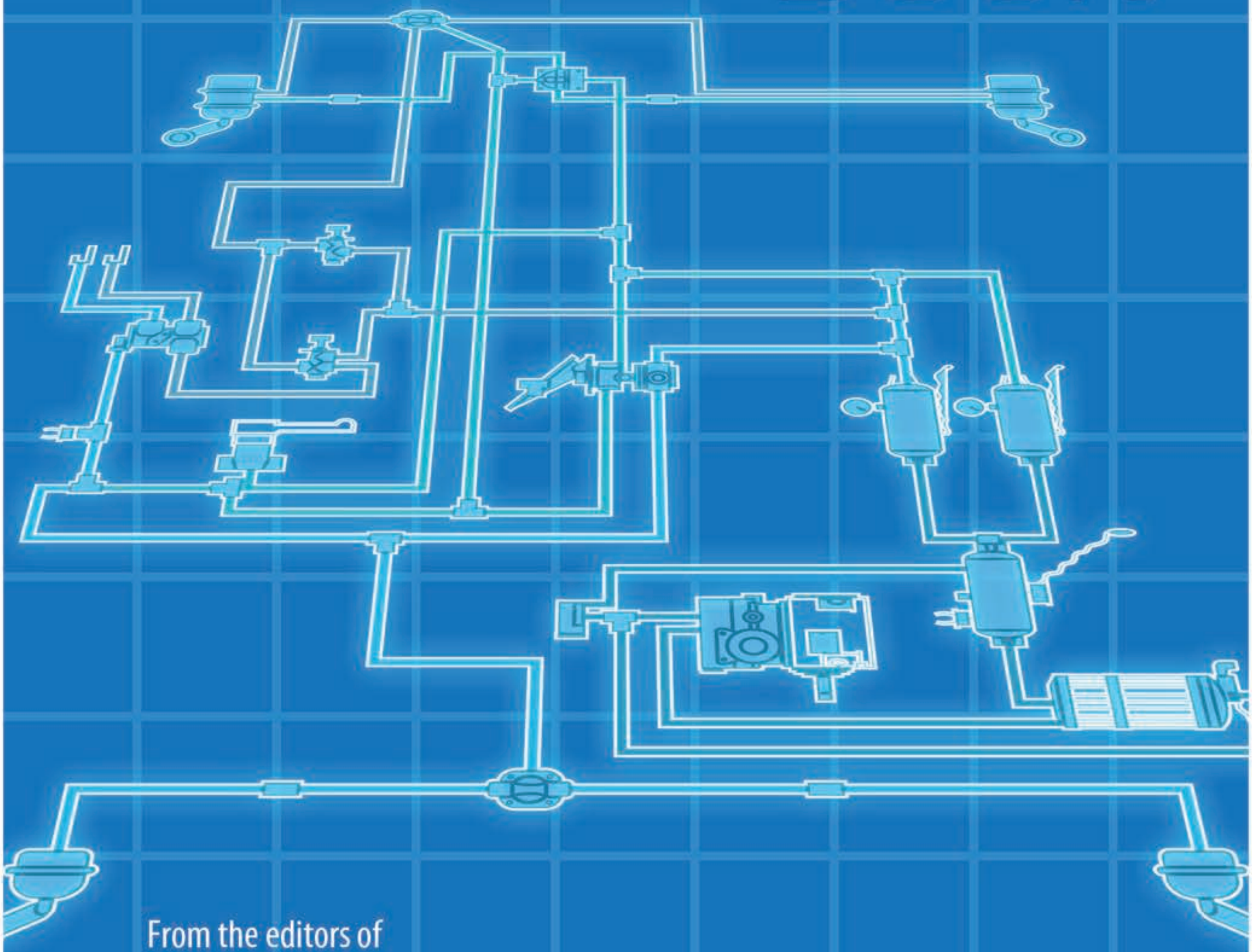
THE AIR BRAKE BOOK

10th EDITION



From the editors of

COMMERCIAL CARRIER JOURNAL

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SINCE 1911

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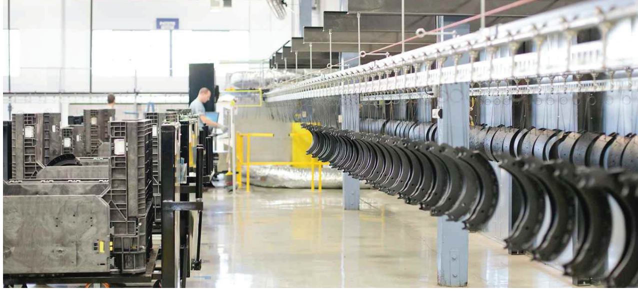

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The ins and outs of air brake systems and components

As commercial vehicle brake systems continue to evolve, so does *Commercial Carrier Journal*'s Air Brake Book, now in its 10th edition. Since we published the last edition in 2014, industry suppliers and the truck maintenance community have improved performance and maintenance practices for commercial vehicle braking systems.

The 10th edition of the Air Brake Book adds an update on air disc brake market penetration and the pros and cons fleets should consider as they explore the newer brake technology, as well as a chapter on the important role that drivers play in developing comprehensive brake preventive maintenance practices.

Thanks to the Commercial Vehicle Safety Alliance, we are able to provide a synopsis of the all-new 2019 CVSA out-of-service criteria surrounding brakes and brake systems, as well as CVSA's Air Brake Pushrod Stroke guidelines. For more detailed information and to order a full set of CVSA's 2019 OOSC criteria, visit cvsa.org.

Brakes continue to be one of the most-often cited vehicle-related violations in the Vehicle Maintenance Behavior Analysis Safety Improvement Category, part of the Federal Motor Carrier Safety Administration's Compliance Safety Accountability program. We have provided an up-to-date list of the brake-related CSA violations and their corresponding violation severity weights so fleet maintenance managers can get a better picture of how improper brake maintenance procedures can impact a fleet's CSA scores.

CCJ also is proud to continue its relationship with the American Trucking Associations' Technology & Maintenance Council. The organization graciously has provided four of its TMC Recommended Practice bulletins for use in the Air Brake Book, including a revised Aftermarket Brake Lining Classification (RP 628C) that was updated since we last published the Air Brake Book.

Since 1911, *CCJ*'s mission has been to help our readers be productive and successful. And our goal for the Air Brake Book is to help keep you up to speed on air brake systems — today, and for as long as big wheels are rolling. Let us know how we're doing.

—*CCJ* editorial staff

Cover design by David Watson.

Air Brake Book, 10th Edition

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CHAPTER 1: Air brake system anatomy

Understanding the three components of a commercial vehicle air brake system is crucial to diagnosing and repairing complex brake problems.

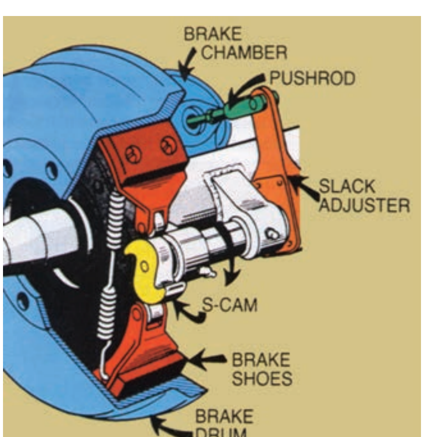
By *CCJ* staff

Air brakes operate differently from hydraulic brake systems found on automobiles and light-duty trucks. All air brake systems differ somewhat depending on manufacturer designs and application-specific options. This chapter will detail the three basic systems of air brakes you should be familiar with before attempting maintenance or replacement work.

1. Supply system

The supply system provides the pressurized air that will actuate its components, and is in many ways the heart of any air brake system. An engine-powered air compressor supplies air to a governor, which controls the compressor's output by cycling air into the system as needed or unloading if the system is at its correct pressure — usually between 100 and 120 psi for most vehicles. The vehicle's driver can monitor the air system pressure via a dash-mounted pressure gauge. If pressure in the system falls below 60 psi, a switch in the system must come on and send an electronic signal to a dash light or buzzer in the cab and alert the driver that there is a problem.

Air in the system is stored in air reservoirs – usually three or more per tractor – until it is needed. Check valves prevent pressurized air from passing back through the compressor while it's not running to make sure the air gets to where it is needed. Should the system become over-pressurized with too much air, "pop-off," or safety, valves open to allow air to escape before damaging air lines, the reservoirs or other system components.



Foundation brake operation. When pushrod is extended, brake adjuster, cam-shaft and S-cam rotate. S-cam spreads brake shoes apart and against brake drum.

The air reservoir nearest the compressor is often called the supply tank (sometimes called a "wet" tank), because that is where atmospheric moisture condenses in the greatest quantities. Moisture is an air brake system's No. 1 enemy, and great care must be taken to ensure a vehicle has the cleanest, driest air possible circulating through its brake system. To that end, reservoirs are equipped with either automatic or manually actuated drain valves allowing water to be purged from the system.

Air dryers then condense and remove any water not drained from the system by forcing air through a canister containing desiccant material. Prior to air dryers, alcohol sometimes was injected into the air system in cold weather to prevent any water from freezing and clogging air lines, but this practice is strongly discouraged today.

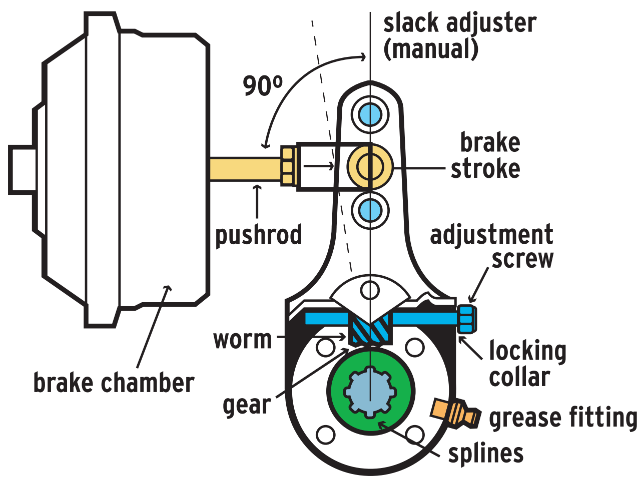
2. Control system

Air in the reservoirs has to be routed to the various components in the system before any braking action can take place. Enter the control system, a series of pneumatic valves that direct and control the air as it flows through the system to make sure it gets to where it's needed. These valves usually are found in a common housing unit on the vehicle, although for simplicity's sake we'll look at them individually here.

The dual-control foot value is the main actuator in the system. It is actually two valves that operate simultaneously in response to input from the driver's foot on the brake pedal. Two valves are needed because after leaving the supply tank, air in the system splits into two separate and protected brake circuits that are divided between the primary and secondary reservoirs. This backup source of air allows the driver to bring the vehicle to a complete stop in the event of a system failure.

When the driver steps on the brake pedal, air flows from the primary reservoir and through the primary portion of the dual-control foot valve to actuate the rear axle brakes. At the same time, air flows from the secondary reservoir through the secondary portion of the dual-control foot valve to actuate the front axle brakes. A two-way check valve senses the air pressure in both the primary and secondary air systems and allows the system with the higher pressure to actuate the trailer brakes (if present). Primary air also can be manually supplied to the trailer by means of a hand valve, which is usually found near the vehicle's steering wheel. In addition, the two-way check valve actuates the vehicle's stop light switch, thereby ensuring the stop lamps are actuated in the event of a failed circuit.

BRAKES FULLY APPLIED



Action of chamber on brake adjuster (manual type shown). With chamber pushrod fully extended, properly set adjuster forms 90-degree angle with pushrod.

But it takes time to get air through a brake system in order to stop or slow a vehicle. Relay valves are used on trailers and the rear axles of long-wheel-based tractors to ensure faster system reaction times. These relay valves are directly supplied with system pressure and use air from the dual-control foot valve as a signal to quickly direct airflow to the brakes they serve. If the vehicle is equipped with an anti-lock braking system, ABS valves are combined with relay valves on a trailer to supply modulated air to the anti-lock brake mechanism.

Relay valves' delivery pressures are affected by their respective "crack" pressure setting. Crack pressure is the amount of air pressure required at the input from the foot valve before the relay valve will send air pressure to the brakes controlled by that valve. Crack pressure is an important element of brake timing and balance. It is determined for each axle on the vehicle by how heavily loaded the axle served by the valve is, how big the brakes are and how aggressive the linings are on those brakes.

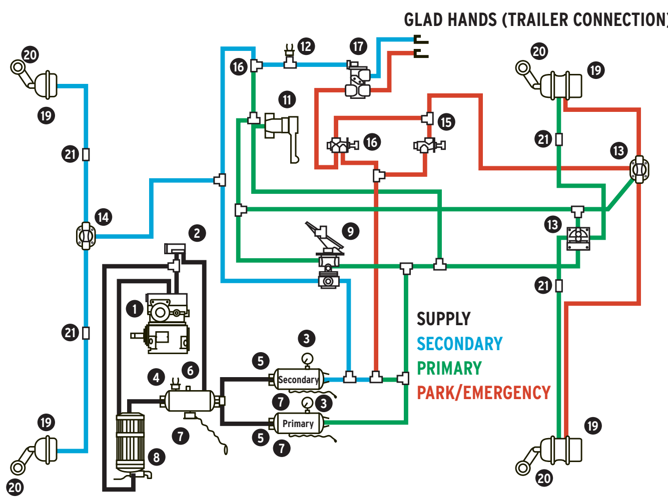
A valve that cracks at too low a pressure for a given axle can cause that axle's brakes to operate at a lower control pressure while the other axles do not and can lead to a large braking imbalance. Likewise, a valve that cracks at too high a pressure can also cause braking imbalance for the same reasons. Because of incompatibility and wear issues, OEMs and component manufacturers through the Technology & Maintenance Council, the Society of Automotive Engineers and other industry organizations have worked hard to standardize valve crack characteristics. (For more information, refer to SAE recommended practice J1505 for brake balance procedures and J1860 for recommended component labeling practices.)

Once a stopped truck is ready to go, having air travel all the way back through the system would cause a noticeable lag time between the time the driver removed his foot from the brake pedal to when the brakes released. To combat this problem, quick-release valves located near the brakes they serve quickly expel air from the system and allow fast brake release times.

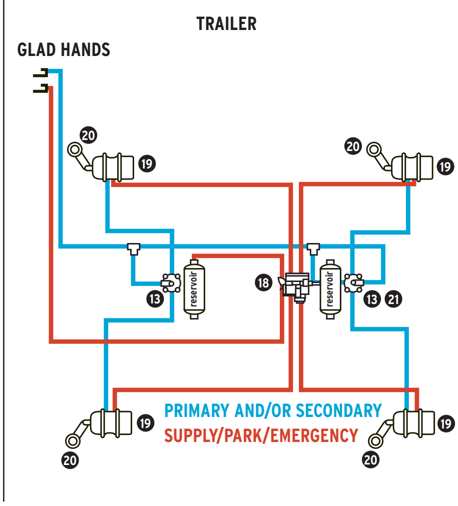
Dash-mounted air valves inside the cab control air pressure to the parking brakes. In most cases, these are spring-applied brakes, which are actuated gradually by descending air pressure in the brake system. Conversely, when air is applied by pushing in on the dash control valve (parking control valve), the brakes will be fully released in the 60- to 70-psi range. This provides a fail-safe feature in the event all air is lost; the vehicle still can be parked and can be used as part of an emergency brake system.

Effect of brake chamber type (diaphragm area) on pushrod output force, with constant 60-psi application. Except where noted, illustrations courtesy of Meritor, Bendix and Dana.

Tractor Air Brakes



Trailer Air Brakes



The tractor protection valve maintains air pressure in the lines that carry air to the trailer if one is being pulled behind the vehicle. Quick-connect fittings at the rear of the tractor – called "gladhands" – supply air to the trailer. In the event of an emergency – either a substantial leak in the air lines or a trailer breakaway – the tractor protection valve automatically closes to maintain air pressure in the tractor circuit. The valve also works in conjunction with the dash-mounted trailer parking brake valve to shut off air to the trailer circuit before disconnecting the trailer from the tractor.

The trailer spring brake valve – sometimes called the multi-function valve – releases the trailer park brakes and controls the charging of the trailer service reservoirs. It also works with an integral check valve to isolate a failed reservoir, which otherwise would allow the parking brakes to apply automatically, whether they were needed or not.

