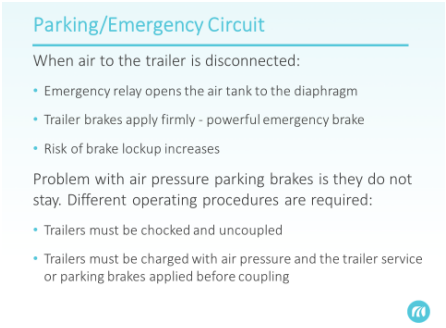
  These are not to be used for parking.

  Prior to 1976, trailers were equipped with air parking brakes. This system is still used on most converter dollies and on some specialized equipment for heavy hauling.

- As of January 1, 1976, Section 121 of the Canadian Motor Vehicle Safety Standards (CMVSS) requires spring parking brakes on trailers.

  The trailer's air system communications are the same as modern spring brake trailers, so any tractor can pull any trailer. Pushing the trailer air supply valve (red button) releases the trailer's air pressure parking brakes and maintains air pressure in the trailer's air supply tank. Under normal conditions the service brake circuit works the same as the tractor service circuit. They control the air from the tractor signals relay, and application air is delivered to the trailer chambers from the local service tank.

Slide: 62 Type: Presentation



- When the air supply to the trailer is disconnected, the emergency relay opens the air tank to the diaphragm in the service chambers. Service air pressure will cause trailer brakes to apply firmly. This is a very powerful emergency brake - twice as powerful as spring parking brakes. It can create an increased risk of brake lockup in an emergency application.

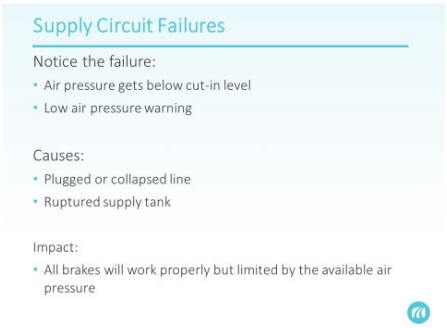
  The problem with air pressure parking brakes is that they do not stay on. As air pressure drains out of the system, the parking brakes will release. Very different operating procedures are required. Trailers must be chocked when uncoupled to prevent them from moving. Additionally, trailers must be charged with air pressure and the trailer service or parking brakes applied before coupling.

Slide: 63 Type: Presentation

- The failure is noticed when the air pressure gauges do not replenish when the air pressure gets below the cut-in level. In some vehicles the low air pressure warning comes on.

  The supply circuit failure could be caused by anything from a plugged or collapsed line to a ruptured supply tank.

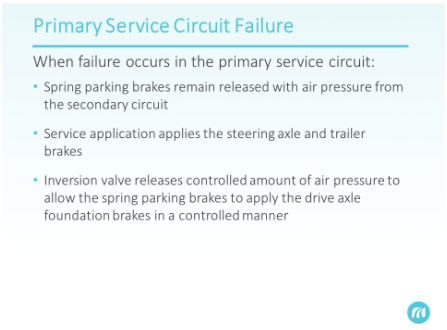
  All brakes will work properly, but they will be limited by the amount of air pressure available in the service tanks.



Slide: 64 Type: Presentation

- The failure occurs in the primary circuit. Spring parking brakes remain released with air pressure from the secondary circuit. A service application will apply the steering axle and trailer brakes. Many trucks are outfitted with a tractor spring parking brake valve, sometimes called an inversion valve.

  This valve releases a controlled amount of air pressure from the spring parking brakes. This allows the spring parking brakes to apply the drive axle foundation brakes in a controlled manner.



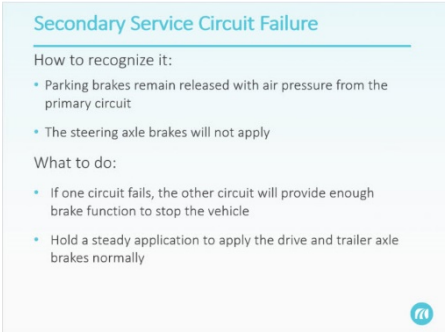
  This valve uses the secondary service circuit to release an equal amount of circuit air pressure from the tractor's spring parking brakes. However, more air pressure is used to release the spring parking brakes when the service brakes are released.

  A steady brake application should be used to stop the vehicle if an air pressure gauge is seen dropping and when the low air pressure alarm activates.

Slide: 65 Type: Presentation

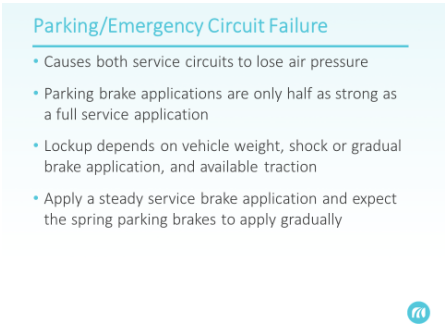
- If the failure occurs in the secondary service, the parking brakes remain released with air pressure from the primary circuit. This is the only tractor air system failure that will cause a service circuit's brakes not to work during a service application. In this failure, the steering axle brakes will not apply.

  Having two delivery circuits is a safety feature that ensures if one circuit fails, the other circuit will provide enough brake function to stop the vehicle. By holding a steady application, the drive and trailer axle brakes apply normally. A steady brake application should be used to stop the vehicle if an air pressure gauge is seen dropping and when the low air pressure alarm activates.



Slide: 66 Type: Presentation

A failure in the parking circuit causes both service circuits to lose air pressure. Spring parking brake applications are only half as strong as a full service application, and a lockup depends on the weight of the vehicle, how sharply the brakes apply (shock or gradual), and available traction. Once the brakes apply there is no control of the vehicle if it starts to slide.

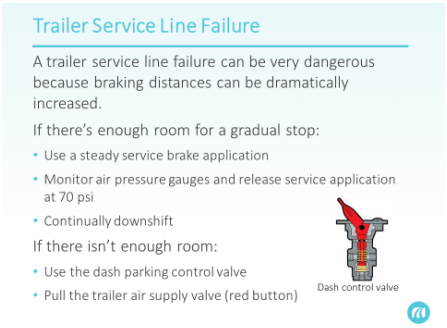


ABS only operates on service circuits; it will not assist in this situation.

For a parking and emergency circuit failure, apply a steady service application and expect the spring parking brakes to begin to gradually apply as the air pressure is reduced to approximately 55 - 60 psi (380 - 414 kPa). Both air gauges drop and the low air alarm activates.

Slide: 67 Type: Presentation

A trailer service line failure can be very dangerous. For example, a Super-B combination weighing 63,500 kg (139,994 pounds) will have its braking capacity reduced to a tandem 22,500 kg (49,604 pounds) loaded straight truck. Braking distances will be dramatically increased.



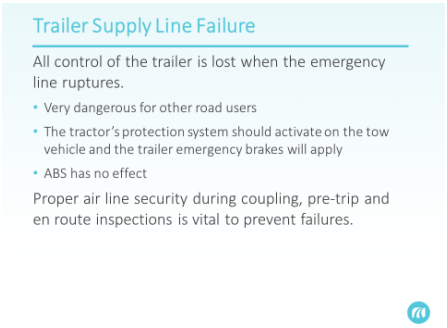
If there is enough roadway ahead of the vehicle for a gradual stop, a steady service brake application should be used. Monitor the air pressure gauges and release the service application when air pressure reaches approximately 70 psi (483 kPa). The air pressure will rebuild when the service brakes are released. The vehicle should be continually downshifted to allow the compressor to rebuild air pressure faster and make the auxiliary retarder more effective.

The dash parking control valve is rarely used for emergency braking. It would be used in any situation where a service line failure or a trailer service tank failure causes a loss of service brakes and a quick stop is required.

The disadvantage of this is that the tractor's drive axle service brakes will be decreased by half if it is fitted with a bobtail drive axle relay. Service brakes will have to be applied harder to meet the same braking requirements.

You do not have much time to think during an emergency situation. If the trailer service brakes are not working and the vehicle must be stopped quickly, pull the trailer air supply valve (red button).

Slide: 68 Type: Presentation



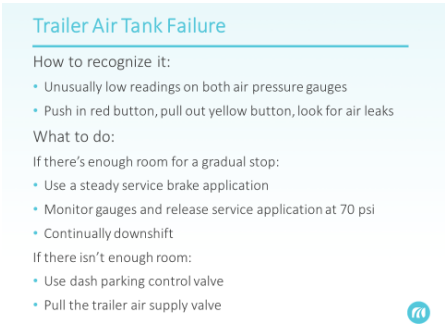
All control of the trailer is lost when the emergency line ruptures. The tractor's protection system should activate on the tow vehicle and the trailer emergency brakes would apply.

Whether this causes the trailer axles to lock up depends on the weight on the axles, how rapidly the brakes are applied and the traction.

ABS has no effect on this situation, and if the trailer loses traction it will swing. Typically, the trailer will swing to the right because of the pavement crown. Centrifugal force in a turn will swing the trailer to the outside of the turn.

A trailer emergency line failure can be very dangerous for other road users. Proper air line security during coupling, pre-trip and en route inspections is vital. If there is any doubt about the security of the gladhand couplers, repairs must be made.

Slide: 69 Type: Presentation



A trailer air tank failure is indicated by an unusually low reading on both air pressure gauges. The response to this situation is the same as a trailer service line failure discussed earlier.

The trailer air system must be charged during pre-trip and en route inspections. Pushing in the trailer air supply valve (red button) with the parking control valve (yellow button) pulled out during these inspections allows any air leaks to be noticed and dealt with before the equipment is put into service.

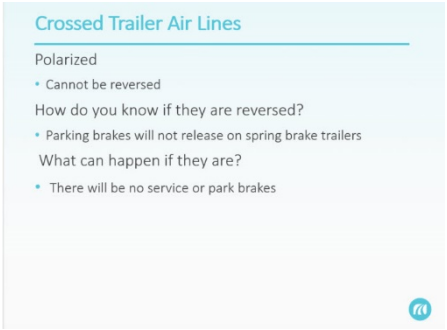
If there is enough roadway ahead of the vehicle for a gradual stop, a steady service brake application should be used. Monitor the air pressure gauges and release the service application when air pressure reaches approximately 70 psi (483 kPa). The air pressure will rebuild when the service brakes are released. The vehicle should be continually downshifted to allow the compressor to rebuild air pressure faster and make the auxiliary retarder more effective.

The dash parking control valve is rarely used for emergency braking. It would be used in any situation where a service line failure or a trailer service tank failure causes a loss of service brakes and a quick stop is required.

As previously mentioned, if there is any sign that the trailer service brakes are not working and the vehicle must be stopped quickly, pull the trailer supply valve.

Slide: 70 Type: Presentation

- Gladhand couplers that are polarized and in good shape cannot be reversed. Parking brakes will not release on spring brake trailers if trailer lines are reversed. However, reversed air lines on an older style air parking brake trailer can be a problem. If the trailer tank is empty, there will be no service or parking brakes. During driving, repeated service brake applications will cause the trailer air parking brakes to drag as air pressure accumulates in the trailer's tank.