3. Foundation and parking brake systems

The systems mentioned above exist and work together to supply the proper amount of controlled air pressure to actuate the vehicle's foundation, or service, brakes. When the brakes are applied on a vehicle equipped with air brakes, air pressure is directed to the brake chambers at each wheel end. The brake chamber itself consists of several interconnected components, including a pressure housing, diaphragm and pushrod.

As the system exerts air pressure on the diaphragm, the pushrod on the other side of the diaphragm extends outward. The force this pushrod exerts as it moves outward is a result of the amount of air pressure applied in psi combined with the area of the diaphragm in square inches. For example, if 100 psi of air pressure is supplied to a pressure chamber with a 16-square-inch diaphragm, then the amount of force generated at the pushrod would be 1,600 pounds. Using the same formula, a 100-psi application of air pressure into a chamber with a 30-square-inch diaphragm will produce 3,000 pounds of pushrod force. Obviously it is important to make sure brake chambers are matched properly to avoid severe brake imbalance problems.

In an S-cam brake system, the pushrod is connected to a lever called a brake adjuster (also called a slack adjuster). When actuated by air pressure in the brake chamber, the pushrod forces the brake adjuster outward. The brake adjuster is connected to a shaft that runs perpendicular to the plane formed by it and the pushrod. As the pushrod extends outward, it causes the brake adjuster to rotate the shaft. As the shaft rotates, it turns an "S"-shaped cam located between the brake shoes. This action forces the brake shoes apart, placing them against the inner portion of the brake drum, creating the friction needed to slow the vehicle. The amount of friction produced depends on several factors, most notably the size of the brake shoes, the coefficient of friction (aggressiveness) of the brake lining material and the mass and heat rejection of the drum.

Brake shoes – their lining material, in particular – are self-destructive by nature. In other words, the friction created by pushing the shoe against the brake drum creates heat and naturally wears away the brake lining as it works to slow the vehicle. The brake adjuster is equipped with a slack adjustment mechanism to compensate for constantly wearing brake linings and ensure consistent stopping force when the brakes are applied. This system, as its name implies, automatically adjusts as the brake lining wears away so that the pushrod does not have to travel farther and farther to apply braking pressure. Without the brake adjuster, the pushrod soon would be unable to extend far enough outward to apply the brakes.

Brake adjusters have another important function as well. They are force multipliers – essentially levers that multiply brake forces in proportion to their length. A 5 1/2-inch-long brake adjuster, for example, converts 1,000 pounds of force at the pushrod into 5,500 inch-pounds of torque at the brake camshaft. Because of this, the brake adjuster's length and the brake chamber size are the two components most commonly altered to meet different vehicle braking requirements. ABAs are rated by an "AL factor" — the product of chamber area (type) times the length of the ABA.

Engineers express the product of these two values as the brake system's "AL factor." This factor, when multiplied by 60-psi air pressure, is the industry standard for braking calculations. Using this formula, 60 psi of air pressure applied to an air chamber with a 16-square-inch diaphragm (the "A" portion of the AL factor) creates 960 pounds of pushrod force. This becomes 3,840 pound-feet of torque applied to the brake camshaft when multiplied by a 4-inch brake adjuster.

Brake chambers do more than simply apply the service brakes in everyday driving. On rear tractor axles and trailer axles, they also apply the parking brakes. These spring brakes use a second chamber with a second diaphragm and a powerful spring. A driver must push in the dash-mounted parking brake valves in order to put a vehicle in normal service. Once these valves are in the "run" (pushed-in) position, air pressure is applied to the spring chamber on the side of the diaphragm opposite the spring itself. Air pressure on the diaphragm compresses the spring, holding the parking brakes off as long as there is adequate air pressure in the system. This does not affect the action of the service brakes in normal vehicle operation.

When the vehicle is parked, the driver pulls the dash valves out. This action exhausts the air holding the spring brakes back, allowing them to deploy and hold the vehicle in place. FMVSS 121 typically defines vehicle parking minimum requirements for loaded vehicles.

As a safety precaution, the spring brakes are designed to apply automatically in the event of a loss of air pressure in the brake system. If air pressure is lost for any reason, the parking spring brake overcomes hold-off air pressure in the secondary brake chamber, and the brakes are applied automatically to provide emergency stopping power.

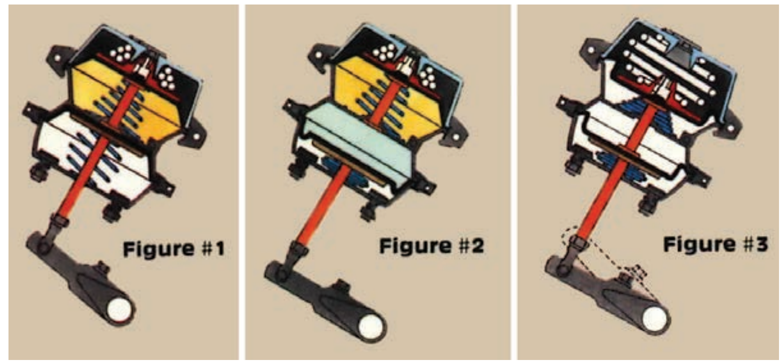


Figure 1: Normal driving position. Hold-off air in rear (yellow) chamber compresses parking spring, releasing parking brake. Service brake is not applied. **Figure 2: Service brake application.** Air pressure in first (light blue) chamber pushes diaphragm and pushrod, rotating slack adjuster. **Figure 3: Parking.** Hold-off air is exhausted from rear chamber, allowing spring to apply parking brake.

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CHAPTER 2: Weighing the costs and benefits of air disc brakes

Despite maintenance and pad life advantages, price remains the biggest hurdle to air disc brake adoption.

By *CCJ* Staff

Of the two brake options available for heavy-duty trucks today – drum brakes and air disc brakes – the latter generally are considered to be the more elegant choice based on their inherent design advantages and simplified maintenance demands.

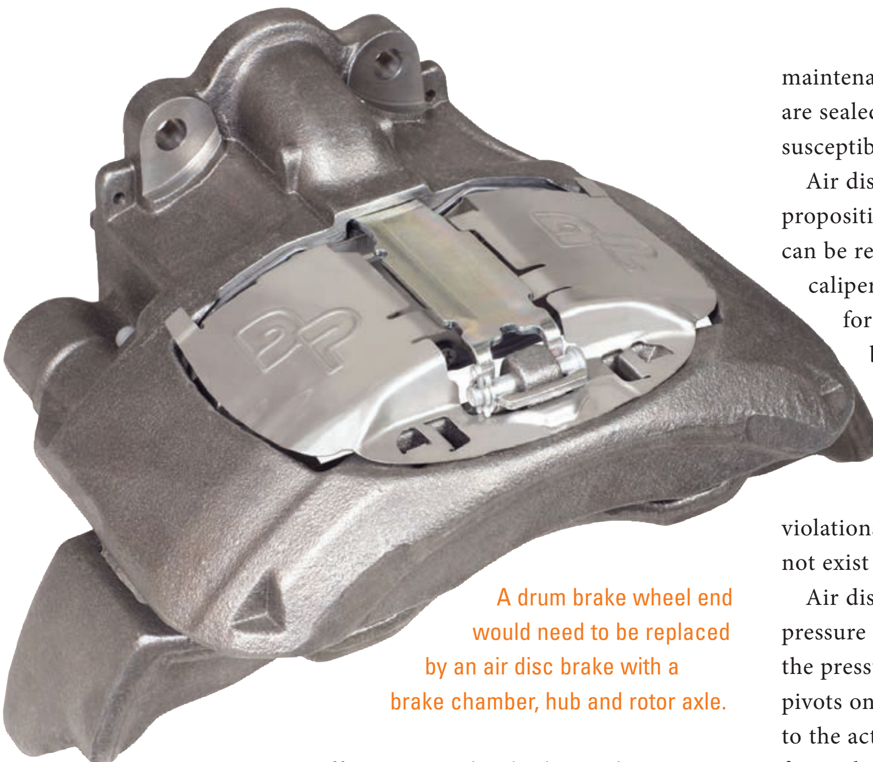
The design and geometry of how air disc brakes work – pads clamping down on a disc, as opposed to brake shoes expanding outward to make contact with a drum – allow for a smoother brake application across all driving conditions as brake torque is more even and consistent. Commercial vehicle drivers who prefer air disc brakes over drum brakes often cite them for providing a safer braking feel more like that of a passenger car.

At the height of their market domination, drum brakes held a commanding 94 percent share in the heavy commercial truck market, with air disc brakes making up the rest.

In 2013, when new stopping distance regulations from the National Highway Traffic Safety Administration took effect, many in the industry thought that a push toward widespread air disc brake adoption by fleets was a sure thing. But while their market share has increased since those regulations came into effect, drum brakes continue to dominate the industry. Still, air disc brake adoption could reach 30 percent or more by 2020 as fleets continue to explore the benefits and drawbacks of each braking option.

Pros and cons

In response to increased market demand, truck



A drum brake wheel end would need to be replaced by an air disc brake with a brake chamber, hub and rotor axle.

OEMs now offer more air disc brake products as both standard and optional equipment on new tractors, particularly on steer axle configurations. Even with their built-in braking performance advantages in all weather conditions, market penetration has been an uphill climb due to higher initial acquisition costs of as much as a $1,200 increase per axle.

To give credit where it is due, design tweaks on drum brake systems have allowed them to deliver improved braking performance well within NHTSA's stopping distance guidelines. Drum brakes today feature larger chambers and 24-square-inch diaphragms with a long 3-inch stroke; this compares to a 20-square-inch diaphragm with a 2-1⁄2-inch stroke on older brakes.

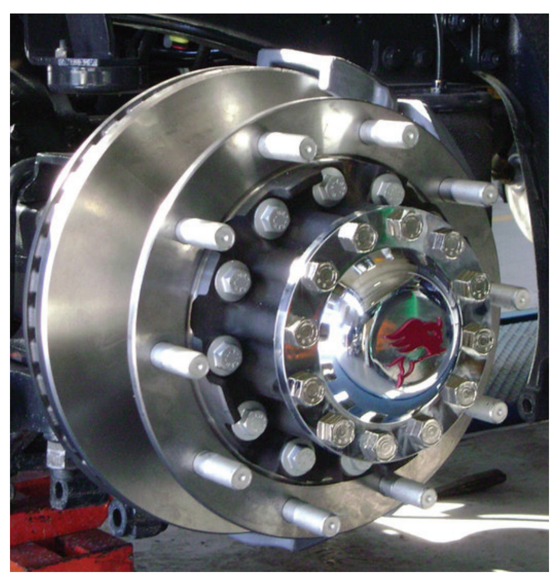
Also, modern drum brakes have precision camshaft journals, an improvement of the brake's geometry that helps reduce variation and improve overall braking performance, as well as greater width for increased braking surface, improved heat dissipation, reduced fade and lower cost per mile.

Although air disc brakes are more expensive on the front end, their overall cost of ownership is coming down thanks to a simpler design and ease of maintenance for pad replacement. Air disc brakes are sealed, eliminating rust-jacking and lowering susceptibility to contamination.

Air disc brakes also boast a better value proposition on the maintenance end. The brake pads can be removed and replaced without removing the caliper assembly, lowering the turnaround time for the relining process. In addition, air disc brake pads may last twice as long as drum linings, depending on the service application.

Air disc brakes also typically net fewer Compliance Safety Accountability violations since the out-of-adjustment concern does not exist in their design.

Air disc brakes apply braking force by using air pressure from the service brake chamber to move the pressure plate and pushrod against a lever that pivots on an eccentric bearing and transfers motion to the actuating beam. Moving against return spring force, the actuating beam moves two threaded tubes and tappets that force the inner brake pad into contact with the brake rotor. Further movement of the actuating beam forces the caliper, sliding on two stationary guide pins, away from the rotor, which



The weight benefit afforded by air disc brakes depends upon the overall wheel-end components chosen as part of the package.

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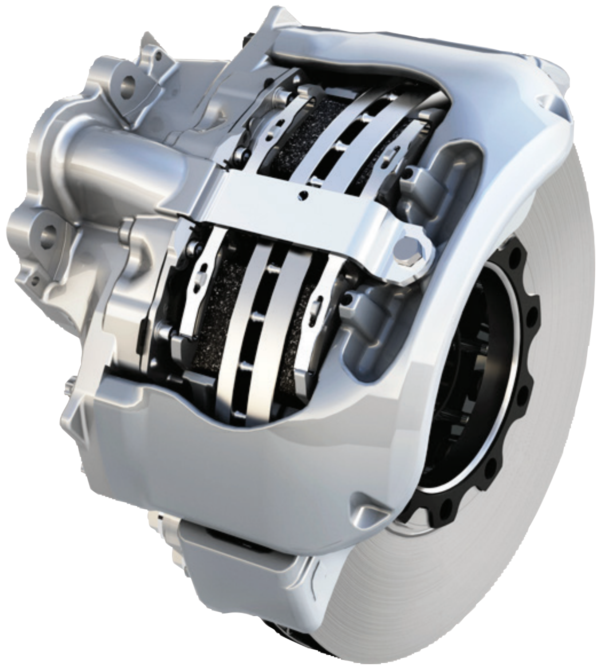

Acquisition costs are higher for air disc brakes, but lifecycle cost and resale values can make up for that in the long run.

pulls the outer brake pad into the rotor. The clamping action of the brake pads on the rotor applies braking force to the wheel.

Releasing the foot brake releases pressure in the service brake chamber. With no pressure in the service brake chamber, return springs force the air disc brakes into a neutral non-braked position that is controlled mechanically by a brake adjuster mechanism in the caliper.

The design is simple enough that even an entry-level technician easily can back off the adjuster, replace the pads and reassemble the system. On the negative side, rotor wear – and subsequent damage to the brake calipers – can be time-consuming and expensive, and rotor damage generally means hub disassembly and reassembly.

Before spec'ing air disc brakes, it is important to understand the applications and environments in which the tractor will operate. Air disc brakes often do not perform as well as drum brakes in dirty, gritty environments such as Northern Canada or Alaska, where there is a lot of sand on the roads.

Weight savings often depend on several factors, such as the air disc torque plate. Generally, the more robust the design spec'd, the heavier it is. In most cases, however, air disc brakes are lighter than conventional drum brake systems, freeing up additional cargo capacity. Air disc brakes often are used in weight-sensitive applications, but lightweight drum brake options exist to lessen the weight differential between the two systems.

Retrofitting tractor wheel ends with air disc brakes is possible but often is an expensive and time-intensive process. A drum brake wheel end – including the hub, drum, brake, slack adjuster and brake chamber – would need to be replaced by an air disc brake with a brake chamber, hub and rotor axle. A torque plate enables the adaptation of the air disc brake to the installed drum brake axle.

Trailers: The final air disc frontier

Tractors aren't alone in seeing the benefits of air disc braking systems. Experts say they also offer superior braking performance when fitted on trailers. But for many fleets – particularly those with high trailer-to-tractor ratios – the initial acquisition costs for trailer air disc brakes makes them a harder sell.

Trailer OEMs to-date have been more hesitant to add air disc brake options, but some specialty trailers now are offered with air disc brakes as standard equipment. Brake system suppliers urge fleets using air disc brake-equipped tractors and drum brake-equipped trailers to balance the brake systems so the brake load is even between the two. Failure to do so will result in one system working harder and wearing out faster as it bears the brunt of the work to stop the vehicle.

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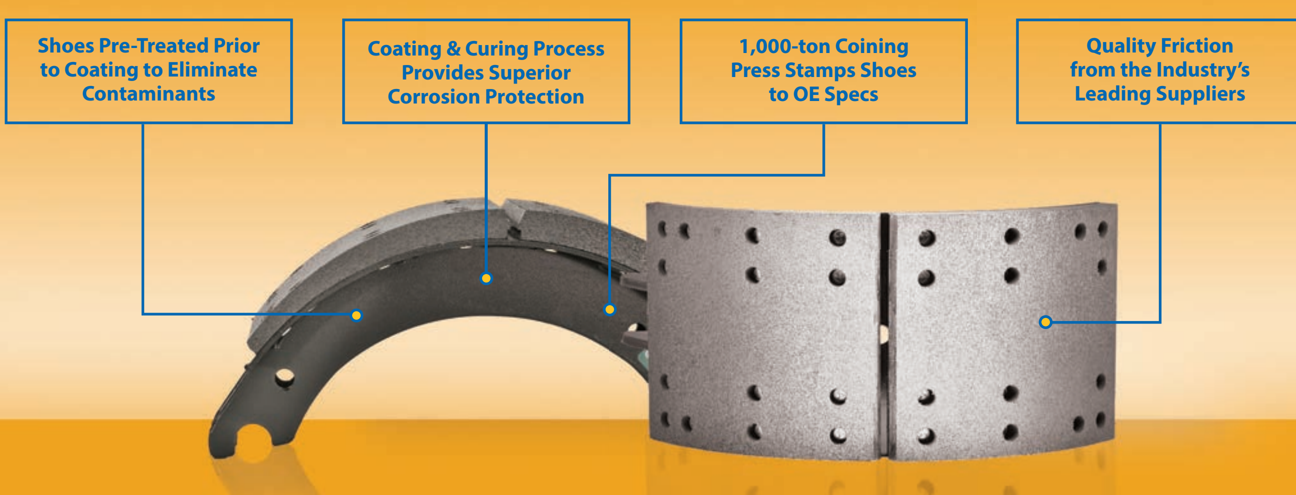

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RP 652

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SERVICE AND INSPECTION OF AIR DISC BRAKES

PREFACE

The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual.* Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

1.0 PURPOSE AND SCOPE

The purpose of this Recommended Practice (RP) is to offer guidelines for the service and inspection of air disc brakes used on medium- and heavy-duty commercial vehicles in North America.

1.1 GENERAL INFORMATION

⚠ CAUTION : Air disc brakes are high-performance braking equipment. Consequently, it is strongly recommended that only original equipment (OE) or equivalently performing replacement parts be used when servicing and maintaining air disc brakes. repairs. Otherwise the braking system may not perform as designed or intended.

On vehicles equipped with air disc brakes, both wheel ends of each axle should always be equipped with identical rotors, pads, air chambers, and valve crack pressures. All four wheel ends of tandem axles should also be equipped with identical rotors, pads, and air service chambers; however, it is not necessary for front axle brake equipment to be the same as rear driving axles. Depending upon the vehicle configuration and weight ratings, parking chambers may be used on one or both tandem axles.

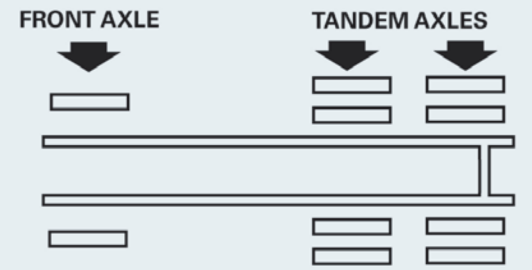


Figure 1

1.2 BRAKE PADS

⚠ DANGER: Although the majority of the brake linings used in the U.S. and Canada today are asbestos-free, the utmost precautions should be taken to eliminate unnecessary exposure to any brake dust from new or used lining materials. There is no easy way to visually identify asbestos-containing pads and the long-term effects of exposure to non-asbestos pads are unknown. The Occupational Safety and Health Administration (OSHA) regulations concerning asbestos exposure levels, testing, disposal of waste, and methods of reducing exposure (including respirators and exhaust systems) are set forth in U.S. Federal Regulations in 29 CFR 1910.1001.

General rules for proper handling of all brake materials include:

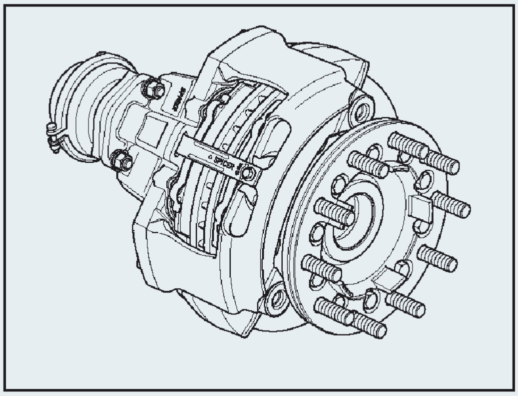
- Use OSHA approved respirators at all times during brake servicing.
- Never use compressed air to clean brake assemblies.
- Always perform brake work in an enclosed cell using filtered vacuums or in a well-ventilated area.

Always follow the vehicle manufacturer's recommended friction guidelines with respect to the pads to be used. Otherwise, adverse conditions could occur. Today's high-performance brake systems must be equipped with proper friction material and these requirements may vary from vehicle to vehicle, depending upon individual system designs. *See TMC RP 606, Brake Lining Procedures*.

Pad thickness should be the same for each pad and on each side of the axle. Some consideration should be given to pads with various performance enhancing profiles.

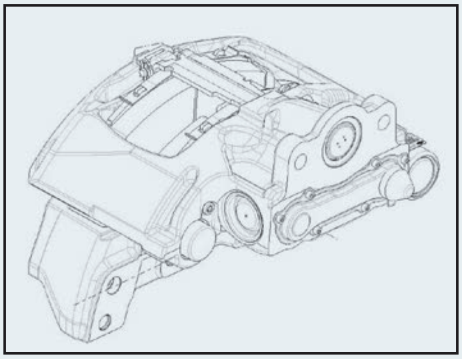
Five air disc brake designs are covered in this RP. (See **Figures 2-6**.) For other types that are not shown, please consult the brake manufacturer.

- Type I—Internal Lever with Internal Auto-



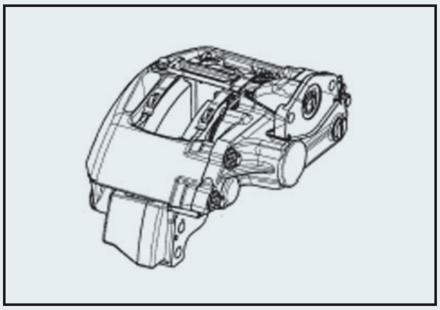
Type I—Internal Lever with Internal Automatic Adjustment (Bendix I - 2002 to present)

Figure 2



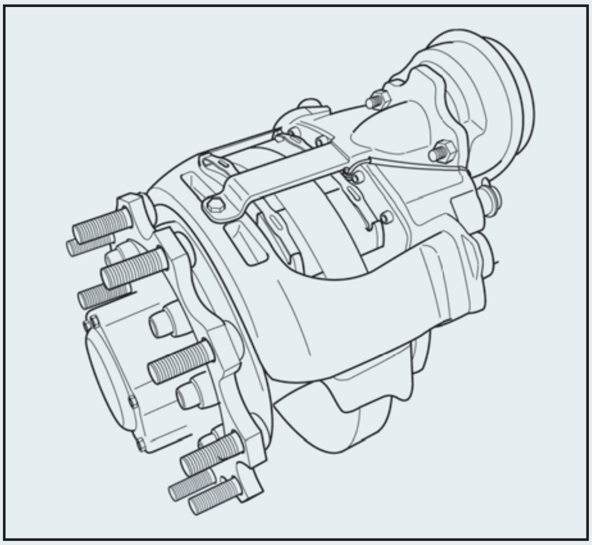
Type II—Internal Lever with Internal Automatic Adjustment (Dana & Bendix II -1994 to present)

Figure 3



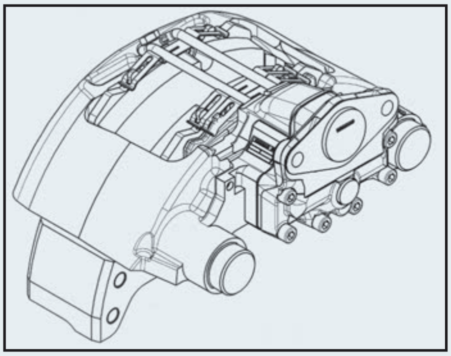
Type III—Internal Lever with Internal Automatic Adjustment (Haldex – 2002 to present)

Figure 4



Type IV—Internal Lever with Internal Automatic Adjustment (Meritor 2003 to present)

Figure 5



Type V—Internal Lever with Internal Automatic Adjustment- Single Piston (WABCO 2002 to present)

Figure 6

matic Adjustment (Bendix I - 2002 to present)
- Type II—Internal Lever with Internal Automatic Adjustment (Dana & Bendix II -1994 to present)
- Type III—Internal Lever with Internal Automatic Adjustment (Haldex – 2002 to present)
- Type IV—Internal Lever with Internal Automatic Adjustment (Meritor 2003 to present)
- Type V—Internal Lever with Internal Automatic Adjustment- Single Piston. (WABCO 2002 to present)

2.0 AIR DISC BRAKE COMPONENTS

Figure 7 illustrates components that are common to all air disc brake systems covered in this RP.

a. Caliper
b. Brake Carrier
c. Pad
d. Air Chamber (Service Chamber Shown)
e. Torque Plate
f. Rotor
g. Hub
h. Slide Pin(s)

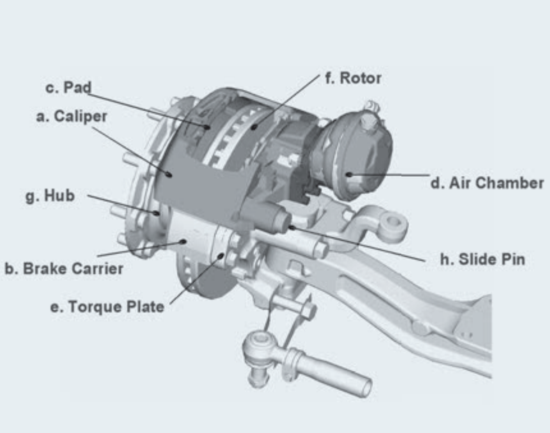
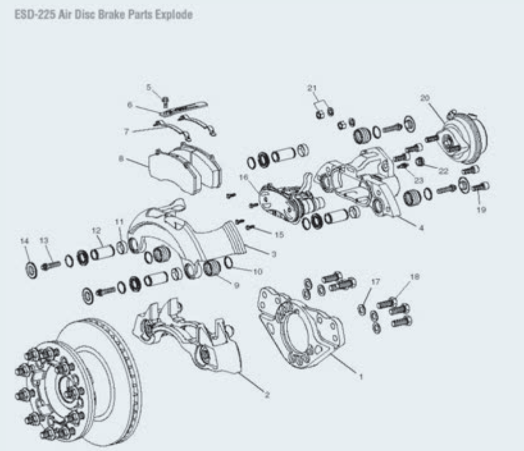


Figure 7

2.1 SPECIFIC AIR DISC BRAKE COMPONENTS FOR EACH BRAKE TYPE

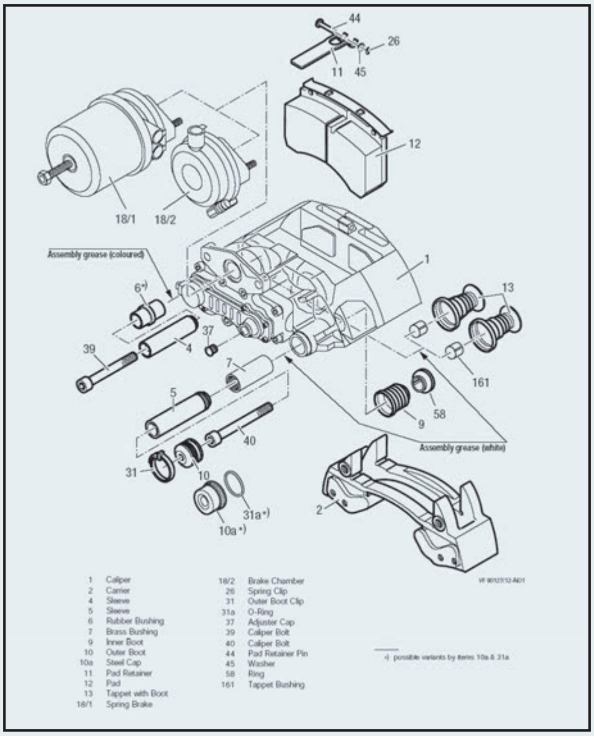
A detailed schematic is provided for air disc brake Types I-V in **Figures 8-13**.



Type I: Bendix I *(Dana)* Air Disc Brake

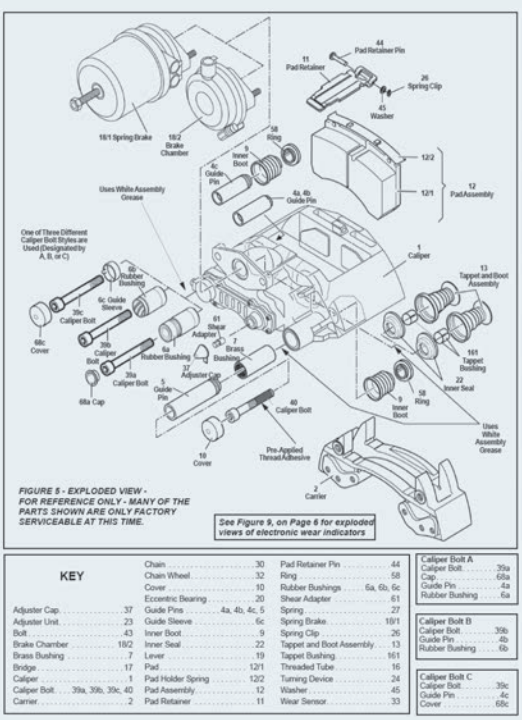
Item	Description Number
1	Torque Plate
2	Frame
3	Caliper Bridge
4	Caliper Housing
5	Retaining Bar Screw
6	Pad Retaining Bar
7	Pad Retaining Spring
8	Pad (Lining)
9	Slider Boot
10	Boot Retaining Ring
11	Slider Bushing
12	Slider Pin
13	Slider Pin Bolt
14	Slider Pin Cap
15	Adjuster Mounting Screw
16	Actuator Assembly
17	Flat Washer (20 mm)
18	Hex Head Screw (M20 x 1.5 50)
19	Socket Head Cap Screw (M16 x 1.5 Bridge Mounting) 4
20	Air Chamber A/R
21	Air Chamber Mounting Nut and Washer
22	Actuator Plug
23	Actuator Extension Assembly

Figure 8



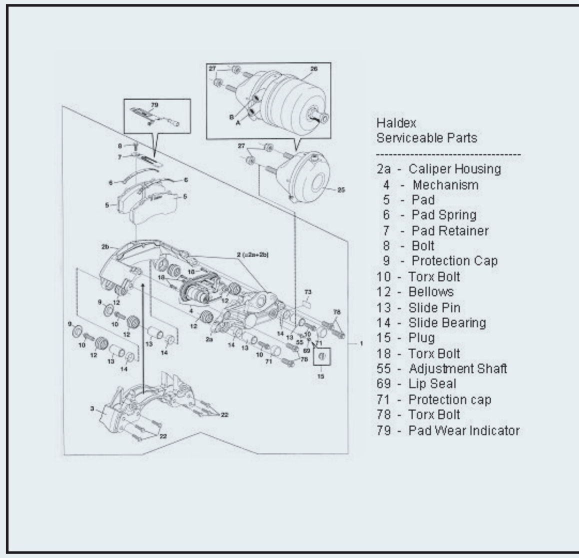
Type IIa: Bendix SB-Series Air Disc Brake

Figure 9



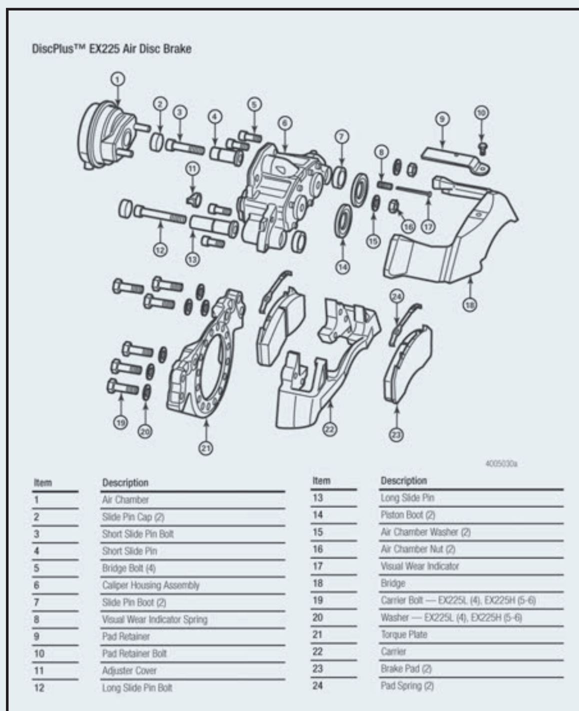
Type IIb: Bendix SN & ADB225™ Air Disc Brake

Figure 10



Type III: Haldex Air Disc Brake

Figure 11



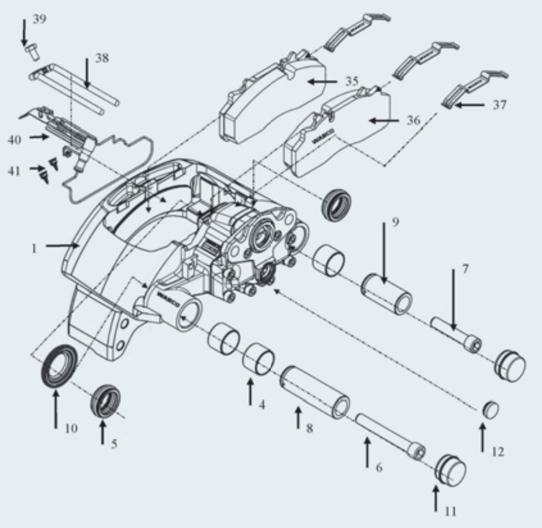
Type IV: Meritor Air Disc Brake

Figure 12

3.0 AIR DISC BRAKE INSPECTIONS

This RP recommends three levels of inspections:

- **Daily Pre-trip Walk-around Inspection**—The intent of this inspection is a pre-trip cursory look at the vehicle and its components by the driver or inspector.
- **Wheels On Inspection**—The intent of this inspection is to be done at the normal vehicle preventative maintenance interval by a qualified maintenance technician.
- **Wheels Off Major Inspection**—This inspection to be performed at each pad reline or a minimum of every two years, whichever occurs sooner by a qualified maintenance technician.