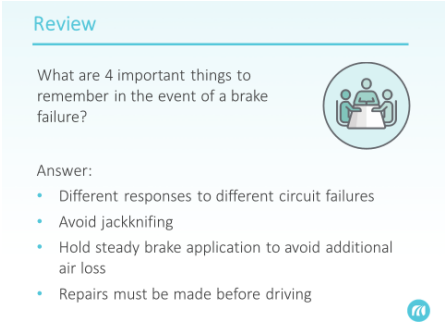
Monitor the air gauges for air pressure loss when pushing in the trailer air supply valve (red button) after coupling to a trailer. This loss is expected and normal. For example, a tridem trailer with empty air tanks and air ride suspension can substantially reduce the tractor's air tank pressure. If the air pressure gauges do not drop, the trailer air tanks are already full or the lines are reversed.

Slide: 71 Type: Discussion

? What are 4 important things to remember in the event of a brake failure?

▶ Wait for students to respond, then click to reveal answers.

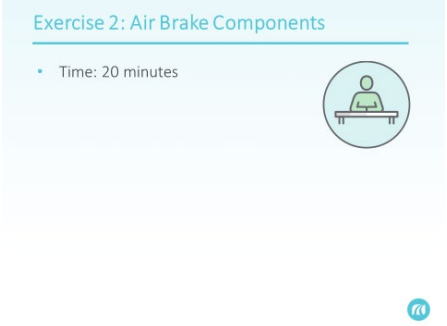
- The vehicle reacts differently to different circuit failures. Care must be used to avoid jackknifing when attempting to stop. Hold a steady brake application to avoid additional loss of air. Once the vehicle has safely stopped it must not be driven until repairs have been made.



Slide: 72 Type: Self-paced Activity

- You will have 20 minutes to complete Exercise 2 in the Exercise Book.

▶ If time permits, you should review the questions after the students have completed the exercise. Alternatively, you may provide a copy of the **Lesson 3 - Exercise Book Answer Key** at the end of the lesson for them to review on their own time.



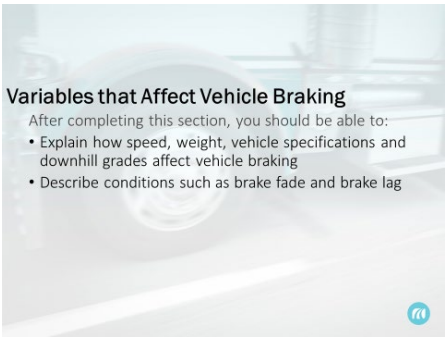
Variables Affecting Braking

Objectives: This section of the lesson explains how speed, weight, vehicle specifications and downhill grades affect vehicle braking, and describes conditions such as brake fade and brake lag.

Time: 55 minutes

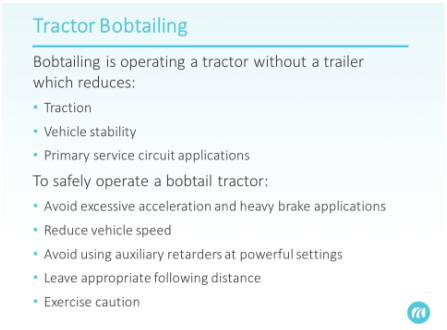
Slide: 73 Type: Presentation

- After completing this section, you should be able to:
  - Explain how speed, weight, vehicle specifications and downhill grades affect vehicle braking
  - Describe conditions such as brake fade and brake lag



Slide: 74 Type: Presentation

"Bobtailing" is operating a tractor without a trailer. Tractor drive axles are designed to carry weight. Removing the trailer significantly reduces the traction of the drive axle. A brake application causes weight to transfer to the steering axle, further reducing drive axle traction. Strong engine power and brakes, with very little traction, can cause a serious loss of vehicle stability.



Highway tractors are designed to carry a lot of weight. Driving a bobtail with no weight on the axles can be dangerous. Exercise caution even during safe road conditions.

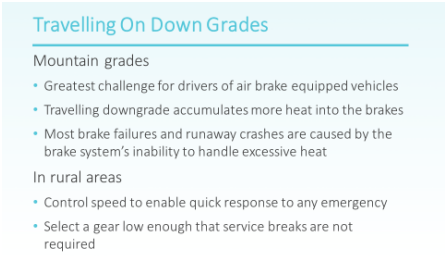
Tractors with bobtail relays cut primary service circuit applications by as much as 80 per cent when the trailer air lines are empty.

To safely operate a bobtail tractor:

- Avoid excessive acceleration and heavy brake applications
- Reduce vehicle speed when road surfaces are slippery
- Avoid using auxiliary retarders at powerful settings
- Leave an appropriate following distance from the vehicle ahead
- Exercise more caution when bobtailing in poor weather

Slide: 75 Type: Presentation

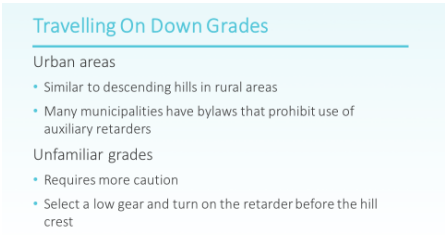
Driving down mountain grades is a challenging skill. Downgrades present one of the greatest challenges for drivers of air brake equipped vehicles because travelling downgrade accumulates more ongoing heat into the brakes. Almost all brake failures and runaway crashes are caused by the brake system's inability to handle excessive heat.



In rural areas, control your speed so you can respond to any emergency. Follow advisory speed limits while allowing for the vehicle weight, grade steepness, weather and road conditions. Select a gear low enough that the service brakes are not required (one to two gears lower than what is required to climb the grade. Use your four-way flashers and stay in the right lane where possible. Use auxiliary retarders.

Slide: 76 Type: Presentation

Descending hills in urban areas is similar to rural areas, except many municipalities have bylaws prohibiting the use of auxiliary retarders. Control the speed to be able to respond to any emergency. Select a safe speed that is not too fast for the vehicle weight, grade, weather and road conditions. Use the auxiliary retarder unless signs prohibit its use.

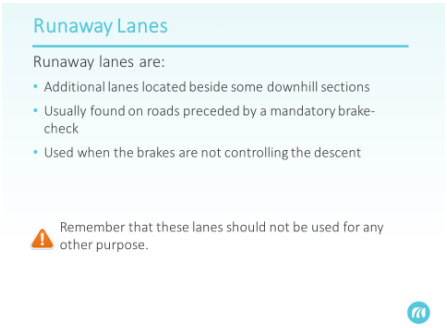


Unfamiliar grades require more caution. When descending an unfamiliar grade, select a low gear and turn on the retarder before the hill crest. Stay in that gear until the steepest part of the descent. If the gear lowers the engine significantly, shift up one gear at a time, testing each new gear (avoid splits). On extreme grades, avoid shifting. A balance between retarder, speed, load and grade is reached when speed is maintained without service brakes.

If speed increases, apply the brakes firmly to reduce speed by 10-15 km/h. The brakes should be cold at this point. Downshift to a lower main gear (do not use splitter valve). Continue down the hill using auxiliary retarder to control the speed. Repeat this process until the retarder can maintain the speed without the service brakes. If the vehicle is in the proper gear before descending the grade this process will not be necessary. Descending hills often requires slower speeds in large trucks than for other vehicles.

ⓘ **Manual Reference:** Chapter 7: Demands on Brakes While Driving.

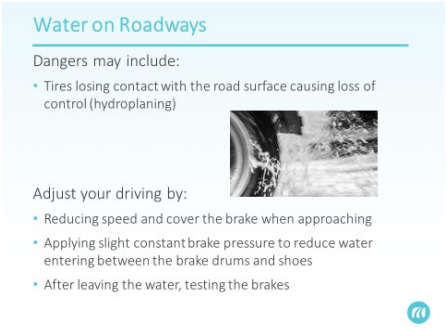
Slide: 77 Type: Presentation



Runaway lanes are additional lanes located beside some downhill sections, usually on roads preceded by a mandatory brake-check. They are often located on downhill grades where runaways have previously occurred. They provide an extra path to help vehicles slow down and stop if the brakes fail.

When using a runaway lane remember to use the lane when the brakes no longer control the descent, but before the vehicle is out of control. A narrow steep runaway lane will be hard to see if the vehicle is out of control on the highway. These lanes should not be used for any other purpose.

Slide: 78 Type: Presentation

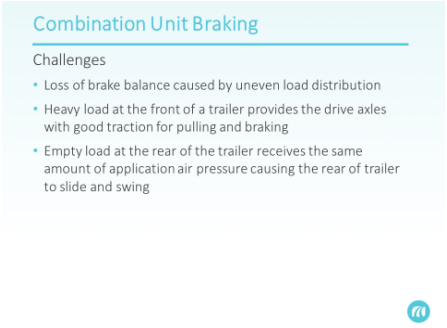


On wet roads, your tires may lose contact with the road surface. This is called hydroplaning. The loss of contact between the road surface and your tires can cause you to lose control of your vehicle.

If this happens, do not brake. Release pressure on the accelerator to allow the vehicle to slow. Look and steer where you want the front of the vehicle to go.

Reduce your speed before driving through large volumes of water. If water enters the brake drum, it affects braking efficiency. However, if it is necessary, reduce speed and cover the brake when approaching. Apply slight constant pressure while driving through the water to reduce the amount of water entering between the brake drums and shoes. After leaving the water, test the brakes for safe operation. This also helps dry them out.

Slide: 79 Type: Presentation

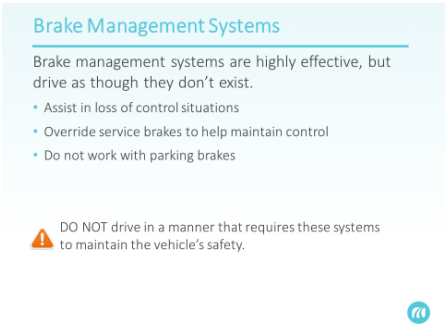


The biggest challenge for combination units is the loss of brake balance caused by uneven load distribution. For example, a heavy load at the front of a trailer provides the drive axles with good traction for pulling and braking. However, the brakes under the empty rear of the trailer will receive the same amount of application air pressure as the drive axles, without the load to hold them on the ground. This can cause the rear of the trailer to slide and swing. ABS can help to maintain brake balance.

Slide: 80 Type: Presentation

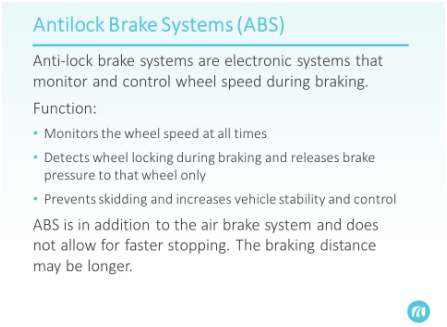
- All vehicles have some type of brake management system. You do not need to know the details of how they work, but you should understand how to use them and how to recognize when service is required.

  Brake management systems are highly effective, but drive as though they don't exist. Brake management systems are technology that assists in loss of control situations. They override service brakes to help maintain control but do not work with parking brakes. DO NOT drive in a manner that requires these systems to maintain the vehicle's safety.