1	Brake Caliper with Brake Carrier
4	Guide Pin Bushes
5	Guide Pin Gaiters
6	Internal Hexagon Bolt (long)
7	Internal Hexagon Bolt (short)
8	Guide Pin (long)
9	Guide Pin (short)
10	Adjuster Screw Gaiter
11	Caps / Covers
12	Plug
35	Brake Pad, Wheel Side
36	Brake Pad, Actuation Side
37	Hold Down Springs
38	Pad Hold Down Hoop
39	Screw
40	Wear Indicator (pre-mounted)
41	Cable Clips

Type V: WABCO PAN 22 Air Disc Brake WABCO Serviceable Parts

Figure 13

3.1 INSPECTION LEVEL 1: DAILY PRE-TRIP WALK-AROUND INSPECTION

NOTE: Prior to beginning any inspection, first check to make sure that the vehicle is properly parked with the parking brakes applied and wheels chocked.

a. Check for loose parts, broken or cracked air hoses, air system leaks, and damaged components. Check that brake hoses and cables are properly secured, but allow the caliper full movement during normal operation and allow for full pad wear.

b. Check for presence of lining pads. Also check any visual lining wear indicators to insure that pads are not worn beyond specification. Some brakes may have electric wear indicators which are covered in **3.2: Inspection Level 2: Wheels on Inspection**. Each brake has different wear indication systems, these systems are summarized in **Figure 14**.

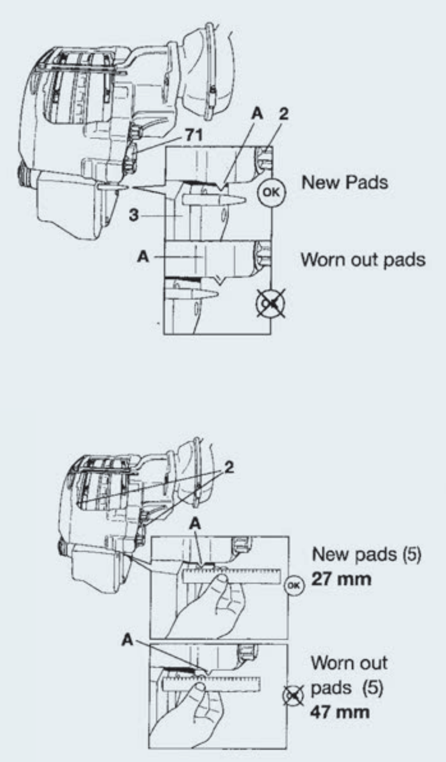


Figure 14

c. Unlike drum brakes, current air disc brake designs do not allow the brake stroke to be easily checked during normal walk around inspections. If it is desired to check brake operation, see guidelines for checking caliper movement in the **Inspection Level 2** instructions.

d. Check for oil or grease contamination of brake assembly.

e. Check that parking springs on parking brake chambers are not caged in the released position with the spring brake dust cover or plug installed, if so equipped.

f. Make sure that the air chamber is not covered with snow, ice, or mud. Air chambers are equipped with breather holes and it is important that they not be obstructed for proper function. See **Figure 18**.

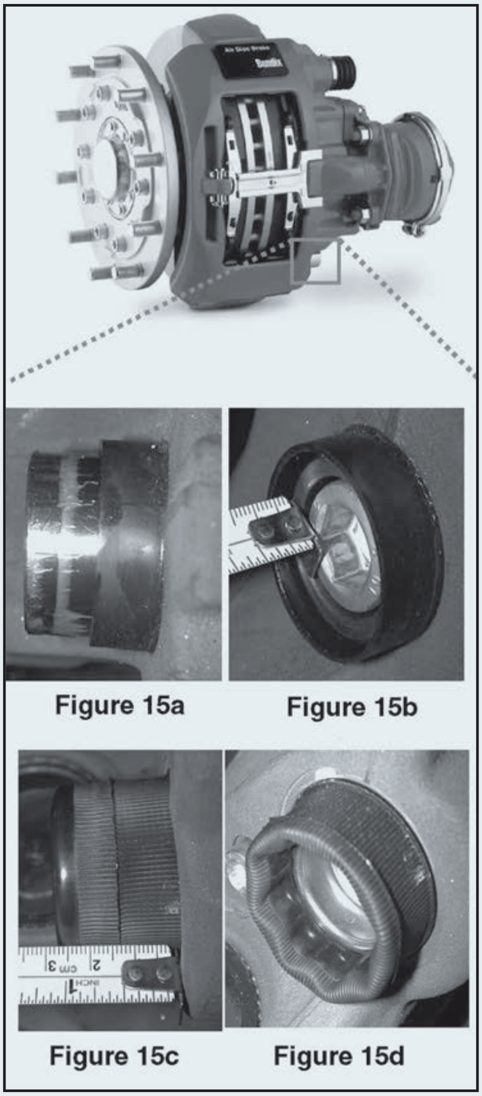


Figure 15

g. Check for presence and condition of rotor ensuring there are no cracks. See Inspection Level 2 for further clarification on acceptable rotor condition.

h. Check that dust cap for manual adjuster access and slide pin boots or caps are in place.

i. Visual Wear Inspection

Visual Wear Inspection – Bendix Type II

- In the SB-series caliper the location of the floating pin with respect to the rubber bushing is in direct relationship to the pad and rotor wear.
- When viewed from the inboard side of the wheel, the floating pin location can be seen as shown below.
- The SB-series caliper and pin location is shown in the first two pictures.
- In new pad and rotor conditions, the pin will be exposed from the rubber bushing 13.6 mm (0.535”). (See **Figure 15a**.)
- With the pads worn to near the replacement thickness and a nearly new thickness rotor, the floating pin will be 4.6 mm (0.181”) below the edge of the rubber bushing. When the rotor is also worn to near the replacement thickness, the floating pin will be 6.6-mm (0.260”) below the edge of the rubber bushing. (See **Figure 15b**.)
- In the ADB225- series caliper the length of the rolling boot is in direct relationship to the pad and rotor wear and is shown in **Figures 15c and 15d**.
- In new pad and rotor conditions, the rolling boot will be extended to a dimension of 27.4 mm (1.08”). (See **Figure 15c**.)
- With the pads worn to near the replacement thickness and a nearly new thickness rotor, the rolling root will have an extension of 16.5 mm (0.650”). When the rotor is also worn to near the replacement thickness, the rolling boot will have an extension of 15.5 mm (0.610”).

Visual Wear Inspection: Meritor Type IV

a. The visual wear indicator shows approximately how much of the lining material is remaining. (See **Figure 16**.)

b. If the indicator extends less than 0.16 inch (4 mm) from the casting the pads require further inspection or replacement.

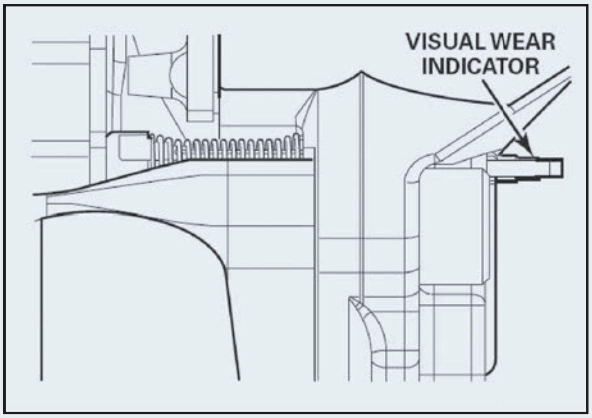


Figure 16

Visual Wear Inspection: WABCO Type V

a. Optical pad wear indication: To provide an optical pad wear indication the brake caliper is equipped with the edge (A) on the rim side. The brake carrier is equipped with the edge (B). The edges (A) and (B) are visible through the rim. The positions of the edges in this picture are only shown to illustrate the visible edges.

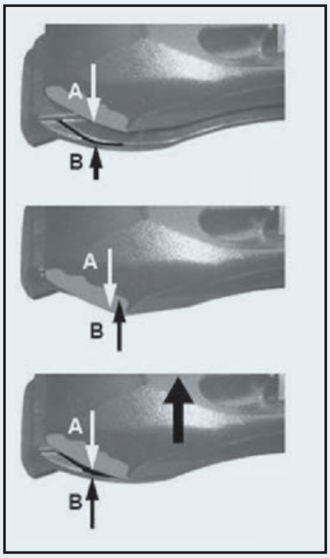


Figure 17

b. Pads in new condition: The edge (A) is positioned in front of edge (B) in the direction of the rim. Edge (B) is not visible.
c. Pads in worn condition: During pad wear the edge in the caliper moves (A) until the same position as the edge (B) in the carrier. In this case the pads have reached their wear limit.

NOTE: These visual inspection parameters are not intended as "out-of-service" criteria. Inspection with wheels removed is required to determine actual pad and rotor thicknesses as specified in **Figure 19**.

If any of the above conditions are not satisfactory, further service is required prior to vehicle operation.

3.2 INSPECTION LEVEL 2: WHEELS ON INSPECTION

NOTE: Prior to beginning any inspection, first check to make sure that the vehicle is properly parked with the parking brakes applied and wheels chocked.

Include all items in Level 1 plus the following:

a. Check for loose parts, broken or cracked air hoses, air system leaks, and damage to components. Check that brake hoses and sensor cables are properly secured, but allow the caliper full movement during normal operation and allow for full pad wear.
b. If possible, visually check the rotor for cracks, grooves, scoring, or hot spots.
c. Check that all brake pad hold-down springs are present and in the correct position.
d. An indication on the degree of pad wear can be obtained without removing the wheels in following manner as pictured in **Figure 17**.
e. With the parking chamber temporarily released and the wheels chocked, check for slight movement of the brake caliper. This very slight movement, less than 2 mm or 0.080" (approximately the thickness of a nickel) in the axial (inboard / outboard) direction, indicates

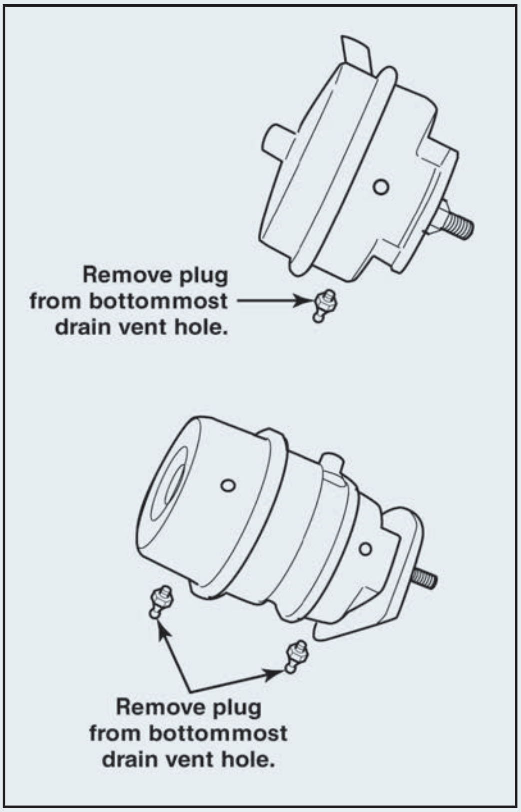


Figure 18

that the brake is moving properly on its slide pins. If the caliper has no movement or appears to move greater than 2 mm or 0.080" other problems may exist – remove the wheels for Level 3 Inspection.

f. The down facing vent hole in the brake chamber or service side of the parking brake chamber must be open and free of any debris. (See **Figure 18.**)
g. The service and parking brake chambers on both wheel ends of each axle must be air disc brake compatible, identical size, type and the same manufacturer.
h. Check that all dust caps and boots are present and that there is no damage visible to either.

3.3 INSPECTION LEVEL 3: WHEELS OFF MAJOR INSPECTION

NOTE: Prior to beginning any inspection, first check to make sure that the vehicle is properly parked with the parking brakes applied and wheels chocked. Please heed the following cautionary notes:

- Do not apply brakes when the pads are removed.
- Take caution that fasteners are installed to the proper torques. Please see individual brake manufactures maintenance manual for specific torque values.
- Wear safe eye protection. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
- Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.

Include all items in Levels 1 and 2 plus the following:

a. Pad Inspection

⚠ CAUTION: Replace the pads on both brakes of a single axle or all four brakes of a tandem axle at the same time. If all pads are not replaced at the same time, poor brake performance will occur.

- Inspect the brake pads for excessive grooving or cracked friction material or if there is severe damage to the surface of the pad. Check if the friction material is loose or detached from the backing plate. Minor damage to the edge of the pad is permitted. If necessary, replace all brake pad assemblies on the axle(s).
- Measure the friction material thickness at both ends or at the thinnest point on the brake pad. Replace the brake pad assembly at or before the lining thickness reaches 0.12 inch (3 mm) at any point. See Item "E" in **Figure 19 on the next page**.

⚠ CAUTION: Consult brake manufacturing for maximum run-out specification.

- Inspect pad material for oil contamination. When pad material is oil soaked, it should be replaced. It is not recommended to "clean" and reuse an oil contaminated disc pad assembly. Follow the guidelines above and replace all wheel ends on the axle(s).

b. Pad Abutment Wear

- Remove the disc pads and pad retainer clips from the disc brake assembly.
- Inspect the disc pads and carrier surfaces for the presence of any dirt or contamination. (See **Figure 20**.)

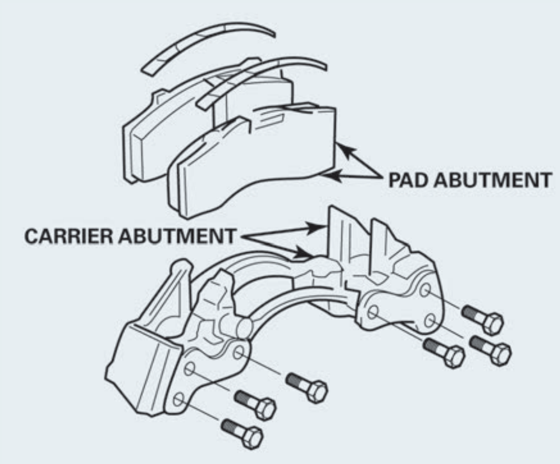
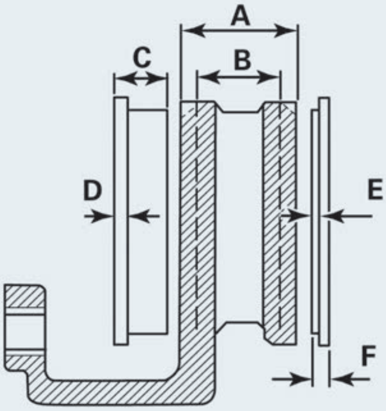


Figure 20

- Clean the disc pads and carrier surfaces as appropriate with a wire brush or similar tool. Take care not to damage boots, seals or other brake assembly components.
- Inspect the edges of the disc pads and the pad abutment surfaces of the carrier (as shown for any indications of noticeable wear, brinnelling or grooving, which would prevent the disc pads from sliding smoothly on the abutment surfaces or the carrier, or which would prevent full contact of the disc pads with the carrier abutment surfaces.



	Dimension					
	Rotor Thickness New Condition (A)	Rotor Thickness Worn Condition (B)*	Overall thickness of Pads New (C)	Backing Plate Thickness (D)	CVSA Minimum Thickness of Friction Material (E)	Minimum Overall Pad Thickness (F)*
Brake Type	**mm/inch**	**mm/inch**	**mm/inch**	**mm/inch**	**mm/inch**	**mm/inch**
Bendix I	45/1.77	41/1.61	30/1.18	8/0.31	3/0.12	11/0.43
Bendix II		37/1.46	30/1.18	9/0.35		12/0.47
Haldex		39/1.54	30/1.18	8/0.31		11/0.43
Meritor		39/1.54	29/1.14	8/0.31		11/0.43
WABCO		37/1.46	32/1.26	9/0.35		12/0.47

Notes:
B: If wear dimension B is within 3 mm of the minimum thickness at the time of reline, then the rotor should be replaced together with pads.*
*B**: Ensure that the wear on both halves of the rotor are approximately even, keeping in mind that they may not be symmetrical.*
F: Consult brake manufacturing for maximum run-out specification.*

Figure 19

- If the edges of the disc pads and the pad abutment surfaces of the carrier are no longer flat, smooth and undamaged, then the disc pads and / or the carrier should be replaced.
- If the edges of the disc pads and the pad abutment surfaces of the carrier are free of noticeable wear, brinnelling, or grooving, reinstall the disc pads in the carrier.
- With the disc pads installed in the carrier, measure the amount of clearance between the disc pads and the carrier abutment surfaces. The maximum permissible clearance due to disc pad wear and/or carrier abutment wear is 2.0 mm max. (See **Figure 21**.)
- If the maximum clearance exceeds 2.0 mm, replace the disc pads, and re-measure the clearance between the pads and the carrier.
- If the maximum clearance still exceeds 2.0 mm, replace the carrier.
- Carrier-to-torque plate fastener torque is important. Consult the brake manufacturer for the proper torque specification.

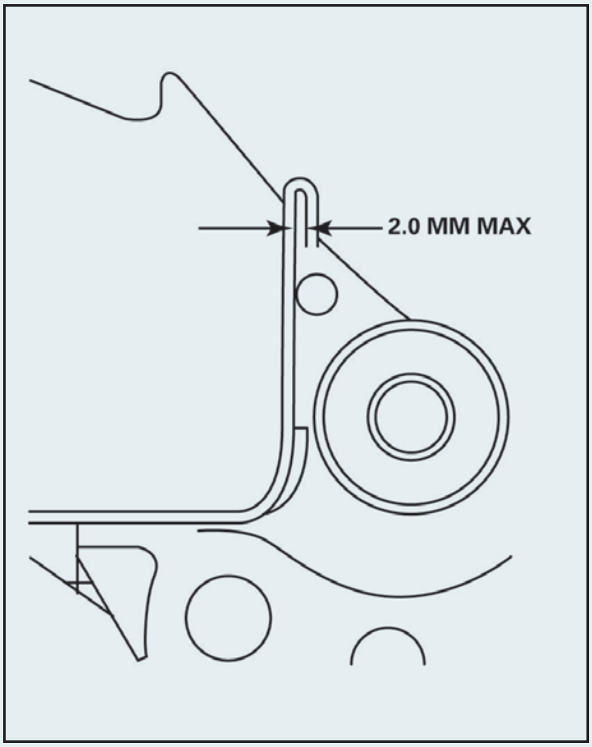


Figure 21

c. Rotor Inspection

- With the pads removed, rotate the wheel and inspect the hub and rotor assembly for damage.
- Inspect both sides of the rotor for cracks and heat checks. Replace the hub, rotor or entire assembly, if necessary.
- Check the hub and rotor assembly for damaged, loose or missing fasteners.

d. Rotor Conditions

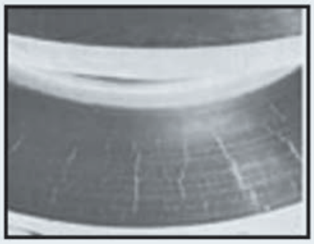
- Cracks—When the crack extends through a section of the rotor, replace the rotor.

  NOTE: Many heat checks are similar in appearance to cracks. If in doubt, a crack is defined as a “surface split” radiating into or from an edge of the rotor and/or over 75 percent in length.

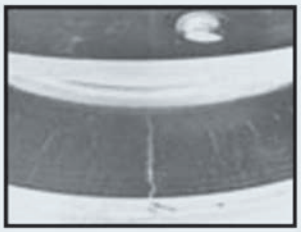
- Heat checks—Heat checks are short, thin, sometimes numerous, radial interruptions of the rotor braking surfaces. They are the result of disc brake operation. They are caused by the heating and cooling that occurs as the brakes are applied time after time. Heat checks will frequently wear away and reform. They may become braking surface cracks, depending on such factors as the lining and rotor wear rate, brake balance, and how hard the brakes are used. There are two kinds of heat checking: light and heavy. (See **Figure 22**.) If possible, visually check the rotor for cracks, grooves, scoring, or hot spots. (See **Figure 22 on the next page**.)
- **Figure 22** shows possible surface conditions on the rotor.
- Replace the rotor if it reaches the minimum allowable rotor thickness shown in the table below. Damage to components can result.
- Use a micrometer to measure the rotor thickness. If you are replacing the brake pads, the rotor should be replaced if the rotor thickness is less than shown in the table below.

e. Rotor Identification

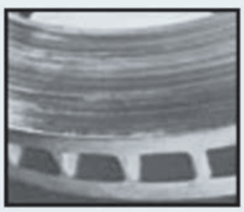
- The dimensions shown in **Figure 23** should help properly identify the correct replacement rotor for the brake used.



Example A1: Light Heat Checking



Example: B1/E1
Heavy Cracking greater than 75% of the Braking Surface Width



Example C1:
Deep Grooves or Scores

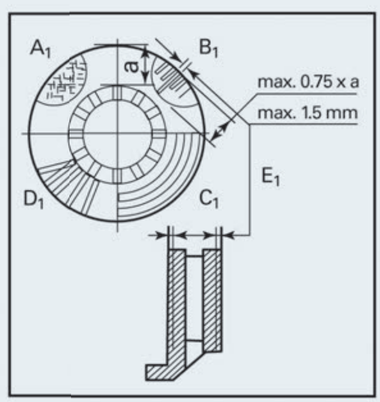
A1: Small cracks spread over the surface **are allowed**

B1: Cracks less than 0.06 in. (1.5 mm) deep or wide running in a radial direction, **are allowed**

C1: Grooves (circumferential) less than 0.06 in. (1.5 mm) wide **are allowed**

D1: Cracks in the vanes **are not allowed** and the **Rotor MUST BE REPLACED**

E1: Radial crack length cannot exceed 75% of the Braking Surface (a)

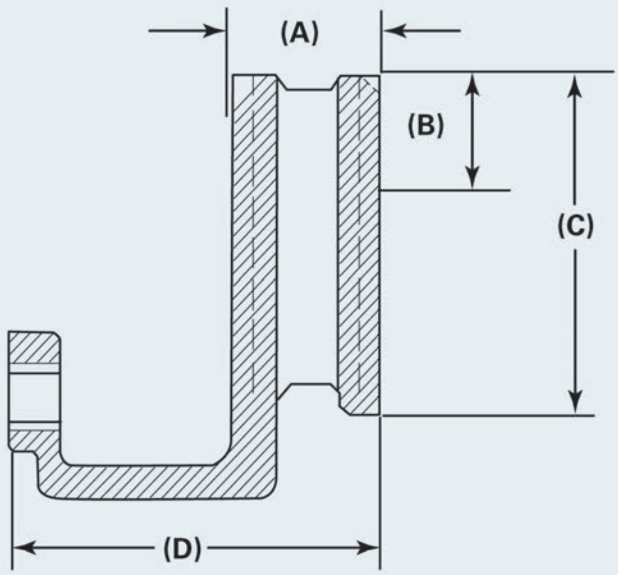


Brake Type	Dimension				
	A_1	B_1	C_1	D_1	E_1
All Disc Brakes	Allowed	1.5 mm (0.06 in.)	1.5 mm (0.06 in.)	Not Allowed	75%

Figure 22

f. Rotor Resurfacing
- Rotor resurfacing is generally not required or recommended. Please consult your brake manufacturers' service manual for additional information. For additional information on brake rotors, please refer to TMC RP 608, *Brake Drums and Rotors*.

g. Brake Adjustment Inspection
Brake adjustment is automatic and manual adjustment should not be necessary. Current adjustment condition can be checked with a dial indicator (preferred) or feeler gauge. The following procedures are suggested. For a dial indicator, do the following.



	Dimension			
	Rotor Thickness New Condition (A)	Rotor Width of Braking Surface (B)	Outside Diameter (C)	Overall Depth (D)
Brake Type	**mm/inch**	**mm/inch**	**mm/inch**	**mm/inch**
Bendix I	45/1.77	90/3.60	430/16.93	By Application
Bendix II	45/1.77	87/3.42	430/16.93	By Application
Haldex	45/1.77	90/3.60	430/16.93	By Application
Meritor	45/1.77	90/3.60	430/16.93	By Application
WABCO PAN 19-1	45/1.77	151/5.94	375/14.76	By Application
WABCO PAN 22-1	45/1.77	174/6.85	430/16.93	By Application

Figure 23

- Attach a dial indicator to the torque plate or axle frame. The dial indicator reading should be taken from a point on the backside of the caliper housing. (See **Figure 24**.)
- Check the brake adjustment by sliding the caliper back and forth, by hand, along the slide pins. Normal operating clearance should be between 0.5 mm (0.020") and 1 mm (0.040"). If the caliper slides more than 2 mm (.080") the brake is out of adjustment and requires further inspection or replacement.

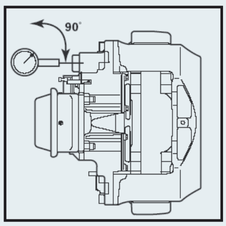


Figure 24

- If the adjuster clearance is less or more than the dimensions outlined above, the adjuster may not be functioning correctly. Check adjuster function as noted above.
- For feeler gauge inspection, insert a feeler gage between the pad backing plate and its mating surface. Normal operating clearance should be between 0.5 mm (0.020") and 1 mm (0.040"). If the caliper slides more than 2 mm (0.080") the brake is out of adjustment and requires further inspection or replacement. (See **Figure 21** as shown previously).
- If adjuster clearance is more or less than the dimensions listed above, the adjuster may not be functioning correctly. Check adjuster function as noted previously.

h. Brake Adjuster Function Check
Before beginning this procedure, check the air pressure gauge on the dash to insure that the air system has a minimum 30 psi of pressure.
- Remove protective cap from the adjuster screw.
- De-adjust the brake 1/4-turn with a box end wrench. If the brake does not de-adjust, the adjuster mechanism is not functioning properly and may need replacement. (See **Figure 25**.)

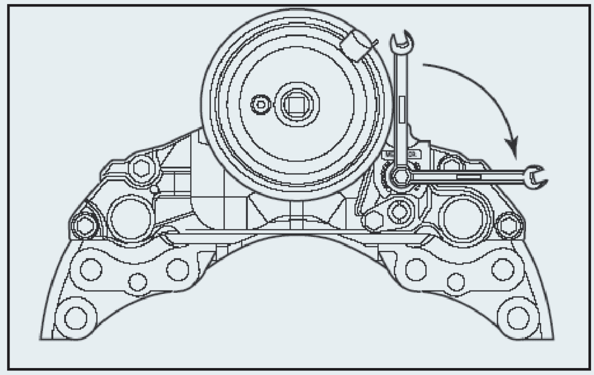


Figure 25

- Leave the wrench on the adjuster stem. Make sure there is adequate clearance for the wrench, and then actuate the brake several times.
- If the wrench rotates and maintains its position when you actuate the brake, the adjuster mechanism is working properly.
- If the wrench does not rotate in the direction of adjustment when you actuate the brake then the adjuster mechanism is not working correctly, the caliper may need replacement—consult the brake manufacturer.
- Make sure the brakes are properly adjusted before returning the vehicle into service.
- Reinstall the protective cap prior to returning the vehicle to service. If damaged, replace the cap.

i. Inspection of Brake Assembly
Pad Removal
- Remove pad retainer bolt or pin and pad retainer bar. (See **Figure 26**.)
- Remove pad retainer spring along with the brake pads.
- Inspect brake pads for excessive grooving, cracked or loose friction material. Replace if any of these conditions are present.

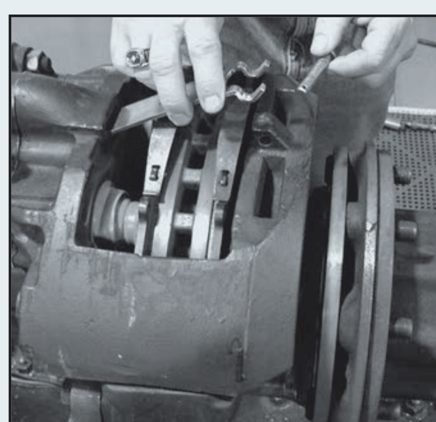


Figure 26

- Check the thickness of the pad material. The minimum dimension is 3 mm. Replace brake pads if necessary.
- Inspect pad springs/retainers for abnormal wear.
- Verify that the caliper moves freely by hand
- Inspect caliper slide pin and piston boots.
- Install new pads. Make sure that the wearable friction material faces the rotor.

Reinstall the retainer bolt or pin and retainer bar.

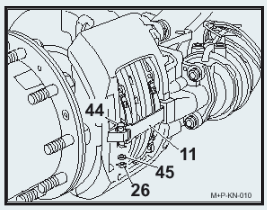


Figure 27

j. Pad Replacement
- Prior to installing new pads, inspect the condition of the piston boots
- Turn the adjuster screw (item 23) as shown in **Figure 28**, clockwise until the boots are clearly visible and inspect.
- If boots are damaged, they should be replaced.

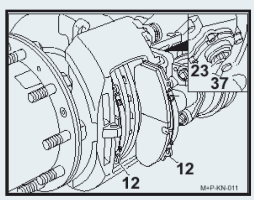


Figure 28

k. Pad Installation
- Turn the adjuster screw counterclockwise to fully retract the pistons to provide space for the new pads.
- Insert new pads and replace the hold down bar, pin, washer and retainer clip.
- Turn the adjuster screw clockwise until the pads are substantially tight against the rotor and back off two audible clicks to provide initial adjustment. Automatic adjustment mechanism will complete proper adjustment.

l. Actuator Piston Boots
- With pistons extended, carefully inspect the piston boots for cuts, tears, or burns; and ensure that they are properly seated. (See **Figure 29**.) If the piston boots are not intact, the caliper internals may have become contaminated. Consult the brake manufacturer's maintenance manual for further inspection and boot replacement instructions.

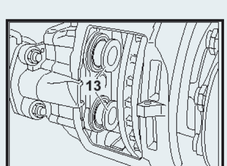


Figure 29

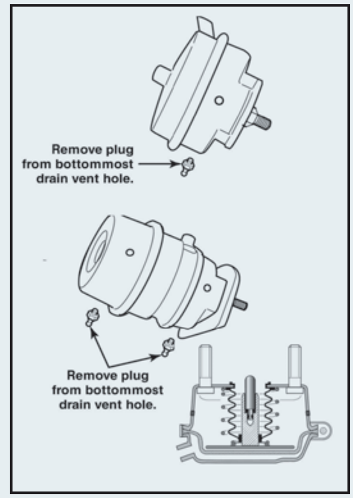


Figure 30

m. Lubrication
- No periodic lubrication is required for any of the air disc brake designs covered in this manual. Attempting to lubricate air disc brakes is discouraged and could void the manufacturer's warranty.

n. Air Chamber Inspection

NOTE: Service and parking brake chambers on both wheel ends of each axle must be air disc brake compatible and the identical size.

NOTE: To ensure proper performance and sealing, take care when replacing air chambers to make sure that the replacement chamber model and manufacturer are the same as original equipment. Inspect the seal surface of the caliper for signs of corrosion and pitting. (See **Figure 31**.) Consult brake manufacturer for any additional questions.