Slide: 81 Type: Presentation

- An anti-lock brake system (ABS) is an electronic system that monitors and controls wheel speed during braking. The system monitors the wheel speed at all times. If it detects a wheel locking up during a brake application, the system releases brake pressure to that wheel only. This prevents the wheel from skidding and increases vehicle stability and control even when braking on wet or ice-slicked roads, through curves or during lane changes.



  When driving a vehicle with ABS, apply the brakes as normal to stop in time. When the ABS starts working, do not release the pressure you have applied to the brake pedal. Avoid pumping the brakes as the system automatically applies and releases the brakes up to five times per second, much faster than you can pump the brake pedal.

  If you encounter a slippery road surface when using an engine brake, the ABS will detect the wheel lock-up and automatically turn off the engine brake until traction is regained, then resume engine braking.

  ABS systems have been mandatory on all air brake trucks, buses, and trailers since April 1, 2000. ABS is additional to the air brake system and does not allow for faster driving or stopping. In some situations, the braking distance may be greater.

  ABS is handled by sensors, modulators and a computer. Sensors mounted on the axle ends relay a voltage signal that is interpreted as wheel speed by the ABS computer.

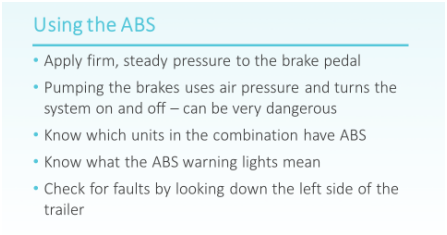
  The computer calculates any differences in wheel speed and directs a modulator to release air pressure in the service chamber of the slower rotating wheels. The modulators can be mounted separately, near the chambers they control, or wing-mounted directly to the relay or quick release valve of the axle group.

- Alternative delivery method: Provide job aid about anti-lock brakes as alternative to reading the notes. If providing the job aid, ensure "How does it apply to my driving?" section is covered at minimum.

Lesson 3 – Anti-Lock Brake System Job Aid

Slide: 82 Type: Presentation

- To learn how to use ABS safely, read the manufacturer's manual. Apply firm, steady pressure to the brake pedal. Pumping the brakes uses air pressure and turns the system on and off – and can be very dangerous. Be careful when steering around obstacles. Make sure you know which units in the combination have ABS. If the tractor or any of the trailers do not have ABS, then use a light steady braking technique.



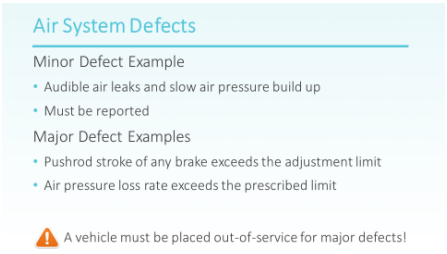
The ABS warning light on the vehicle's dash is similar to other system warning lights. The light will flash on when the ignition is started (bulb test) and will normally stay unlit. A continuously flashing light indicates that the ABS is controlling the service brakes and a steady light indicates a problem with the system.

Trailers equipped with ABS brakes will have an ABS warning light located at the rear of the left side. How the "bulb test" functions depends on how the trailer's ABS system receives electric power. If electric power is only available through the stop light circuit, the light will come on when the service brake is applied and go out, indicating a normal function. Most modern tractors have steady electric power through the blue wire of the trailer light cord (centre pin) when the ignition is on. The bulb will light when the ignition is turned on and go out, indicating a normal function. In either case, a system fault is indicated if the light stays on.

It is a good practice to look down the left side of the trailer when the ignition is turned on, and occasionally when braking, to look for ABS faults.

Slide: 83 Type: Presentation

- There is a difference between major and minor defects. Minor defects must be reported before the next required inspection and the vehicle can continue to be driven. Major defects require the vehicle to be placed out-of-service, even if it is in the middle of your shift.



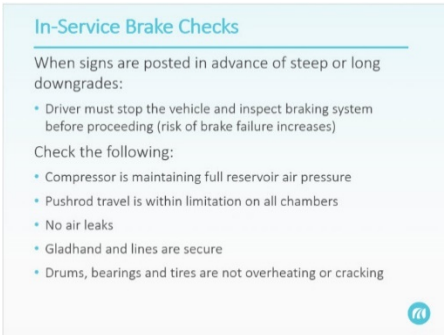
Minor defects must be reported but do not impact the vehicle's ability to be in service. Audible air leaks and slow air pressure build-up are examples of minor defects.

ⓘ Additional information on commercial vehicle inspections can be found here: https://www.gov.mb.ca/mit/mcd/carriers_drivers/pdf/guide/vehicle_maintenance.pdf

- A vehicle must not be driven with any of the following major defects:
  - Pushrod stroke of any brake exceeds the adjustment limit
  - Air pressure loss rate exceeds the prescribed limit
  - Tractor protection system malfunction in towing vehicles
  - Low air pressure warning system fails or activates
  - Service or parking/emergency brake malfunction

Slide: 84 Type: Presentation

- In some areas signs are posted in advance of steep or long downgrades. These signs indicate that you must stop the vehicle in the pullout area and inspect the braking system before proceeding. The risk of brake failure increases on steep or long downgrades.



  Check that:

  - The compressor is maintaining full reservoir air pressure
  - Pushrod travel is within limitations on all chambers
  - There are no air leaks
  - The gladhands and the lines are secure
  - The drums, bearings and tires are not overheating or cracking
  - The trailer supply valve is operating properly

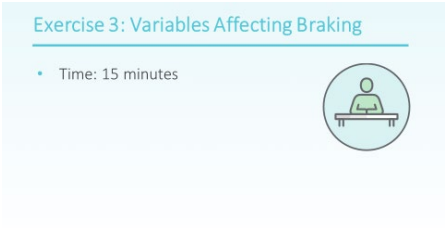
  This should be used as an in-service check only and not mistaken as a daily pre-trip air brake inspection. In-service brake checks involve examining the brake systems that are monitored while the vehicle is in motion.

  Monitor the following while driving:

  - Air pressure gauges
  - Low air pressure warning indicator
  - Be aware of brake system response when brakes are applied

Slide: 85 Type: Self-paced Activity

- You will have 15 minutes to complete Exercise 3 in the Exercise Book.



▶ If time permits, you should review the questions after the students have completed the exercise. Alternatively, you may provide a copy of the **Lesson 3 - Exercise Book Answer Key** at the end of the lesson for them to review on their own time.

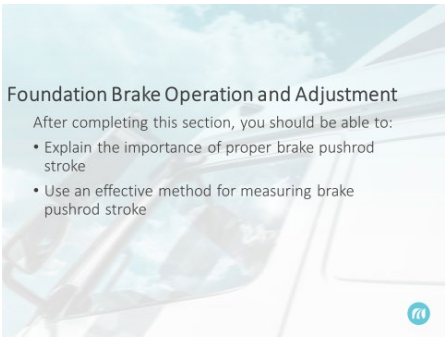
Foundation Brake Operation and Adjustment

Objectives: In this section, students will learn to explain the importance of proper brake pushrod stroke and learn to use an effective method for measuring brake pushrod stroke.

Time: 70 minutes

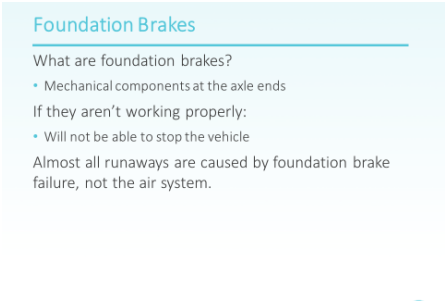
Slide: 86 Type: Presentation

- After completing this section, you should be able to:
  - Explain the importance of proper brake pushrod stroke
  - Use an effective method for measuring brake pushrod stroke



Slide: 87 Type: Presentation

- Foundation brakes are the mechanical components at the axle ends. If they are not working properly, the air brake system will not be able to stop the vehicle. Almost all runaways are caused by failures in the foundation brakes, not the air system. They are activated by the service or parking brake circuits and can be either drum or disc brakes.

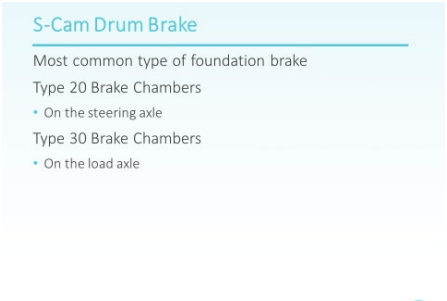


ⓘ **Manual Reference:** Chapter 6: Foundation Brakes

Slide: 88 Type: Presentation

- The "S" cam brake is the most common type of foundation brake used on commercial vehicles with air brake systems.

  The mechanical process starts from the brake chamber. Air pressure is converted from a service brake application to physical force based on the multiplication of the diaphragm's surface area and air pressure being applied. There are type 20 brake chambers on the steering axle and type 30 brake chambers on load axles (drive and trailer).



Slide: 89 Type: Presentation

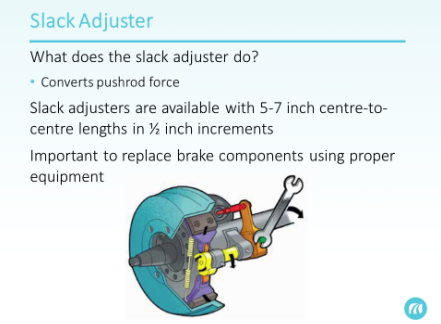
- The cam lobes on the s-cam shaft cause the brake shoe platforms to expand, pressing the lining into the drum with the s-cam head.

- Show the various layouts that are available, ensuring students understand that the mechanical processes are the same.

Slide: 90 Type: Presentation

- The slack adjuster converts pushrod force from the brake chamber to torque on the s-cam shafts. They take up extra clearance created by normal brake wear. Self-adjusting slack adjusters have been around since 1996.

  Slack adjusters are available with 5-7 inch (125 – 179 mm) centre-to-centre lengths in 1/2 inch (13 mm) increments, with either coarse or fine splines on different s-cam shaft thicknesses.

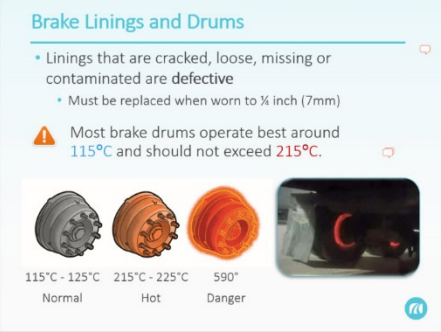


  It is vital that brake components are replaced using the proper equipment. Understanding brake balance is a complex process and Original Equipment Manufacturer (OEM) engineers have created systems that work properly and efficiently.