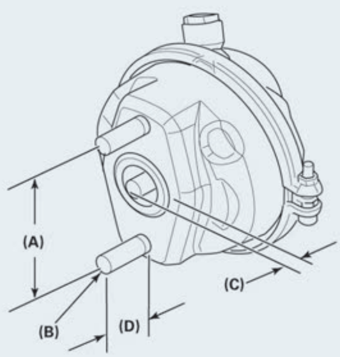
- Air disc brake chambers are different than drum brake chambers. Air disc brake chambers have an external seal and an internal boot to prevent contaminants from entering the caliper.

n. Final Inspections and Checks
- The wheel ends must be correctly installed for the proper function of the brak-

ing system. Refer to TMC RP 608 for proper wheel inspection and installation techniques.

- Take care that fasteners are installed to the proper torques. Please see individual brake manufactures maintenance manual for specific torque values.

⚠ CAUTION: All wheels and valve stems are not compatible with air disc brakes. Please check to make sure that the wheels being used are compatible with air disc brakes.



			DIMENSION Metric Units Italicized		
	Stud spacing (A)	Stud size (B)	Push rod length (C)	Nut torque	Stud length (D)
Brake Type	mm/inch	mm/inch	mm/inch	mm/inch	mm/inch
Bendix I	*120.7+/–0.25* 4.75+/–0.009	5/8"-11 UNC	*15+/–0.5* 0.59+/–0.019	*180-200* 135-150	*43* 1.69
Bendix II		*M16x1.5*			
Haldex		*M16x1.5* 5/8"-11 UNC			
Meritor		*M16x1.5*			
WABCO		*M16x1.5* 5/8"-11 UNC			

Figure 31


Meet Phil DeSouza
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CHAPTER 3: Defining the driver's role in brake maintenance

Drivers must do their part to keep trucks rolling, not out of service.

By Jason Cannon

During the Commercial Vehicle Safety Alliance's Brake Safety Week inspection spree in September 2018, law enforcement agents in the United States and Canada placed 4,955 commercial vehicles – 14.1 percent of those inspected – out of service for brake violations.

"Brake- and air leak-related road calls are our number-two problem — about 13 percent of all road calls," says Taki Darakos, vice president of maintenance for Transervice, a provider of full-service fleet leasing and dedicated contract maintenance services.

While brakes can fail or fall out of compliance at any given time, a proper and thorough pre-trip inspection is a fleet's first line of defense in catching the problem before an inspector finds it.

"I have always trained our drivers to document however long [an inspection] takes," says Michael Frolick, director of safety compliance for Toronto-based TransPro Freight Systems. "Some may do it in 30 minutes — 15 minutes for the tractor and 15 for the trailer, which is a standard benchmark for a tractor-trailer. But different configurations such as LCVs, heavy equip-

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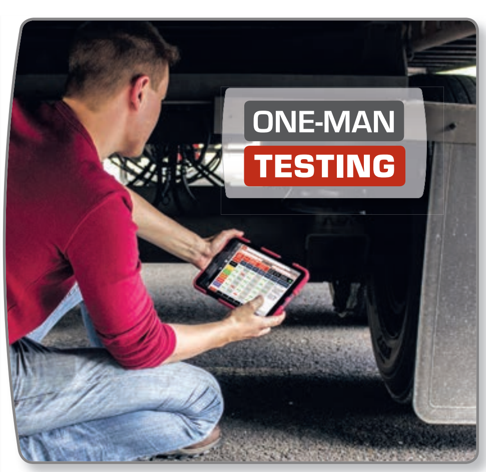

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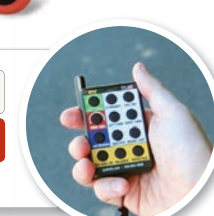

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ment, floats and flatbeds may need more time."

Regardless of how long the inspection takes, drivers should know what they are looking at and what they are looking for.

"Get [drivers] out there and observe them doing a pre- and post-trip [inspection]," says Tom Fallon, a regional safety director for Ryder, noting that younger drivers tend to be better at the 147-point inspection because they are fresh out of school. "If you can teach your folks to pre-trip and post-trip that truck right and get it fixed, that's going to improve your [Compliance Safety Accountability] scores."

Getting problems fixed

When a brake issue is flagged by the driver, the problem must be addressed by the maintenance staff. Open communication between drivers and the shop is key.

"It's a symbiotic relationship," Darakos says. "Maintenance and operations depend on each other. If we're not doing good maintenance on our end, we're going to get into a vicious cycle where the driver says, 'Every time I bring something up to the shop, no one listens to me.' And then maintenance says, 'Every time this guy comes in, he's got a problem. He just needs to drive.' "

It's also up to operations to note repeat violations and determine at what point the issue could have been avoided altogether. Brake woes at TransPro led the company to make a friction change.

"We had the mechanics do an analysis of why the shoes were being removed," Frolick says. "We were using reman brakes at the time, and the techs noted they were cracking prematurely and causing drum wear." The company transitioned away from reman brakes and saw an immediate improvement, he says.

Transervice transitioned from drum brakes to disc brakes in 2012, with many of the trucks going through their service life – 750,000 miles – never needing a brake job.

"Techs love the idea of not having to do as much maintenance," Darakos says. "The negative is that it can lull you to sleep. If disc brakes are worn down and no one catches it, it can become a pretty expensive repair by wearing down to the point that the rotor is damaged."

Disc brakes are about a $1,200-per-axle premium over drums but offer reduced maintenance costs if they are maintained adequately.

"They're not indestructible," he says. "They wear down like everything else. If you let things wear down and you get rotor damage, that can be a $2,000 to $3,000 [repair] bill, and you lost all the things you tried to do."

Post-trip inspections

If a pre-trip inspection is the first line of defense, a post-trip inspection is the last, Frolick says.

"[Post-trip inspections] help the next driver ensure he not only isn't wasting time getting needless repairs that could have been done earlier when he should have been departing, but also to avoid needless violations that could have been easily fixed had they been reported to the company at first notice to allow them to get it repaired," he says. "Instilling this procedure into protocol with your drivers is a key component to help reduce, if not eliminate, roadside violations and citations in your fleet."

If having a first and last line of defense isn't finding your brake problems before the scale house does, in-house inspections are a good middle ground.

"We have to see every piece of equipment every three months, including owner-operators' trucks," Frolick says. Trucks are brought in for inspection an additional three times per year beyond quarterly checks. "Every time a guy comes in for an oil change, we're going over their truck," he says.

If you're looking for a fast, easy inspection, be warned that the wheel area of trucks and trailers is a dark place, Darakos says.

"Lighting is important," he says. "If lighting is poor, you are going to miss things at PM time like chaffing. Also, yard lighting is important. Having a well-lit area where drivers can inspect a unit helps. We have handed out flashlights to drivers at safety meetings. You can't inspect what you can't see during a pre- and post-trip. Many times, the majority of runs are going out early in the morning."

Staying on the same page

Transervice maintenance personnel regularly partici-

Disc brakes are about a $1,200-per-axle premium over drums but offer reduced maintenance costs if they are maintained correctly.

pate in driver safety meetings, detailing any truck spec changes and setting up equipment to guide drivers through pre- and post-trip inspections.

"Sometimes you change something on the spec side, and people don't understand the technology in terms of how it works and what the benefit is," Darakos says. "Then you are not really getting the full benefit. We probably have folks that don't understand the visual indicator and what it is telling them."

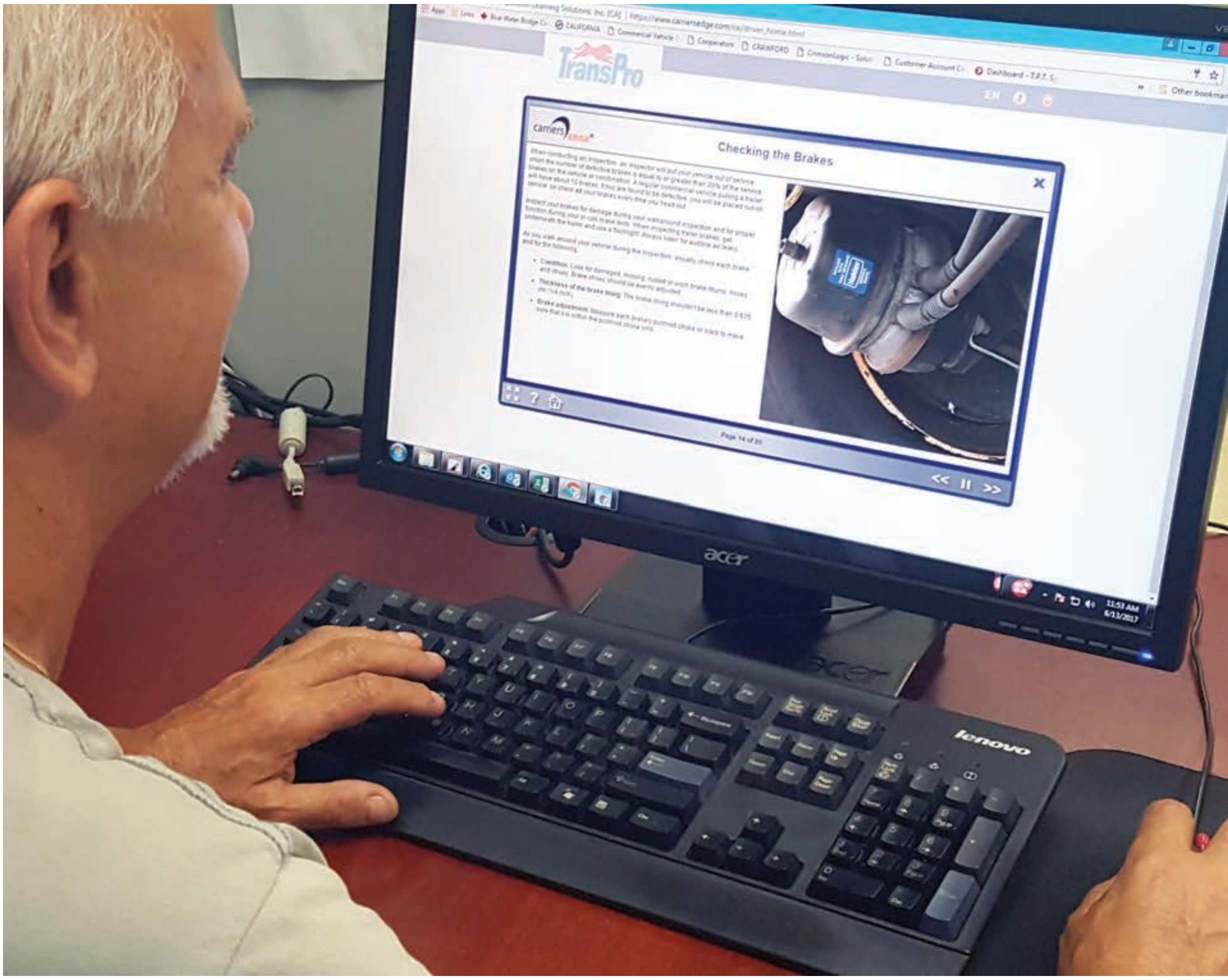
Often, Darakos will set a fault in the truck and walk the driver through the process of finding it, which yields a good idea of who is and who is not performing high-quality checks.

"If there are folks that it's not part of their routine, maybe they're just looking around ad hoc, you can usually pick it up pretty quick," he says.

Driver training is one of the biggest keys to dropping CSA violations, says Fallon, who advises fleets to get copies of CVSA's Out-Of-Service Criteria [see Chapter 5, page 53] and use the commercial driver's license training manual as a minimum standard for inspections.

"A lot of drivers don't know the required minimum tread depths," he says. "They still want to pull the coin out of their pocket. That's not the way. They should be measuring it, because that's what the [U.S. Department of Transportation] does."

For trucks not equipped with brake stroke indicators, TransPro's brake inspections consist of measur-



TransPro uses Carriers Edge's online training program that features interactive modules, which also includes pre-trip inspection training and education coupled with the carrier's own safety program.

ing from the back of the brake chamber to the middle of the center of the clevis pin, applying the brake and remeasuring.

When conducting a road test with a driver, Frolick includes the "mark and measure" method to determine if the brakes are in proper working order and not out of adjustment.

"Regardless if [the drivers] pass or fail, it also allows me to not only get an idea of what kind of training they have had previously, but also to ensure the vehicle is safe since I will be a passenger," Frolick says.

Part of training, Darakos says, also is making sure drivers and technicians understand how otherwise little things can add up to cause major brake problems.

"It's also important for drivers and technicians to take care and hang gladhands up, and not just toss them on the back of the catwalk," he says. "This leads to problems, [and] it can also lead to contamination. A good habit is to have some extra gladhand seals that you can pop in. They're not that much from a cost standpoint, but they can cause a significant delay."

Training drivers and dispatch

When a truck fails a brake inspection at the scale, drivers take the brunt of the blame, but Frolick says fleets bear a responsibility to support the truck and driver to ensure each operates safely.

"I believe drivers want to do a good job and are proud of their profession," he says. "I do have sound knowledge after interviewing someone that they have either had some training or very little. I do believe, sadly, that there are still some carriers out there that are more concerned about the dollar than the driver's or public's safety."

TransPro uses Carriers Edge's online training program that features interactive modules including pre-trip inspection training and education coupled with the carrier's own safety program.

"Our road test is two-and-a-half hours long, with a review afterward and a consistent mentor program to help new drivers over a four-week average program to share their knowledge and nurture a new driver coming out of school," Frolick says. "Our drivers also go through two mandatory safety meetings a year."

At TransPro, a driver's training is tested in unannounced safety blitz inspections in the yard. Coordination with dispatch also is important to prevent equipment in need of service from being sent with another load only because of its proximity to the customer.

"It's one thing for the computer to tell us maintenance is due, but it's another thing for us to actually be able to get it into the shop," Frolick says. "Dispatch doesn't operate the same way maintenance does. They may dispatch trucks and trailers closest to a load when the shop may be looking at them for maintenance."

Incentivizing drivers

When a driver performs poorly, fleets don't have an issue meting out punishment. But Frolick says it's just as critical to offer rewards for drivers who consistently have clean inspections.

"I think there's a disconnect in what [drivers] are trained to do and what they're motivated to do," he says. A clean Level II scale inspection is worth $25 for TransPro company drivers and $50 for owner-operators. A clean Level I inspection is worth double to each group.

Offering financial buy-in to the drivers saves far more than it costs in the long run, Frolick says.

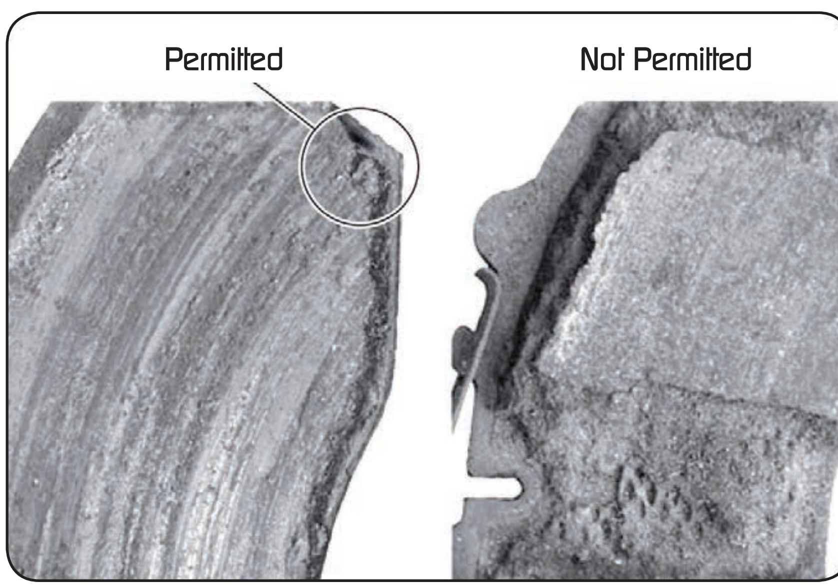
During CVSA's 72-hour International Roadcheck campaign in June 2016, A total of 62,796 inspections were conducted of which 42,236 were Level I, the most comprehensive vehicle inspection level. Of vehicles placed OOS, brake adjustment and brake system violations combined to represent 45.7 percent of those OOS vehicle violations – about 4,111 trucks.