- **You may wish to provide a copy of the CVSA Self-Adjusting Brake Adjusters Postcard:** https://www.cvsa.org/wp-content/uploads/Brake-Postcard.pdf

Slide: 91 Type: Presentation

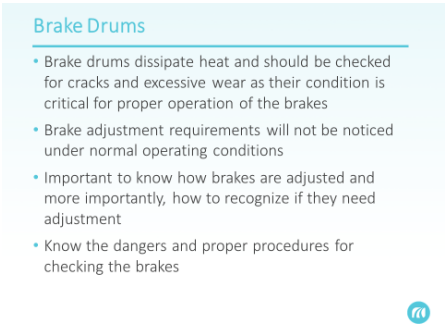
- When inspecting the foundation brake components, the driver must check for cracked, loose, missing or contaminated (with oil or grease) brake linings. Brake linings must be replaced when worn to ¼ inch (7mm). The 1/4 inch (7 mm) minimum lining thickness is from the Commercial Vehicle Safety Alliance (CVSA) roadside inspection out-of-service criteria.



  Brake linings are expanded into the drum by the s-cam shaft. This creates the friction and heat needed to stop the vehicle. Brake linings must be replaced when worn to 1/4 inch (7mm).

  Most brake drums operate best around 115°C and should not exceed 215°C.

Slide: 92 Type: Presentation



Brake drums dissipate the heat into the atmosphere. The drum condition is critical to proper operation of the brakes. They should be checked for cracks and excessive wear.

When the brake is released, the pushrod is at the back of the chamber. The s-cam is rolled back and the brake lining does not contact the drum. Properly adjusted brakes will use the upper half of available pushrod stroke.

Brakes out of adjustment will be using the lower half of available pushrod stroke. However, you may not notice a change in braking capacity under normal operating conditions.

With increased lining to drum clearance, the pushrod stroke is longer. The application is more than half of the available stroke.

Brake adjustment requirements cannot be felt when driving. You may “feel” that the brakes are good, only to have them fail when more is required of them.

You should always check the brakes to ensure they are adjusted correctly.

When adjusted incorrectly (cold drum): with normal brake application pressures this brake will seem to be effective.

When adjusted incorrectly (hot drum): Brake fade occurs partly from component expansion and from reduced brake co-efficiency between the lining and the drum. Cast iron drums expand when heated requiring pushrods to stroke further. Eventually the chamber can bottom out, which creates a total loss of brakes.

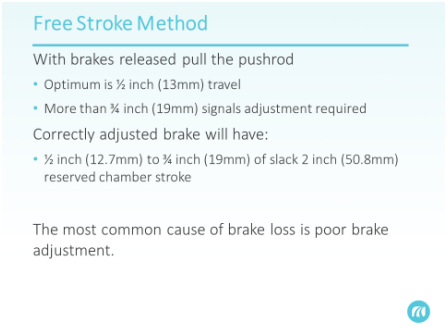
Many companies do not want their drivers adjusting brakes. However, it is important to have a functional understanding of how brakes are adjusted, and more importantly, how to recognize if brakes need to be adjusted before putting equipment into service.

Tractor trailers can have the spring parking brakes alternated on the tow and trailer vehicles. Push in the park control valve (yellow button) and pull out the trailer air supply valve (red button) to check tractor brakes, and pull the yellow button out and push the red button in to check the trailer brakes. Do not leave the ignition key in the vehicle and ensure wheels are properly chocked. Leaving the transmission in gear is not a replacement for properly chocking the wheels.

- Alternative delivery method: Provide a job aid about brake drums as alternative to reading the notes. If providing the job aid, ensure “How do they apply to my driving?” section is covered at minimum.

Lesson 3 – Brake Drums Job Aid

Slide: 93 Type: Presentation



With the brakes released, pull the pushrod. Optimum is 1/2 inch (13mm) travel with a firm hand-pull or pry bar. Less than 1/2 inch (13mm) may drag some brakes, and more than 3/4 inch (19mm) must be adjusted. The optimum 1/2 inch (13 mm) free stroke and the re-adjustment guideline of 3/4 inch (19 mm) applies to manual slack adjusters. Automatic slack adjusters will feel loose, but still within the required applied stroke.

The most common cause of loss of braking is poor brake adjustment. The popular type-30 air chamber has 2-1/2 in. (63.5 mm) of available stroke. A correctly-adjusted brake will have 1/2 in. (12.7 mm) to 3/4 in. (19 mm) of slack, leaving 2 in. (50.8 mm) of reserve chamber stroke. When slack reaches 3/4 in. (19 mm) the brakes MUST be adjusted.

Here's why:

- At an 80 psi (552 kPa) application, a brake chamber with 3/4 in. (19 mm) of slack will stroke 1-3/4 in. (44.5 mm) due to component stretch. This reduces reserve chamber stroke to 3/4 in. (19 mm).
- Cast iron expands when heated. On a hot brake drum this can cause the chamber to stroke a further 1/2 in. (12.7 mm), reducing reserve stroke to 1/4 in. (6.4 mm).
- At high temperature, brake lining wears rapidly. Lining wear thickness of three sheets of paper causes the chamber to stroke a further 1/4 in. (6.4 mm), resulting in the chamber "bottoming out" and a probable runaway truck.

Even with cold drums, a vehicle with poorly adjusted brakes will have a stopping distance of up to 75% longer than normal.

Slide: 94 Type: Presentation

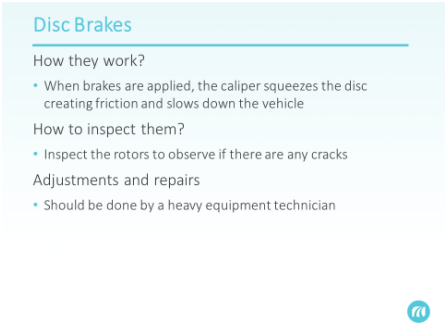
Vehicles manufactured with automatic slack adjusters cannot be retrofitted with manual slack adjusters. Automatic slack adjusters have been installed on all trucks, tractors, trailers and buses since 1996.

Automatic slack adjusters are designed to continuously and automatically maintain the brakes in proper adjustment during normal use. However, they must be checked daily to ensure they are maintaining proper pushrod travel - less than 1 in. (25.4 mm) when manually pulled and less than 2 in. (50.8 mm) when the brake is applied. Normally two to four brake applications of 100 psi (689 kPa) per day will keep the brakes properly adjusted. If they are badly out of adjustment, it may take up to 12 brake applications of 100 psi to adjust them. If they are still out of adjustment, they must be repaired.

Do not try to adjust them yourself unless you have been trained by a mechanic or trainer who is familiar with setting up and backing off this type of automatic slack adjuster.

Slide: 95 Type: Presentation

When the brakes are applied, the caliper squeezes the disc creating friction and slowing the vehicle. The brake chamber forces the caliper to clamp the brake lining against the rotor. Most air disk brakes feature internal automatic brake adjustment mechanisms.

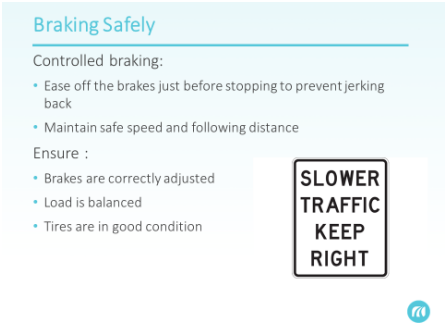


Inspect the rotors to observe cracks. Rotors can be hard to see, with cracks hiding behind the brake pads and backing plate. However, some part of the rotor is generally visible. By inspecting the rotors often, any cracks will eventually become visible.

Adjustments and repairs should be done by a qualified heavy equipment technician.

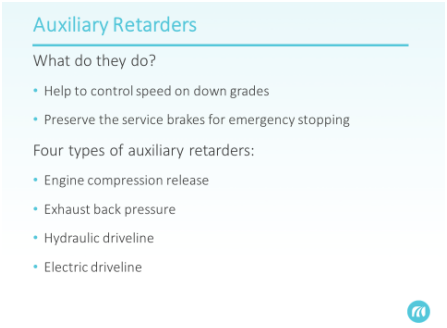
Slide: 96 Type: Presentation

Effective and controlled braking is important to the safe and efficient operation of equipment. Ease off the brakes just before stopping to prevent jerking back. Maintain a safe speed and following distance. Ensure brakes are correctly adjusted, load is balanced and tires are in good condition.



Slide: 97 Type: Presentation

Many heavy vehicles have auxiliary retarders to assist the service brakes. They help to control speed on downgrades and preserve the service brakes for emergency stopping.



There are four types of auxiliary retarders: engine compression release, exhaust back pressure, hydraulic driveline, and electric drive line.

Engine brakes help control speeds when properly used, but are not intended for emergency braking. Auxiliary retarders provide additional braking control, but do not meet sudden or large braking demands.

Engine retarders change the exhaust valve timing by opening the exhaust valve at the top of the compression stroke, essentially turning the engine into an air compressor. Compressing combustion chambers, without the rebound of compressed air and diesel combustion, works against the driveline. This technique is common in North American engines.

Exhaust retarders can be thought of as a stovepipe damper closing the exhaust pipe. Exhaust can be retarded by either a butterfly type valve or a sliding gate valve. Retarding increases back pressure in the exhaust, making it harder to push the spent combustion gas from the cylinder. This increases the crank's resistance as it pushes the rods up into the increased back pressure.

Limiting this is the strength of the exhaust valve springs. If the back pressure is too high, the exhaust valves start to float open, causing them to hit the piston tops at the top of their stroke. The exhaust retarders need to be adjusted so the back pressure stays within the engine's back pressure capacity.

Hydraulic driveline retarders are similar to torque converters. The rotor vanes pump oil into the housing vanes, which puts resistance into the driveline. You need to be mindful of engine oil temperature and turn the retarder off when the engine oil becomes too hot.

Electric driveline retarder is an electromagnet designed to retard drive shaft rotation. All the heat generated is vented out through the rotor vanes and housing. These can be found on all types of vehicles, but are primarily installed on transit buses, emergency vehicles and waste disposal vehicles. They are activated by service brake applications, unlike the operation of the previous three retarders.

Auxiliary retarders work best with lower speeds, and with the engine just under the rated RPM. When using auxiliary retarders, select the appropriate gear before starting downhills. Be cautious on slippery roads. They can overpower available traction, causing loss of control.

Be aware of excessively loud retarders in urban areas. In many urban areas they are prohibited.

- Alternative delivery method: Provide a job aid about retarders as alternative to reading the notes. If providing the job aid, ensure "How do they apply to my driving?" section is covered at minimum.

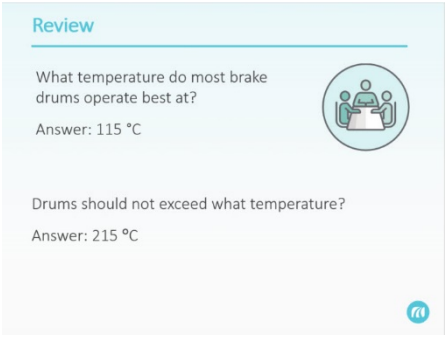
Lesson 3 – Retarders Job Aid

Slide: 98 Type: Self-paced Activity

- You will have 15 minutes to complete Exercise 4 in the Exercise Book.
- If time permits, you should review the questions after the students have completed the exercise. Alternatively, you may provide a copy of the **Lesson 3 - Exercise Book Answer Key** at the end of the lesson for them to review on their own time.

Slide: 99 Type: Discussion

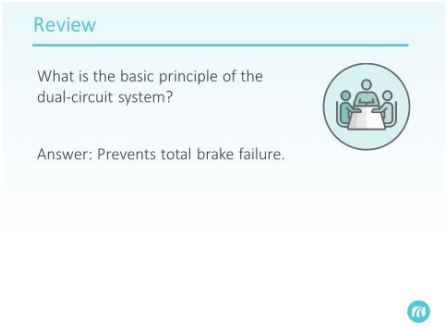
- ? What temperature do most brake drums operate best at?
- Wait for students to respond, then click to reveal.
- ? Drums should not exceed what temperature?
- Wait for students to respond, then click to reveal.



Slide: 100 Type: Presentation

? What is the basic principle of the dual-circuit system?

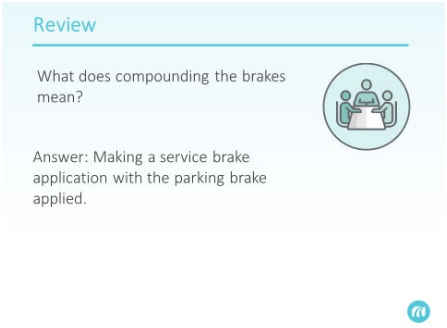
▶ Wait for students to respond, then click to reveal.



Slide: 101 Type: Discussion

? What does compounding the brakes mean?

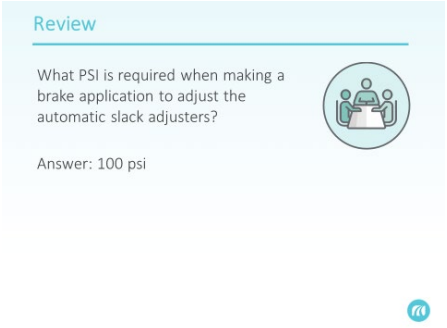
▶ Wait for students to respond, then click to reveal.



Slide: 102 Type: Discussion

? What psi is required when making a brake application to adjust the automatic slack adjusters?

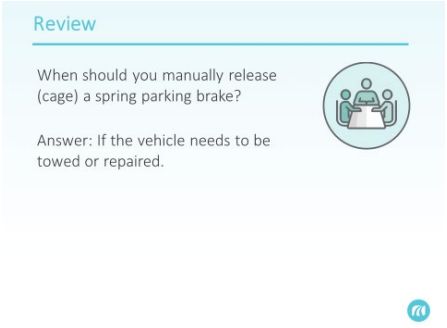
▶ Wait for students to respond, then click to reveal.



Slide: 103 Type: Presentation

? When should you manually release (cage) a spring parking brake?

▶ Wait for students to respond, then click to reveal.



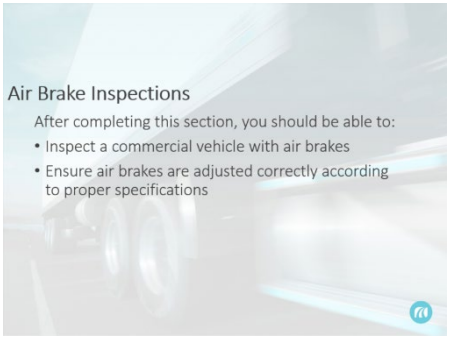
Air Brake Inspections

Objectives: This section explains how to inspect a commercial vehicle with air brakes.

Time: 5 minutes

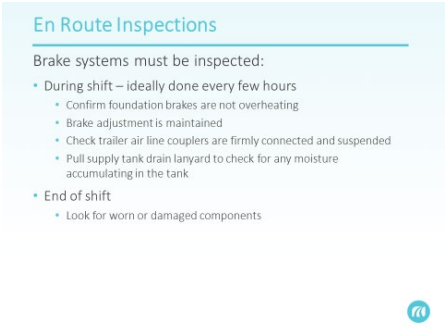
Slide: 104 Type: Presentation

- After completing this section, you should be able to inspect a commercial vehicle with air brakes and ensure air brakes are adjusted correctly according to proper specifications.



Slide: 105 Type: Presentation

- Brake systems must be inspected during and at the end of a shift. During the shift:
  - Confirm that the foundation brakes are not overheating and brake adjustment is maintained
  - Check that the trailer air line couplers are still firmly connected and suspended
  - Pull the supply tank drain lanyard (or crack the drain valve) to check for any moisture accumulating in the tank

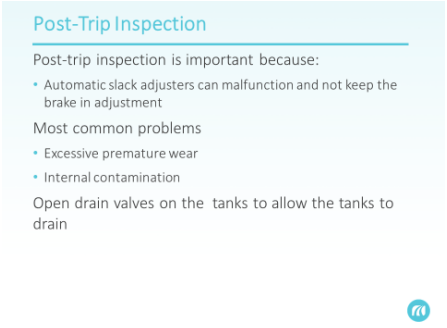


Ideally an en route inspection should be done every few hours to confirm that the vehicle can remain in service.

At the end of shift look for worn or damaged components.

Slide: 106 Type: Presentation

- At the end of the shift, conduct a post-trip inspection and report any defects for repair. Confirm that the foundation brakes have not overheated. Ensure that they have maintained proper adjustments. Open the drain valves on the tanks (supply first) to allow the tanks to drain.



Automatic slack adjusters can malfunction and not keep the brake in adjustment, especially when the vehicle has been in service for a long time. The two most common problems are excessive premature wear and internal contamination. Through normal usage, the internal components that sense when an adjustment is required wear out, resulting in more stroke required for the lining to contact the brake drum. If not checked the brake could be out of adjustment.

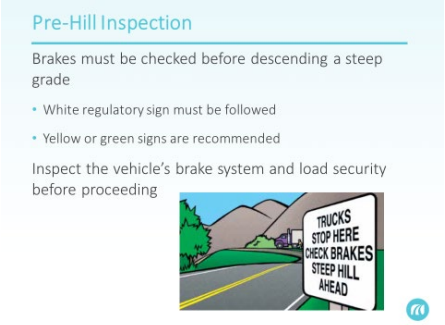
If even a small amount of water is sucked into an automatic slack adjuster mechanism, it can cause corrosion or, in winter, it can freeze the internal sensing components and inhibit or prevent adjustment.

Slide: 107 Type: Presentation

- Brakes must be checked before descending a steep grade. White regulatory signs mean brakes must be checked. Yellow or green signs mean brake checks are recommended.

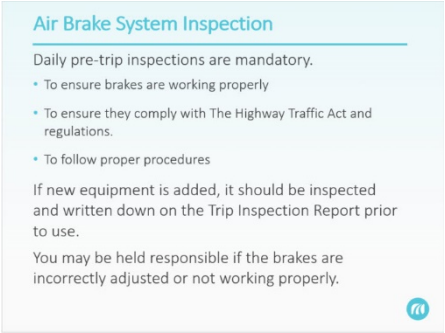
  Park in the pullout area and inspect the vehicle's brake system and load security before proceeding.

  Brake check pullouts have information signs advising you what you should be inspecting. Additionally, many have signs that provide information about the grade ahead.



Slide: 108 Type: Presentation

- The Commercial Vehicle Safety Regulation of the Traffic Safety Act outlines the requirements of daily vehicle trip inspections. Equipment in service is covered by a daily vehicle trip inspection report, which is valid if it was completed within the previous 24 hours. If any new equipment is added to the vehicle, it should be inspected and written down on the trip inspection report prior to its use.



  Daily pre-trip inspections are mandatory to ensure brakes are working correctly, to ensure compliance with HTA regulations and to follow proper procedures.

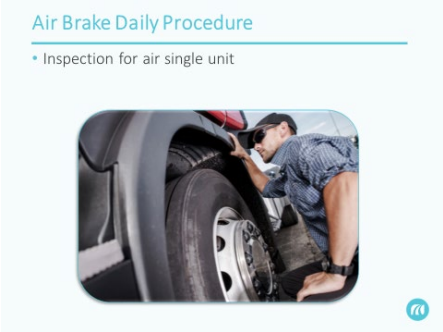
  The air brake system pre-trip inspection ensures the brake system works properly. It is performed during the daily vehicle trip inspection. Trucks pulling trailers should be inspected after coupling, and the trailer is charged.

  The procedure to check an air system has been designed to be included with other vehicle trip inspection activities, rather than being conducted as a separate procedure. There is no mandatory order for conducting a vehicle trip inspection, but all drivers must incorporate the air brake pre-trip in their normal vehicle trip inspection process.

- The detailed list of major and minor defects is located in the textbook as well as on the Manitoba government website. You will need to have the regulation, inspection schedule and MPI Air Brake Manual accessible to students in this section.

ⓘ Reference: https://www.mpi.mb.ca/Documents/AirBrakeManualNEW.pdf

Slide: 109 Type: Presentation



The daily inspection procedures align with the regulation, and the standards published in the 2014 National Safety Code (NSC) Standard 11B.

Periodic Mandatory Vehicle Inspections are performed by Commercial Vehicle Safety Alliance (CVSA) authorized officers. The Out-of-Service Criteria (or OOSC) informs officers when to place vehicle out of service at roadside safety inspections. The OOSC identifies serious violations that render a commercial vehicle or commercial vehicle operator an imminent danger to the general public. Commercial vehicles and operators placed Out-of-Service cannot operate until those items that rendered them out of service are remedied or repaired.

ⓘ For more information, visit the Canadian Council of Motor Transport Administrators http://www.ccmta.ca

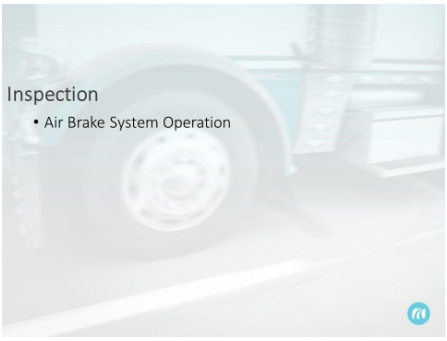
Inspections: System Operation

Objectives: This section explains the step by step procedures for inspecting air brake system operation.

Time: 20 minutes

Slide: 110 Type: Presentation

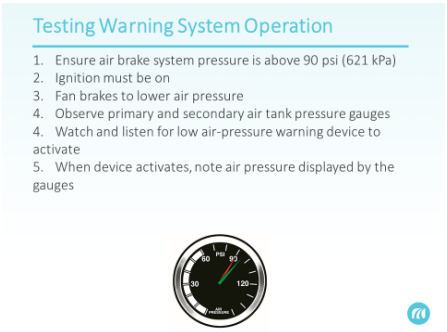
- In this section, we will review in detail the inspection procedures, confirming the air brake system is operational.



Manual Reference: Chapter 10: Inspecting Air Brake System Operation

Slide: 111 Type: Presentation

To test the low air-pressure warning device, pressure in the system must be reduced to the point where the device activates or 55 psi (380 kPa), whichever is higher. The pressure when the warning device deactivates during a rise in pressure is not necessarily the same point at which it activates during a drop in pressure. Begin the test with the pressure above 90 psi (621 kPa) and the engine running. Reduce pressure by fanning the brakes (repeatedly pressing and releasing the brake pedal).