While inspection bonuses are independent of the company's safety awards, Frolick says it stands to reason that drivers who routinely earn inspection bonuses are hitting their safety marks.

"That could be $2,000 to $3,000 more a year," he says of the driver's earning potential. "There's no better feeling than being at that scale and knowing that you know everything about that truck."

With fleets fighting over drivers, Frolick says adding incentives for clean inspections allows TransPro to further compensate its best performers. When driver pay rises, turnover generally recedes.

"Gone are the days of the dinosaur where you tell them to do it or else," he says. "We want our drivers to buy into it and show them why it is required, not just because it's the law. And they are rewarded handsomely for it, as it's part of their performance safety bonus. Training is where it's at, and we deliver that as well."



Inspectors look over brake system components to identify loose or missing parts, air or hydraulic fluid leaks and cracked, damaged or worn linings, pads, drums or rotors.

Perfecting pre-trips and preventive maintenance

Brake violations were among the three most cited by the Federal Motor Carrier Safety Administration over a 50-month stretch from December 2010 to February 2015, and they were the top offense in 12 states.

While braking systems on today's commercial trucks are safer due to technological advancements, they are only as effective as their maintenance routines.

"It is critical [brakes] are kept within their adjustment spec, which will give the vehicle even and balanced braking for better control," says George Bowers, director of maintenance operations for Ryder. "Proper brake inspection is more than just the ability to stop the vehicle. It is about vehicle control."

Inspection is also a key step in extending the brake system's life.

"Issues identified through inspection might eliminate accelerated wear, brake component damage and/or damage to other components within the system," says Keith McComsey, director of marketing and customer solutions for Bendix Spicer Foundation Brake.

Safety and wear-and-tear aside, failing a brake inspection also can be expensive.

"A breakdown is a tremendous loss of productivity, efficiency and uptime," says Randy Petresh, vice president of technical services for Haldex.

Bowers says the cost of a brake-related mobile service repair can exceed $1,000 easily, and that's assuming you don't need a tow.

"If the officer deems the unit unsafe, towing will most likely be required," he says. "Service calls for units on the side of the road take time away from the shop to manage scheduled work."

As repair bills and downtime mount, fleets consistently cited for violations also risk scaring off potential business.

"Customers deciding which carrier to use will also factor safety ratings into their selection," McComsey says.

Brake systems are only as effective as their maintenance routines.

Getting in front

Matthew Mendy, product segment manager for Daimler Trucks North America Aftermarket, says fleets can lower their cost of operation by having brake maintenance procedures meet all industry standards and state and federal regulations.

"Thirty percent of Class 8 vehicle accidents last year showed those vehicles' brakes were classified out of service," Mendy says. "The number-one ticketed item during DOT inspections is brake stroke."

Jon Morrison, president of Wabco Americas, says out-of-adjustment drum brake concerns account for nearly half of out-of-service roadside commercial vehicle inspection violations.

A driver's pre- and post-trip inspections are critical parts to identifying issues before violations occur. Obvious red flags for drivers include rust streaks, air leaks, oil stains, air lines rubbing on crossmembers or frame rails, bad or missing glad-

-hand seals and brake components that are worn, missing, broken or loose.

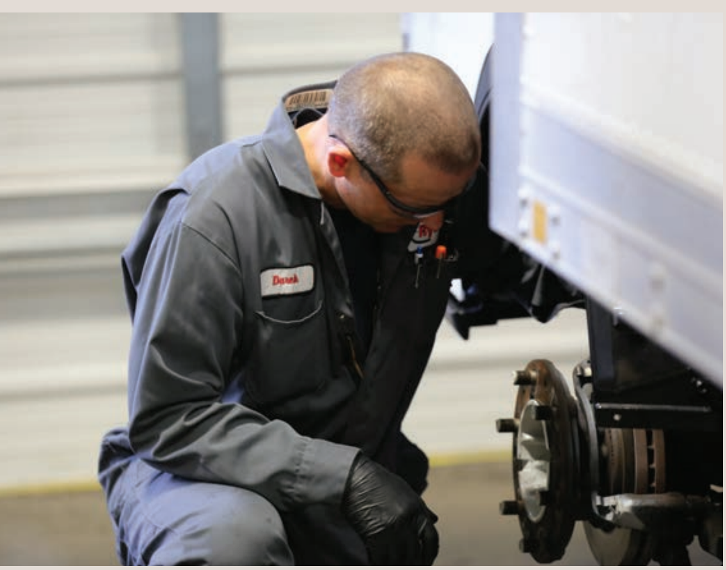
"Look for rust streak marks on brake components, which usually means loose components," Bowers says. "If the backing plate or wheel seal area starts to show signs of oil, report it immediately to prevent shoe damage."

Kevin Pfost, coordinator of technical service for Bendix Spicer Foundation Brake, says drivers should be proactive in their inspections and not simply look for obvious signs of problems.

"Take a look at components such as air chambers that may be corroded or severely rusted," he says. "Check the air system for contamination or water. Look for loose parts like chambers, the slack adjuster, brackets and air lines that may be hanging low and may hook on road debris."

Mendy suggests drivers build pressure in the air system while keeping parking brakes applied, then walk around the truck to listen for leaks.

"Look at the air gauges to see if the compressor is building correctly," Mendy says. "Check to see if the ABS or electronics components warning lamp is illuminated." A slack adjuster with an excessive stroke may indicate an out-of-adjustment wheel end and a possible worn shoe, he says.



A fleet's brake maintenance procedures should meet or exceed all industry standards and state and federal regulations.

"Most of the time, you can hear (air leaks), and they are indicative of a lot of things," Petresh adds.

Morrison says drivers should inspect the pad's thickness visually or measure caliper position with a ruler and inspect the rotors for cracks every four to six months.

"This also helps reduce any potential hard-part failures by being proactive in preventive maintenance," he says.

Once a problem is identified, drivers should seek advice from their manager.

"Find someone quickly before moving the vehicle," Mendy says. "Call dispatch, and have them make a service decision."

"The brake system must be inspected and repaired, if needed, by a qualified technician," Bowers adds. "Any potential brake system issue must be properly inspected, so never attempt to move the unit until that inspection and repair have been completed."

Often overlooked

Another part of a proactive inspection, Petresh says, is to remember there is something behind the tractor that often gets overlooked.

"Spring brake issues on trailers pop up because trailers don't get a lot of the maintenance they should get," he says. "If it feels like the trailer is pushing the tractor, there's a problem on the trailer side."

Another problem, Petresh says, is that pre- and post-trip inspections often are not consistent and loosely enforced.

"We try to encourage fleets or the operator to implement inspection requirements, or even expand them so the drivers are more capable and more knowledgeable of what to look for," he says. "Walking around without seriously looking at it isn't going to show [the driver] anything. What they need are some guidelines with what they should be looking for."

CHAPTER 4: Step-by-step air brake inspection

A strong preventive maintenance program and frequent, thorough air brake inspection practices can lower the risk of brake failure and out-of-service orders.

By *CCJ* Staff

Inspecting air brakes should be done any time a truck or tractor is in the shop as an integral part of a preventive maintenance schedule to ensure safe operation on the road. If you are inspecting brakes, you should become familiar with federal and state periodic inspection requirements. Anyone performing required periodic inspections must meet specific criteria in terms of experience and training. If your vehicle cannot meet these criteria at a roadside inspection, it will be placed out of service.

Generally speaking, a commercial vehicle air brake system should be visually inspected at least every three months, with more thorough inspections carried out according to application and manufacturer recommendations. This often includes an in-depth inspection for linehaul tractors every six months or 100,000 miles – whichever comes first – and every four months in on-highway linehaul applications when seals are replaced and brakes relined. Bear in mind that application plays a major role in air brake inspection intervals. Trucks and tractors working in harsh vocational and off-highway environments require more frequent inspections since abrasive materials found in such workplaces will accelerate lining wear and aggressively corrode other brake system components.

Visual inspection should focus on obvious signs of worn or damaged parts. But you should also be alert for more subtle signs of problems: chafed parts, poorly routed air lines or any indication that a component could eminently fail. Experts recommend you inspect the air brake system as a whole entity at one time, starting at the front and systematically working your way toward the back of the vehicle. Since abundant, clean air is the very lifeblood of any air brake system, start your inspection with the compressor under the hood.

Compressor check

If you're working on an older model truck or tractor, start by inspecting its air compressor drive belt for proper tension, cracking and general wear and tear before you do anything else to the belt. Next, start the engine. According to Bendix, after it is warmed up, run it at full-governed rpm. The air compressor should build pressure in the system from 85 to 100 psi in 40 seconds or less on vehicles with normally sized air reservoirs. If it takes longer than 40 seconds to reach specified pressure levels, you're going to have to check the system for leaks or problems with the air compressor.

During your PM inspection, disconnect the discharge line from the compressor to see if it's clotted up to the point where its inner diameter is noticeably reduced. That's a sure sign the compressor is passing excess oil and needs service. An air compressor can introduce oil into the brake system if its rings are worn. The oil can gum up components and damage brake valves. Following a PM schedule for changing air compressor oil (or engine oil if the compressor uses or shares it for lubrication) is the easiest way of preventing premature ring damage.

Leaks and adjustment

Once the compressor has been checked, it's time to make sure there are no leaks in the air system. Start the engine, and run it until the air brake system is fully pressurized. With the air brakes released, shut off the engine, release the service brakes, and time the

Any air brake inspection should start under the hood with brake compressor and air line checks.

resulting air pressure loss. The loss rate should be less than 2 psi per minute for straight trucks and less than 3 psi per minute for combination vehicles.

Next, apply the service brakes to at least 90 psi, and time the pressure drop while holding steady pressure on the pedal. (Don't count the initial air pressure drop that will occur when you apply the brakes.) Here, the air pressure loss rate should be less than 3 psi per minute for straight trucks and less than 4 psi per minute for combination vehicles.

If the pressure on the gauge drops more than that, you've got an air leak to track down. One tried-and-true method of locating air leaks is to paint the air lines and connections with soapy water and watch for bubbles. You also can use an ultrasonic leak detector. Refer to the CVSA guidelines for specific out-of-service criteria.

If the system is holding air, you can move on to wheel end and brake component checks. Begin by checking that both wheel ends of each axle have the same linings and drums. All four tandem-axle wheel ends also must have the same linings and drums. Remember that it is not necessary for the front axle brakes to be the same as the rear driving axle brakes.

Now you're ready to check all the brake chambers and make sure the spring brakes are applying and releasing as they're supposed to. Improperly adjusted brakes can cause a host of technical problems, especially when all the brakes on the vehicle are not adjusted to the same degree. When one or more brake assembly is out of adjustment, they're not doing their fair share of the work in stopping the vehicle. This results in brake imbalance and increased stopping distances. Of course, this means that other brake assemblies are doing extra work stopping the vehicle. So bear in mind that while a heat-damaged drum and prematurely worn linings at one or more wheel ends could indicate a dragging brake, it also could be a sign of an out-of-adjustment brake elsewhere on the vehicle.

To start, the return springs must retract the shoes completely when the brakes are released. Likewise, the spring brakes must retract completely when they are released. Then measure brake chamber strokes. To do this, check both the free stroke and the power stroke at each wheel end. Free stroke indicates how far the pushrod moves before the lining contacts the drum. Power stroke indicates how far the pushrod moves when the brake chamber is pressurized to 80-90 psi. Before taking measurements, verify that the parking and service brakes are fully released.

Next, measure the distance from the center of the large clevis pin to the mounting surface of the air chamber while the service brake is released. This is

Check for air leaks by fully pressurizing the system, applying the brakes and timing any pressure drop. Less than 3 psi per minute for straight trucks and 4 psi per minute for combination vehicles is acceptable.

To avoid imbalance problems, make sure all brake chambers and spring brakes are applying and releasing as they're supposed to.

your released, or reference, position. Use a pry bar to move the slack adjuster just enough to bring the linings in contact with the drum, and again measure the distance from the face of the chamber to the center of the large clevis pin. (If it is out of adjustment at 80 to 90 psi, you may be in violation of CVSA out-of-service criteria.) The difference between these two measurements is the free-stroke. Free-stroke should be 0.5-0.625 inch (12.7-15.9 mm) for drum brakes. If the measurement is too short, linings can drag, and damage to components can result. To determine power stroke, start the engine, build reservoir pressure to between 90 and 100 psi, and then shut the engine off (if pressure is over 100 psi, pump the service brake to bring it back down into the 90 to 100 psi range). Fully apply the service brake (pedal to the metal), and once more take a measurement from the large clevis pin to the face of the chamber. This part will take two people, one to apply the pedal and one to make the measurement. The difference between this last measurement and the reference or release stroke measurement is your power stroke.

The proper power stroke is a function of the brake chamber type, and you must refer to a table in the manufacturer's literature to obtain the maximum allowable value. If the power stroke is too long, braking power (and vehicle safety) will be reduced, and you can be put out of service at a roadside inspection.

While it is OK to adjust manual slack adjusters to obtain the proper free and power strokes, it is not OK to adjust automatic slack adjusters. The adjusting nut on the automatic slack adjuster is just for setup during initial installation of the adjuster or during brake relines; never use it otherwise. If they are not maintaining the correct strokes, something is either wrong with the adjuster, or there is a problem in the foundation brake, and further diagnosis is required.

Lubrication is a crucial aspect of proper brake system maintenance. If you're lubing a truck chassis as part of a scheduled PM check, it's a good idea to make sure brake adjusters, air chamber brackets and anchor pins are lubricated properly as well. Doing so will ensure proper automatic adjuster function and that manual adjusters are easy to manipulate. It also allows camshafts to rotate freely and reduces wear and tear on components. Always follow manufacturer recommendations when lubricating brake components, and take special care to ensure no grease or oil gets on brake linings.

Relining and component inspection

Sooner or later it will be time to reline the brakes on your commercial vehicles, although a huge number of variables such as weather, operating environment, application and PM schedules make reliably predicting intervals impossible. Careful tracking and experience will give you a general idea of when the vehicles in your fleet are due for brake relining, but remember that the same variables that make broad relining recommendations impossible can and will shorten or lengthen service intervals for individual trucks. This is why a good inspection policy is so important for good brake maintenance programs.

As noted, lining thickness should be measured whenever the vehicle is being serviced, or at least once every three months. If the thinnest part of the brake lining is down to about 1⁄4-inch thickness, it's time to replace the linings. Most linings today have a wear indicator machined into the friction material. In many cases, it's a divot or a line across the material to help you determine if replacement is required. While you're examining lining material depth, it's also a good idea to look for cracks along the edges of the shoe and cracks in the assembly where the rivets are found.

A cracked lining definitely will put that vehicle out of service, so if you find anything amiss, replace the shoes even if the lining material is not worn down to critical levels. You also should check the anchor pins for corrosion and wear, and replace them as needed. Check the brake shoes for rust, expanded rivet holes, broken welds and correct alignment. Replace a shoe with any of the above conditions. Additionally, check the spider for expanded anchor pin holes and cracks. Replace any damaged spiders and anchor pin bushings. Inspect the camshaft bracket for broken welds or cracks, and verify correct alignment. Any damaged brackets must be replaced at this time. (For more detailed information on brake relining, see Chapter 8, page 87.)

Brake drums don't wear as quickly as linings, of course, but now is a good time to inspect them and make sure they are in good operating order, too. You should never allow a vehicle to leave your shop with a

Generally speaking, air brakes should be inspected at least every three months. Incorporating brake inspections into your PM checks is a good way to do this.

brake drum worn or machined beyond the discard dimension indicated on the drum, as this fault may not allow the brake system to operate correctly, causing damage to other vehicle components or resulting in serious injury. Also replace any brake drum if it is out-of-round. Do not turn or re-bore a brake drum, which decreases the strength and capacity of the drum. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting and distortion, and replace them as required.

When replacing brake shoes, you also should adhere to the manufacturer's recommendations. Simply matching the friction letters in the edge code (last two letters in the edge code) does not ensure the part's original friction and wear characteristics will be present in the new part. (For more on brake lining selection, see Chapter 7, page 73.) To get the same characteristics, you must match the entire edge code.

Once you've determined the correct brake shoes, make sure they correspond in size to the parts they're replacing and that all rivets are tight, shoe-to-lining clearances are correct and all slots and holes are the proper shape and size.