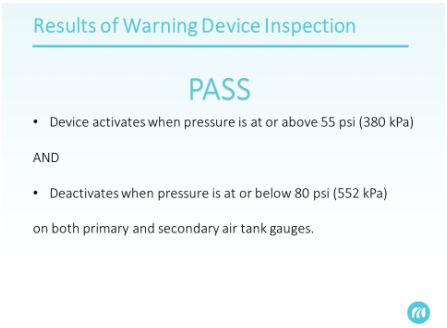
Observe the air pressure gauges and note when the device activates. Most warning devices will activate above 60 psi (414 kPa). If the warning device fails to activate at a minimum of 55 psi (380 kPa), the low air-pressure warning device is defective.

Build pressure to 80 psi (552 kPa). Observe the air-pressure gauges and note when the device deactivates. Most warning devices will deactivate before reaching 80 psi (552 kPa).

Slide: 112 Type: Presentation

- If the warning device fails to deactivate at a maximum of 80 psi (552 kPa), the low air-pressure warning device is defective.

  A warning system pass is when the device activates when pressure is at or above 55 psi (380 kPa) and deactivates when pressure is at or below 80 psi (552 kPa) on both primary and secondary air tank gauges.



  A fail of this system is when the device does not activate or activates when pressure is below 55 psi (380 kPa) on either the primary or secondary air pressure gauge.

  Also a failure is noted when the device does not deactivate or deactivates when pressure is above 80 psi (552 kPa) on either the primary or secondary air pressure gauge.

? Is this a major or minor defect according to Schedule A?

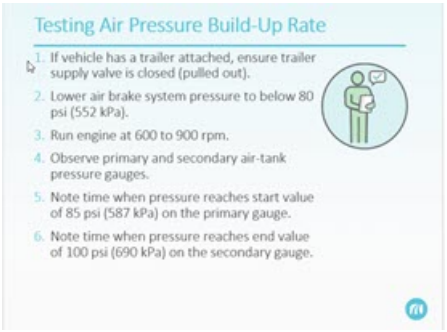
▶ Wait for answers, then provide the correct answer if no one has given it.

- This is a major defect.

Slide: 113 Type: Presentation

- The air compressor must be able to meet the demands of the air brake system and restore pressure to normal range quickly. Confirm this by testing whether air pressure rises to a specified level in a specified time, by reducing the system pressure to below 80 psi (552 kPa).

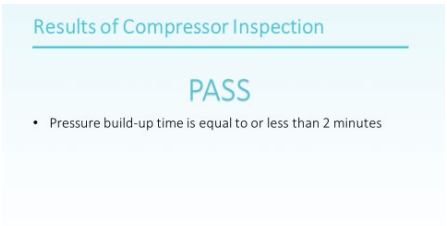
  If the vehicle has a trailer attached, ensure the trailer supply valve is closed (pulled out). With the engine idling between 600 and 900 rpm, observe the time required for the air pressure to rise from 85 psi (587 kPa) to 100 psi (690 kPa).



Slide: 114 Type: Presentation

- A pass occurs if pressure build-up time is equal to or less than two minutes.

  If pressure build-up time is greater than two minutes, this is a failure of the compressor operation and the air brake system is defective.



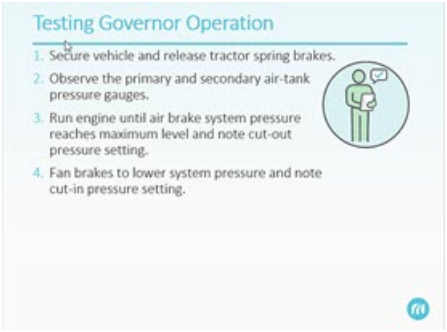
? Is this a major or minor defect according to Schedule A?

▶ Wait for answers then provide the correct answer if no one has given it.

- This is a minor defect.

Slide: 115 Type: Presentation

- Air brake systems must operate with air pressure within a prescribed range. The system's pressure range is controlled by the air compressor governor settings, which determine when the air compressor will cut out and cut in.



  The model year can affect the governor pressure setting. Air brake system operating pressure ranges have increased over the past 20 years. Older systems may operate with lower pressure settings.

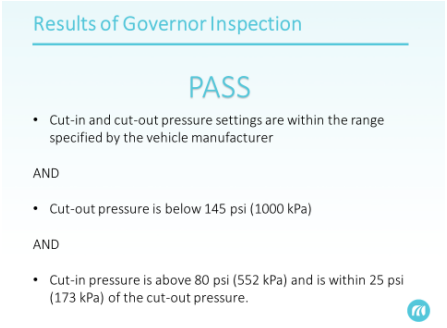
  Air pressure gauges stop climbing with compressor cut-out. When a vehicle uses an air dryer, its exhaust cycle also indicates that the compressor has reached the cut-out setting. Observe the primary and secondary air-tank gauges to confirm when the pressure stops climbing and when the cut-out setting is reached.

  The cut-in pressure setting is normally 20 to 25 psi (138 to 173 kPa) below the cut-out pressure setting. Compressor cut-in changes the sound of the engine and can be observed when the air tank gauges begin to show a pressure increase.

  Cut-out and cut-in pressures should remain within the range specified by the vehicle manufacturer, and any change in these pressures should be reported. Inspection is based on the maximum actual cut-out pressure and maximum actual cut-in pressure.

Slide: 116 Type: Presentation

- Actual cut-out pressure must never be higher than 145 psi (1,000 kPa). Actual cut-in pressure must never be less than 80 psi (552 kPa) or the air brake system is defective.



  In order to pass inspection, the cut-in and cut-out pressure settings must be within the range specified by the vehicle manufacturer: cut-out pressure below 145 psi (1,000 kPa), and cut-in pressure above 80 psi (552 kPa) and within 25 psi (173 kPa) of the cut-out pressure.

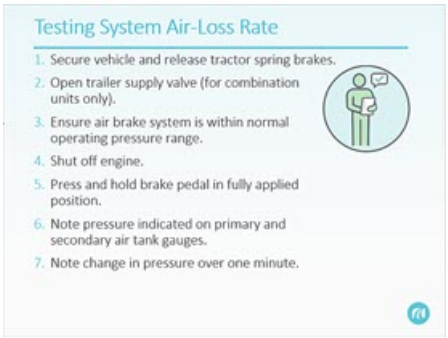
  A failure of the governor operation is when the actual cut-out pressure is above 145 psi (1,000 kPa) or actual cut-in pressure is below 80 psi (552 kPa) or is more than 25 psi (173 kPa) lower than the cut-out pressure.

? Is this a major or minor defect according to Schedule A?

▶ Wait for answers then provide correct answer if no one has given it.

- This is a minor defect.

Slide: 117 Type: Presentation



- Watch for air brake system leaks and pressure loss in the air tanks when brakes are not being used, which indicates air loss in the air brake system. For safety, you should test the air loss rate.

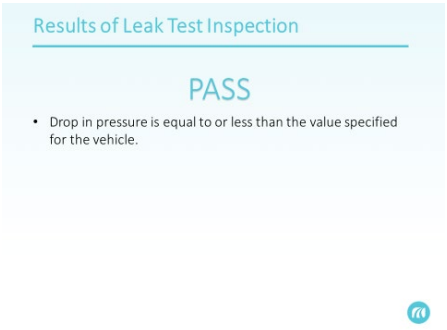
  Properly secure the vehicle.

  Release the spring brakes, establish normal air pressure and shut off the engine. Hold the brake pedal in the fully applied position and observe the air pressure readings for one minute.

  The pressure drops noticeably when the brakes are first applied, but must not continue to drop at a rate greater than specified in the chart in the air brake manual.

  Do not consider the amount of pressure drop that happens when brakes are first applied.

Slide: 118 Type: Presentation



? According to the MPI Air Brake Manual, what results indicate a pass in the leak test?

▶ Wait for answers then provide the correct response if no one has given it (animated slide, click to reveal answer).

- When the drop in pressure is equal to or less than the value specified for the vehicle, the leak test passes the inspection.

? According to the MPI Air Brake Manual, what results in a failure?

▶ Wait for answers then provide the correct answer if no one has given it.

- A failure is when the drop in pressure exceeds the value specified for the vehicle.

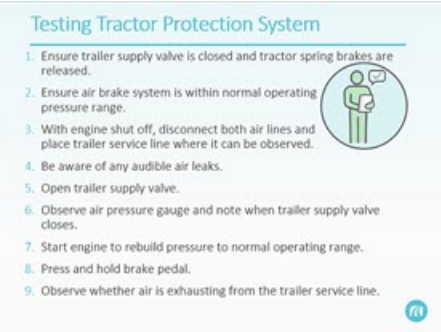
? Is this a major or minor defect according to Schedule A?

▶ Wait for answers then provide the correct answer if no one has given it.

- This is a major defect.

Slide: 119 Type: Presentation

- The tractor protection valve on a tractor ensures that an air loss problem in the trailer does not result in loss of air from the tractor.



  Ensure the trailer supply valve is closed (pulled out) and tractor spring brakes are released.

  Ensure that the air brake system is within its normal operating pressure range.

  With the engine shut off, disconnect both air lines and place the trailer service line where it can be observed. Be aware of any audible air leaks.

  Open the trailer supply valve.

  Observe the air pressure gauge and note when the trailer supply valve closes (pops). Failing to close or closing below 20 psi (138 kPa) indicates a major defect in the trailer supply valve.

  Start the engine (if needed) to rebuild pressure to normal operating range.

  Press and hold the brake pedal.

  Observe whether air is exhausting from the trailer service line.

Slide: 120 Type: Presentation

- If air does not exhaust from the trailer service line, the tractor protection valve has passed inspection.

  If air exhausts from the trailer service line, the valve has failed inspection.

? Is this a major or minor defect according to Schedule A?

▶ Wait for answers then provide the correct answer if no one has given it.

- Exhausting air indicates a major defect in the tractor protection valve as per Schedule A.

Slide: 121 Type: Presentation

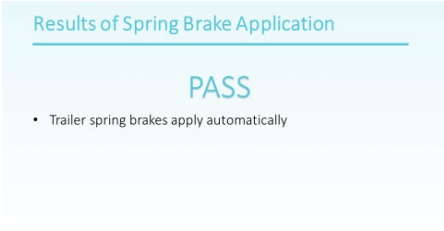
- A trailer's spring brakes must automatically apply whenever the trailer is disconnected from the towing vehicle. To test this, open (push in) the trailer supply valve to fully charge the trailer. Then pull out the trailer supply valve to close it. The trailer spring brakes should apply. Disconnecting the trailer air supply line also activates this function, but closing the trailer supply valve is the recommended testing method. Brake application may be confirmed by gently applying engine power to move the vehicle forward or backward.

Slide: 122 Type: Presentation

- To pass inspection, the trailer spring brakes must apply automatically.

  The vehicle fails the test if the trailer spring brakes do not apply.

  This is a major defect as per Schedule A.



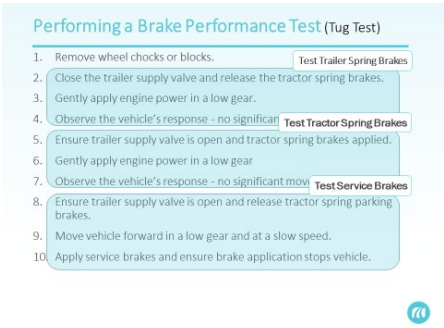
Slide: 123 Type: Presentation

- Animated slide - click for each part of the tug test.

  - A vehicle's spring brakes must be able to hold the vehicle in place, while the service brakes must stop the vehicle when applied. Test the performance of your tractor-trailer brakes by performing separate tests of each braking system.

    To test your trailer spring brakes, remove the wheel chocks or blocks. Close the trailer supply valve and release the tractor spring brakes then move forward slowly. The vehicle may rock and shake and the wheels may move slightly, but there should be no significant movement of the vehicle. Test your tractor spring brakes by repeating this process with your tractor spring brakes applied and the trailer supply valve open. Test your service brakes by opening the trailer supply valve, releasing the tractor spring brakes and moving forward at a slow speed before applying the service brakes. If the vehicle has a hand valve, it should be tested in the same way as the service brakes.

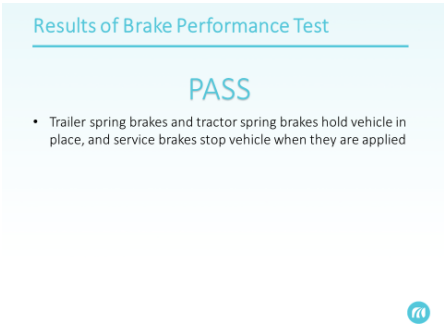
    If equipped with a trailer hand valve, the procedures include four extra steps for testing trailer service brakes. These procedures are covered in the MPI Air Brake Manual.



Slide: 124 Type: Presentation

- If the trailer spring brakes and the tractor spring brakes hold the vehicle in place, and the service brakes stop the vehicle when they are applied, the brakes have passed the inspection.

  An inspection failure is when the trailer spring brakes and the tractor spring brakes do not hold the vehicle in place, or the service brakes are not able to reasonably stop the vehicle.



? Is this a major or minor defect according to Schedule A?

- Wait for answers then provide the correct answer if no one has given it.

  - This is a major defect as per Schedule A.

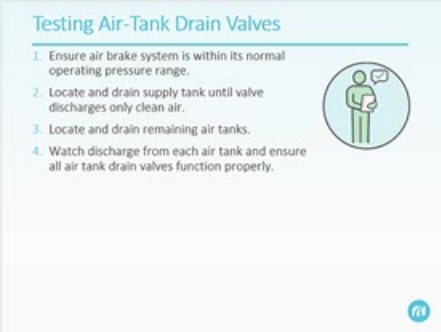
Slide: 125 Type: Presentation

- Ensure that the air brake system is within its normal operating pressure range.

  Locate and drain the supply tank until the valve discharges only clean air. The supply tank should always be drained first to prevent accumulated moisture in the supply tank passing farther into the system.

  Locate and drain the remaining air tanks.

  Watch the discharge from each air tank and ensure that all air tank drain valves function properly.



Slide: 126 Type: Presentation

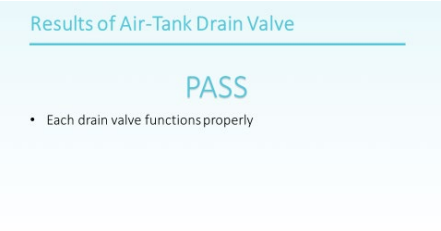
- The vehicle passes the test when each drain valve functions properly.

  The vehicle fails the test when any drain valve fails to function properly.

? Is this a major or minor defect according to Schedule A?

▶ Wait for answers then provide the correct answer if no one has given it.

- This is a minor defect as per Schedule A.



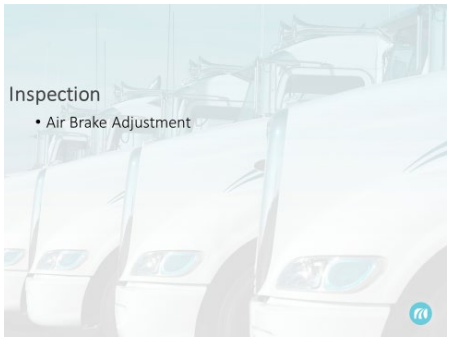
Inspections: Adjustment

Objectives: This section explains the step by step procedures for inspecting air brake adjustment.

Time: 20 minutes

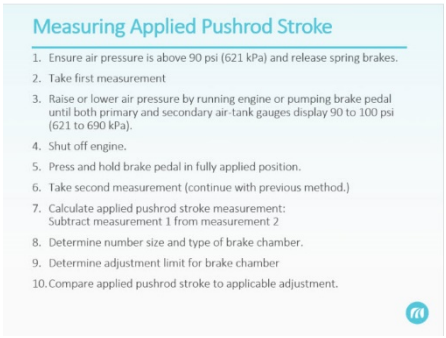
Slide: 127 Type: Presentation

- The next section explains the details of the air brake adjustment inspection procedures.



Slide: 128 Type: Presentation

- Animated slide - click to reveal the two different methods for obtaining each measurement
  - The pushrod stroke of each brake chamber is critical to the proper functioning of a brake system. As the brakes wear, brake pushrod stroke increases. Brake wear occurs at varying rates, depending on the type of vehicle and driving conditions. To determine whether brake adjustment is correct, the pushrod stroke must be inspected at least daily.



  Secure the vehicle with wheel chocks or blocks.

  Ensure air pressure is above 90 psi (621 kPa) and release the spring brakes.

  Select one of the following methods:

- Click to animate.
  - Method 1: Mark the pushrod at the brake chamber or at a suitable fixed reference point (use chalk, soapstone, marker or other similar instrument — marks must be narrow and precise).

    Method 2: Measure the released position of the pushrod. Measure and note the distance from a point on the pushrod to a suitable fixed point at the brake chamber. This is measurement number 1.

- Click to animate.
  - Raise or lower the air pressure by running the engine or pumping the brake pedal until both the primary and secondary air tank gauges display 90 to 100 psi (621 to 690 kPa).

    Shut off the engine.

Press and hold the brake pedal in the fully applied position.

Determine the applied pushrod stroke (continue to use the previously selected method):

- Click to animate.

  - Method 1: Measure the distance from the brake chamber or fixed reference point to the mark on the pushrod.

    Method 2: Measure the applied position of the pushrod. Re-measure and note the distance from the previously selected point on the pushrod to the previously selected fixed point at the brake chamber. This is measurement number 2. Subtract measurement 1 from measurement 2 to calculate the applied pushrod stroke measurement.

- Click to animate.

  - Determine the number size (such as 16, 20, 24, or 30) and type (such as standard or long-stroke) of the brake chamber.

    Determine the adjustment limit for the brake chamber (see the chart in the foldout section).

    Compare the applied pushrod stroke to the applicable adjustment limit and identify any brake that exceeds the adjustment limit as defective.

Hand out **Lesson 3 – Job Aid** for review of how to compare the measured value with the adjustment limit.

  - The Air Brake adjustment limits chart is used to determine the adjustment limit for the brake chamber.

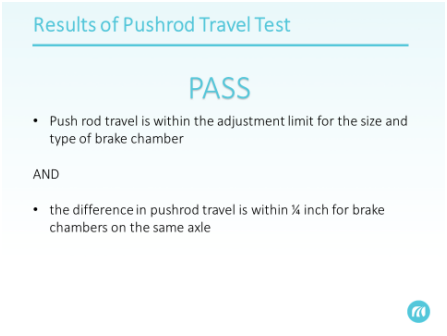
- You may also wish to provide a copy of the CVSA **Air Brake Pushrod Stroke** brochure: https://www.cvsa.org/wp-content/uploads/Airbrake-Pushrod-Stroke-Brochure.pdf

ⓘ **Manual Reference:** Chapter 11: Inspecting Air Brake Adjustment

Slide: 129 Type: Presentation

  - A pass condition is when the push rod travel is within the adjustment limit for the size and type of brake chamber and the difference in pushrod travel is within 1/4 inch (7 mm) for brake chambers on the same axle.

    A failure is when the push rod travel exceeds the adjustment limit for the size and type of brake chamber or there is more than 1/4 inch (7 mm) difference in the pushrod travel of brake chambers on the same axle.



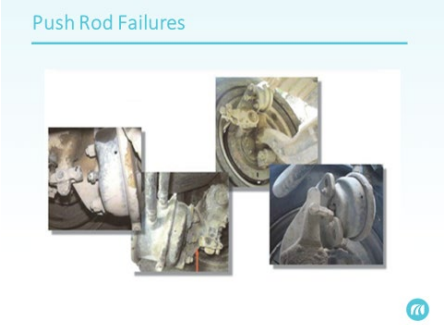
? Is this a major or minor defect according to Schedule A?

- Wait for answers then provide the correct answer if no one has given it.

  - This is a major defect as per Schedule A.

Slide: 130 Type: Presentation

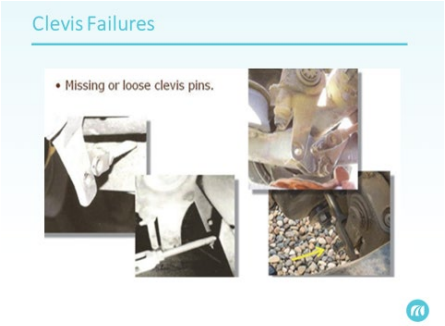
- These are examples of broken push rods. Both service and park applications cannot deliver brake power to the foundation brake.



- Point out the damage to students and advise them that these are not always obvious. If the push rod and slack adjuster are still lined up, damage can be hard to notice. Push rods must be directly looked at to find these failures.

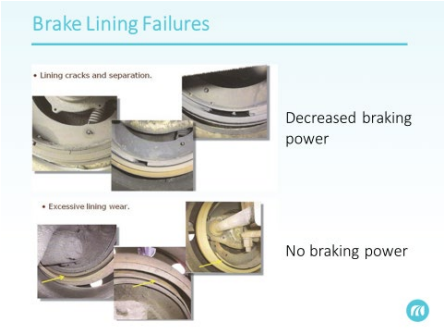
Slide: 131 Type: Presentation

- These are clevis pin failures. The cotter pins sheer and allow the clevis pins to work their way out. The brakes cease to work when the clevis completely separates. The clevis pin in the fourth picture has not completely separated; brake applications will still apply normally. Note that the vehicle in the picture is new. Failures can happen on both new and older vehicles.



Slide: 132 Type: Presentation

- Brake lining failure decreases the friction surface area. How much the brake force is reduced depends on whether any brake lining is missing. These types of failures will decrease brake capacities as the brake material continues to separate.



  These are examples of extremely worn brake linings. There is no brake power in any of these situations.

  Excessively worn brake linings lead to a condition called “cammed over.” This occurs when the lining becomes so thin that nothing stops the rollers from going past the largest radius of the s-cam lobes as the brakes are applied, making the brakes ineffective.

  CVSA standards require at least 1/4 inch (7 mm) lining thickness.

Slide: 133 Type: Presentation

- Oil saturation is caused by leaking wheel seals. It shows up in two different ways. If the oil is leaking while moving, the oil will streak in radius lines around the entire inner sidewall of the inner tire. If the oil is leaking while the vehicle is parked, it will drain down the inner sidewall of the inner tire below the axle and puddle on the ground.

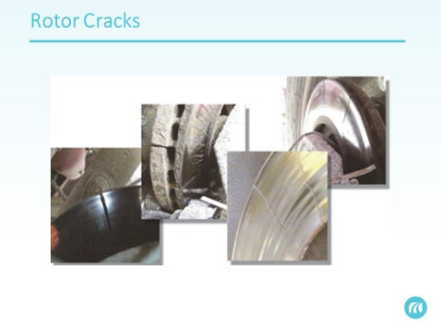
Slide: 134 Type: Presentation

- Cracked drums are caused by a series of overheating and cooling. The cracking starts from the friction surface of the drum and works its way to the outside surface. The centrifugal force on the separated sections causes the cracks to widen, and eventually the drum comes apart.

  This is what happens to drums when early cracks are not repaired. The second picture shows a drum section that has recently separated. Pieces usually become separated while the vehicle is moving, and become dangerous projectiles to other road users. You generally won't know when or where the separations take place or the damage that they may cause.

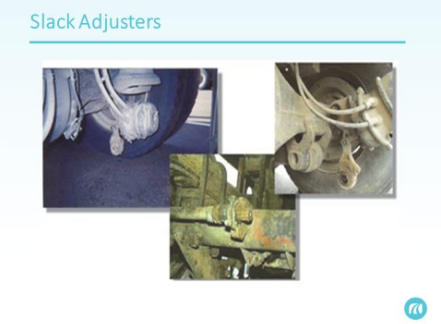
Slide: 135 Type: Presentation

- Rotor cracking is easy to spot unless the rotors are covered by backing plates, or when cracks are hidden under the calipers. Disc rotors should be checked during the inspections and during the work shift.



Slide: 136 Type: Presentation

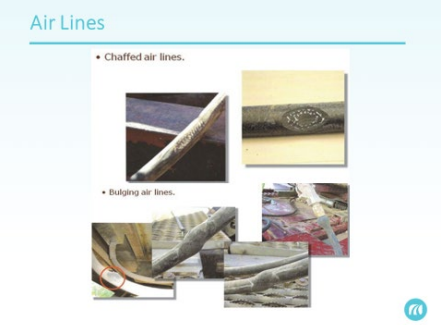
- The first and third pictures are caused by a separated retaining snap ring from the end of the s-cam shaft. The slack adjuster then works its way off of the s-cam shaft's splines. The brakes will apply normally until the moment the slack adjuster separates, after which there will be no applications at the foundation brake. The slack adjuster in the second picture was rusted to the point that a brake application broke it off.



Slide: 137 Type: Presentation

- Chaffed air lines are the result of incorrectly secured air lines which rub on nearby parts. Chaffing does not cause any reduction in brake performance until the hoses rupture. This will cause circuit failures, as discussed previously.

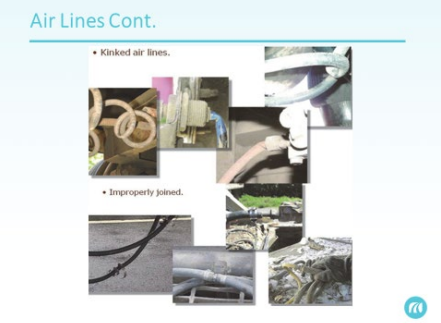
  Hose bulges are caused by internal structure failure or excessive chaffing. Bulging hoses will rupture causing circuit failures.



Slide: 138 Type: Presentation

- Kinked hoses cause reductions in brake performance by restricting or blocking the flow of air pressure. The first three pictures show plastic air line kinks. Once the plastic air line is kinked, it is permanently damaged and must be replaced. The fourth picture is a rubber air line. A rubber air line kink can cause internal structural damage, which can eventually lead to bulging.

  Fittings are designed to cause a minimum of air pressure flow restriction while still securely gripping the hose. Different systems of fittings are not compatible with each other and should never be mixed. Air lines must be installed with the correct fitting system designed for the hose used.



Slide: 139 Type: Presentation

- The compressed parking spring is relatively safe when secured in its housing. However, the corrosion shown in these pictures weakens the chamber so the parking spring can eventually escape with tremendous force. This is an extremely dangerous failure that can cause severe injury or death.

  Any corrosion or damage seen in brake chambers or clamp rings must be immediately repaired by certified heavy equipment technicians.

  The two lower pictures are examples of separated brake chambers. There will be no application at the respective foundation brakes.

Slide: 140 Type: Presentation

- Loose brake chambers can still apply some application force to the foundation brakes depending on how loose they are. The application force is reduced by chamber deflection caused by the failed mounting components. Inspect the mounting fasteners and brackets to confirm that the brake chamber is securely installed.

Slide: 141 Type: Presentation

- Foundation brake component failures can result in anything from a minor application reduction to a complete failure.

▶ Point to pictures from left to right. Describe the specific failures as noted:

  - disconnected return springs
  - separated rollers
  - a separated inner s-cam bracket on a trailer
  - a separated brake shoe

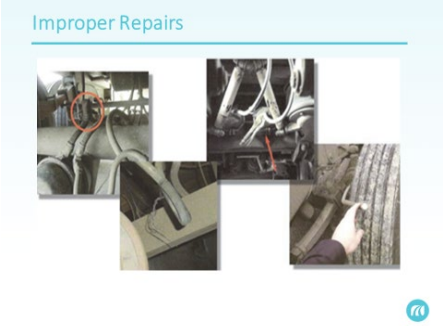
Slide: 142 Type: Presentation

- A loose air tank does not cause a failure until it separates from the circuit it supplies. This causes an immediate circuit failure. During a vehicle inspection, push each end of the air tanks to confirm that they are securely mounted.

Slide: 143 Type: Presentation

- Air system failures are sometimes dealt with by blocking off the air lines that supply the failed component. This reduces the braking capacity of the vehicle and is never acceptable. If there are system failures that affect braking ability, the vehicle must be placed out-of-service until appropriate repairs are made.

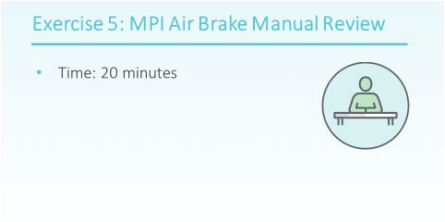
  The first two pictures show air lines that are obstructed by kinking and wired closed. In the third picture, a pair of clamping pliers is used to close off the line. In the fourth picture, a coin is used in a swivel fitting to close off a leaking service chamber.



Slide: 144 Type: Self-paced Activity

- You will have 20 minutes to complete Exercise 5 in the Exercise Book.

- Instruct students to use the MPI Air Brake Manual for this exercise. Review the answers for Exercise 5, using the **Lesson 3 - Exercise Book Answer Key**.

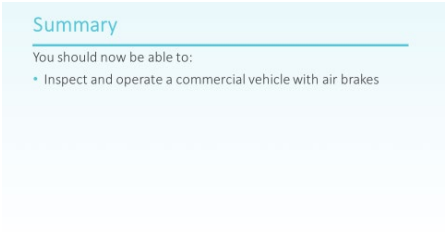


Wrap Up

Time: 5 minutes

Slide: 145 Type: Presentation

- In this module we have discussed the operating principles of air brakes, components of air brakes, variables that affect vehicle braking, foundation brake operation and adjustment.



Knowledge Check

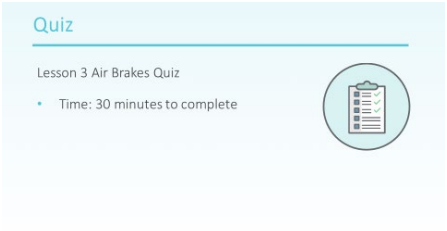
Time: 30 minutes

Slide: 146 Type: Presentation

- Remind students of the scoring and weight of the quiz. Explain what is required for a passing grade.

  When complete, fill out the assessment tracker for each student and the classroom assessment tracker.

Hand out **Lesson 3 – Quiz**.



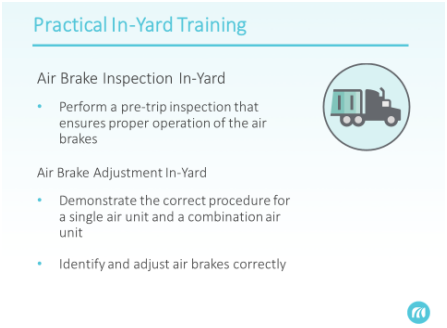
Practical In-Yard Training

Time: 90 minutes

Preparation

- Organize students and time in-yard in order to maximize efficiency.
- Print **Lesson 3 - Practical Job Aid** for each student.
- Ensure the yard and vehicle are prepared for training.

Slide: 147 **Type: Presentation**



You will head out to the yard where an instructor will demonstrate how to:

- Perform a pre-trip inspection that ensures proper operation of the air brakes
- Demonstrate the correct procedure for a single unit
- Identify and adjust air brakes correctly

Then you will do the same inspection and demonstration.

You may wish to take your textbook and air brake manual with the inspection details as it provides details on what you are looking for when doing an inspection and procedures for adjustments.

Each time you attempt the activity during training, you will be provided a copy of your assessment, which you can then review to improve your skills in this area.

? Are there any questions about the practical in-yard training?

▶ **Let the students answer.**

At the end of the classroom session, the instructor and the students will proceed to the yard for the air brake demonstration. The instructor will have about 30 minutes to demonstrate the air brake inspection and adjustment activities to the student, after which the student will perform the activities.

The students will have a minimum of 60 minutes to practice the inspection and adjustment activities. Make decisions about how to organize yard time based on numbers of students, available instructors for proper yard ratio, and physical training space.

Practical In-Yard Assessment

Time: 30 minutes

Preparation

- Ensure the vehicle and yard are set up for assessment.
- Print **Practical Assessment Rubric Evaluator Job Aid** for the evaluator.
- Review **Performing Practical Assessments**.
- Prepare to record assessment performance either on printed **Lesson 3 – Practical Job Aid** sheets or directly into the **Practical Assessments** Excel file.
- Ensure you have access to the **Practical Assessments** Excel file.
- Print **Instructors Class Summary**.
- Print **Instructors Student Summary**.

Slide: 148 Type: Presentation

You will now have a practical assessment where your instructor will assess your understanding and skill competency. This final in-yard assessment will count towards your final course mark. Each time you attempt the activities, your instructor will provide you with a copy of your in-yard assessment, which you should review to improve your skills in this area.

? Are there any questions before beginning the practical assessment?

▶ Wait for students to respond.

ⓘ You must be familiar with the assessment rubric before evaluating the student's practical knowledge and skills.

▶ The instructor will evaluate students using the practical assessment sheet. The list may then be shared with the student to improve their performance. Use one practical assessment sheet each time the student performs the activities.

A minimum of 30 minutes will be used for in-yard assessment.

Check the recorded time in the log as well to confirm accuracy and proper completion of required paperwork for Hours of Service compliance.

ⓘ Use the rubric for evaluating in-yard and in-cab assessments. You are required to enter the results of the assessments in the Excel spreadsheet to calculate the final grades. Assessment sheets can then be printed and signed.