Now is a good time to look carefully at cams and camshafts in the brake assemblies. The cam faces should be smooth and free of any pitting, scoring, ridges, cracks or flat spots. Camshaft journals should be smooth, and any cracked or deformed splines should be replaced. Move the S-cam up and down to check for any radial play. Some movement – only a few hundredths of an inch in either direction – is permitted, although excessive movement can cause uneven brake application and chatter. Use a dial indicator if you're not sure.

Check the chamber brackets for cracks, bent areas, looseness or any worn or damaged bushings (or bearings, if so equipped) and seals. All brake chambers should be inspected, keeping an eye out for cracks, clogged vent holes, bent pushrods, loose mountings or air fittings and clamps. Look over the brake adjusters as well. Again, you're looking for cracks, damaged splines, worn clevis pin bushings or sticking adjustment nuts.

Although some technicians opt to inspect return springs and keep them in service, most manufacturers recommend replacing return springs each time the brakes are relined. Return springs are highly stressed in normal driving conditions, and even if they are slightly corroded, there's a good chance they could fail. Before you service a spring chamber, follow the manufacturer's instructions to compress and lock (cage) the power spring. Also verify that no air pressure remains in the service or spring chamber before you proceed, as the sudden release of compressed air can cause serious personal injury and damage to components.

Additional inspection recommendations

Brake system veterans offer the following well-accepted practices for inspecting air brakes:

• Occasionally squeeze rubber hoses to check for soft spots that indicate internal damage. Blisters inside hoses can restrict air flow and adversely affect system performance. Never pinch hoses with pliers or vise grips, as this will initiate such damage.

• Have drivers exercise care when making tractor-trailer air connections. The gladhands should be checked for debris and wiped down or tapped out if necessary. There's no practical way to completely purge an air system, so a lot of what goes in stays in. Accumulated foreign matter eventually will interfere with proper system operation. Also, air lines should be suspended well above deck plates to prevent hose chafing.

• Wherever possible, specify that brakes be mounted so that, as they are applied, S-cams rotate in the same direction as the wheels they serve. When S-cams apply opposite the direction of wheel rotation, hardware and linings wear out more quickly, and brakes are noisier.

• Don't let the compressor unloader be the forgotten component. Once a year, remove and lubricate it, and replace all rubber parts.

• Don't mix manual and automatic brake adjusters on a vehicle. That's asking for an adjustment imbalance. If you must do it, never mix them on the same axle.

• Use only recommended air dryer or system anti-freeze chemicals. The wrong ones can attack rubber parts and cause serious system leakage.

• Maintaining brake systems before trouble occurs will prevent lots of problems and minimize ones that crop up. You always can take the "Fix it when it breaks" approach, but in the long run, it's going to cost you.

Recommended Practice

RP 619B **VMRS 013-010-001**

AIR SYSTEM INSPECTION PROCEDURE

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual*. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE
This Recommended Practice (RP) provides guidelines for inspecting air systems used on air-braked commercial vehicles.

GENERAL GUIDELINES
Personnel must exercise care to:
- Avoid personal injury to self and others, follow safety rules and use common sense.
- Maintain cleanliness of inspection area and catch contaminants from bleedoffs, etc.
- Use proper tools.

EQUIPMENT
The following equipment will be needed:
1. Two 0-150 psi air gauges with drain cocks.
2. Two 50-cu.in.tank test units (see **Figure 1**).
3. A 0-to-150 psi air gauge with drain cock on a six-foot flexible hose
4. A 2-1/2 gallon bucket.
5. A 12-inch scale.
6. One set of outside calipers (11-inch minimum diameter).
7. A creeper.
8. Pliers.
9. A 3/8-to-3/4-inch set of open-end wrenches.
10. For trailer only leak tests, a 1450-in^3 reservoir, regulator and shut-off cock.

PROCEDURE
1. When the vehicle first enters the inspection lane, shut off engine and chock wheels fore and aft to prevent movement of the vehicle.
2. Complete the top portion of your company's inspection form.
3. Check for operation of the pressure relief valve. (Start engine and charge the system to full pressure, shut engine off and pull relief valve stem.)

3a. Check the operation of the antilock braking system (ABS) malfunction indicator lamp on each vehicle (model year 1998 to present), including in-cab lamp (model year 2001 to present). With the ignition key cycled on, the lights must turn "on" then go "out" after a few seconds.

4. For combination vehicles only, place the tractor protection control lever or dash knob (trailer air supply or trailer emergency valve) in the emergency (air applied) position and install a 50-cu.in. tank test unit in the supply (emergency) and control (service) lines at the gladhands; open shut-off valves on test units,

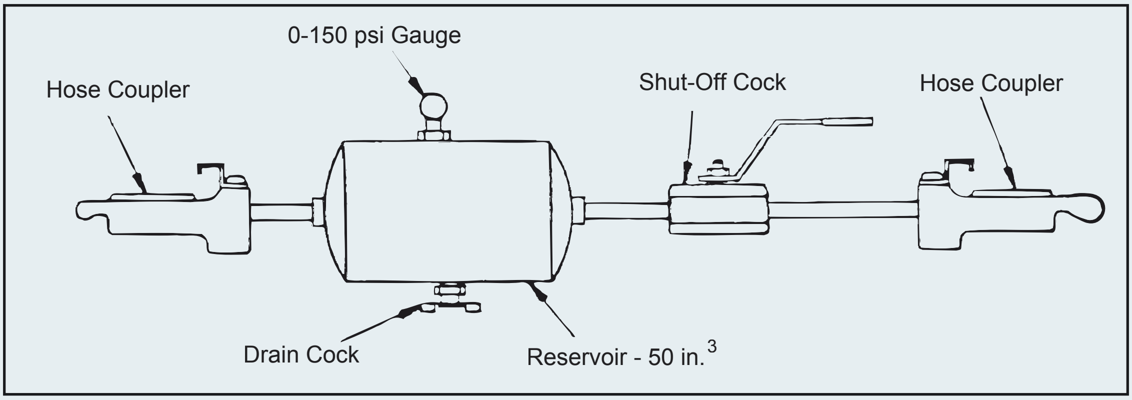


Fig. 1: Diagram of a 50-cu. in. Reservoir Test Unit

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and connect trailer gladhands.

5. For vehicles without an attached trailer, also connect a 50-cu.in. test unit to the supply (emergency) and control (service) lines at the gladhands with the shut-off cocks closed.

5a. For trailer only tests connect a 1450-in^3 test unit to the supply (emergency) line.

6. Place the tractor protection control (trailer air supply or trailer emergency dash valve) back in the normal position (air released) and release any other brakes that may be applied. The transmission of the vehicle remains in neutral throughout the test and all brakes must be in the released position, except as noted.

7. Start engine and charge the system to maximum pressure and shut off engine.

8. Starting upstream (nearest to the air compressor) and using the bucket to catch expelled contaminants, partially open the drain valve on the wet tank and let slowly escaping air remove any contaminants until the air is depleted. Remove the drain cock and install the hose and gauge assembly in the drain port of the wet tank.

⚠ **CAUTION**: Make sure drain valve is not plugged prior to removal.

9. Draining the wet tank should not exhaust the pressure in the supply (emergency) line as noted at the gladhand test gauge. If pressure loss is noted, repair or replace the check valve (at either the primary or secondary reservoir).

10. Repeat the above draining procedure with each protected reservoir, working your way downstream. All reservoirs must be drained even if the system is equipped with an air drier and/or automatic drain valves.

NOTE: If excessive oil or water is evident at any reservoir, steps should be taken to find the cause

NOTE: Lack of air in any protected reservoir indicates a probable malfunctioning check valve for that reservoir. The check valve must be replaced or repaired. Draining of one protected control (service) reservoir on a power unit equipped with a split air system should not exhaust the pressure in the supply (emergency) line as noted at the gladhand test gauge.

11. Start engine and maintain an engine speed of 1200 to 1500 rpm. Check the air governor cut-out pressure at the wet tank test gauge. Reject if higher than 135 psi. Compare the wet tank test gauge reading and supply (emergency) line gauge reading with that of the vehicle gauge reading. Readings must be within 10 percent of each other.

12. Stop engine. Apply and release brakes with foot valve until wet tank pressure is at 90-100 psi.

13. Check all test hardware for leaks (bubble leak detector) and repair as needed before continuing.

13a. Check the unapplied air loss at the wet tank test gauge for one minute. Loss should not exceed two psi for single vehicles and three psi for combination vehicles.

14. All tests for air loss shall be conducted for a period of one full minute unless it is apparent that there is no air loss or the rate of loss is excessive.

15. Restart engine and bring air pressure up to 90-100 psi

15a. Observe brake operation on all vehicles when the foot valve is fully applied and held. Immediate pressure drop for a combination vehicle shall not exceed 15 percent with an FMVSS 121 towing vehicle or 20 percent with a pre-121 towing vehicle, and for non-towing vehicles shall not exceed 12 percent for am FMVSS 121 vehicle or 15 percent for a pre-121 vehicle.

16. Repeat 15a as required.

16a. Continue full application of the foot valve and record the air pressure drop at the wet tank test gauge over a period of one full minute. The drop shall not exceed three psi for single vehicles and four psi for combination vehicles.

17. Repeat 15a as required.

17a. Release the foot valve and make a full hand valve application. (If the vehicle is not equipped with a hand valve, proceed to the next steps.) Verify brake pressure at control (service) line test gauge. With the hand valve applied, time air loss at the wet tank test gauge for one minute, then release the hand valve. Reject if pressure drop exceeds three psi over a period of one full minute.

18. While making this check with the hand valve, also walk around the vehicle and check for audible leaks and chafed or kinked brake hoses and/or lines. After test gauges stabilize, compare the readings of control (service) and emergency line gauges. The service line must be at least 50 percent of supply (emergency) line pressure. Reject if control (service) line pressure is not within the specified tolerance;

any brake fails to operate smoothly; air leaks are audible; the brake hose or line is chafed to a point where a new color is noted on the nylon tubing; or if wire, fibe , or yarn is visible or if the hose or line is kinked or pinched.

NOTE: Replace defective hose or line and correct cause of damage.

19. Start the engine and crack open the drain cock at the wet tank gauge or the supply (emergency) line gauge for combinations and towing vehicles and record the pressure at which the air governor cuts in. Reject and correct the governor setting if lower than 100 psi (85 psi for bus). Turn off engine, but leave the key in run position and allow the system to bleed down until the low pressure warning signal is noted. Record the pressure. Close the drain cock. Repair or replace the warning signal device if air pressure is lower than 55 psi.

19a. With the compressor cut-in (pumping) and the engine at idle, cycle the service brake pedal again until pressure is between 80 and 90 psi, make a full service brake application and hold. The air compressor is required to maintain or build the system pressure.

20. On combinations and towing vehicles, start engine and charge system to 60 psi. Shut off engine. Open control (service) line gladhand and depress and hold the foot pedal. Record the pressure at the wet tank test gauge at which the tractor protection valve closes off air lines to the trailer. Repair or replace the tractor protection valve or trailer emergency (dash) valve if recorded air pressure is higher than 45 psi or lower than 20 psi. Record the cab gauge and wet tank gauge pressures when air stops escaping from the disconnected tractor gladhand. Repair or replace the tractor protection valve or trailer air supply (trailer emergency) valve if air continues to escape from the disconnected tractor gladhand.

21. Check to see that trailer brakes are applied. Disconnect the supply (emergency) line gladhand and check for air leakage from the trailer gladhands. On vehicles equipped with straight air brakes, this indicates a malfunctioning relay emergency valve (pre-FMVSS 121 trailers) or a malfunctioning check valve, pressure protection check valve, or a charging/parking brake control valve (FMVSS 121 trailers). The malfunctioning valve must be repaired or replaced. On trailers equipped with an air-over-hydraulic system, air escaping from the trailer control (service) gladhand may indicate the presence of a bleed-down relay emergency valve. If so equipped, repair or replace only if air leakage is noted at the open trailer supply (emergency) line.

22. Reconnect all gladhands. Start engine and fully charge system, release parking brakes and shut off engine. On vehicles with S-cam brakes, mark the air chamber push rod at the chamber, with the brakes in unapplied (released) position.

23. Depress and release the service brake treadle until the wet tank is at 90-100 psi and hold. Service brakes on all axles of all vehicles must apply.

24. Measure the amount of push rod travel at each wheel end. Travel should not exceed the limits for corresponding size chambers at an applied pressure of 90 psi shown in **Table 1**.

25. If the stroke exceeds the maximum, there is an issue with the foundation brakes that must be fixed. Determine cause and correct. Start engine and recharge system, mark air chamber push rods (if necessary), apply and hold foot valve, and re-measure stroke.

26. For combination vehicles only, apply and release the trailer emergency brakes or trailer parking brakes by operating the tractor protection control knob (trailer air supply or trailer emergency valve) in the cab. Repair or replace the tractor protection control (trailer air supply or trailer emergency valve) or malfunctioning brake chamber(s) if the trailer brakes do not apply and release in normal manner.

27. Apply and release the parking brakes on the motor vehicle using the applicable control in the cab. Repair or replace the parking control or malfunctioning parking brake chamber(s) if the brakes do not apply and release in a normal manner.

28. On FMVSS 121 tractors and towing trucks, check to see that pulling of the parking valve (yellow diamond knob) applies the parking brakes on the towing vehicle and the emergency or parking brakes on the towed vehicles (exhausts the supply (emergency) line on vehicles without an attached trailer). Depression of the valve should release the parking brakes on the towing vehicle. To release the brakes on the towed vehicle (or to repressurize the supply (emergency) line on vehicles without an attached trailer), it may be necessary to depress the red octagonal tractor protection

control valve knob after the yellow diamond knob has been depressed.

29. On FMVSS 121 semitrailers, charge the system and shut off the engine. Check to ensure that the draining of a trailer control (service) reservoir does not cause the previously released parking brakes to apply. Repair or replace if the parking brakes apply. Place the tractor protection control knob (trailer air supply or trailer emergency dash valve) in the emergency position (released) and check to ensure that the trailer parking brakes apply. Place the tractor protection control (trailer air supply or trailer emergency valve) back in the normal (applied) running position and check to ensure that the trailer parking brakes release once the reservoir is fully charged. Repair or replace if brakes fail to release.
30. If the power unit is so equipped, check for proper operation of the emergency stopping system release (third air tank, spring brake release, pre-FMVSS 121 only).
31. Remove the test gauges and reinstall the drain cock in the wet tank.
32. Make certain that all drain cocks are closed, gladhands are properly recoupled, and all brake systems are operating normally before releasing vehicle.

NOTE: Check for leaks at all test ports using bubble leak detector. Repair as required.

TABLE 1:
READJUSTMENT LIMITS FOR BRAKE PUSH ROD STROKE

	Chamber Type	Overall Diameter	Maximum Stroke at Which Brakes Should be Readjusted *
Bolted Flange Brake Chambers	A (12)	6-15/16"	1-3/8"
	B (24)	9-3/16"	1-3/4"
	C (16)	8-1/16"	1-3/4"
	D (6)	5-1/4"	1-1/4"
	E (9)	6-3/16"	1-3/8"
	F (36)	11"	2-1/4"
	G (30)	9-7/8"	2"
Clamp Ring	9	5-1/4"	1-3/8"
	12	5-11/16"	1-3/8"
	16	6-3/8"	1-3/4"
	20	6-25/32"	1-3/4"
	24	7-7/32"	1-3/4"
	30	8-8/32"	2"
	36	9"	2-1/4"
Long Stroke Clamp Ring	16	6-3/8"	2"
	20	6-25/32"	2"
	24	7-7/32"	2"
	24**	7-7/32"	2-1/2"
	30	8-3/32"	2-1/2"
Rotochambers	9	4-9/32"	1-1/2"
	12	4-13/16"	1-1/2"
	16	5-13/32"	2"
	20	5-15/16"	2"
	24	6-13/32"	2"
	30	7-1/16"	2-1/4"
	36	7-5/8"	2-3/4"
	50	8-7/8"	3"

*** See manufacturer for recommendations concerning wedge brakes.**
**** For 3" max. stroke Type 24 chambers**

33. Collect all tools used during inspection, in, on, around, and under the vehicle, and pull the wheel chocks.
34. A copy of the dated and signed form, showing items corrected or to be corrected, should be distributed as per company policy.

REFERENCES

- Commercial Vehicle Safety Alliance *North American Standard Out of Service Criteria*
- Federal Motor Vehicle Safety Standard (FMVSS) 121
- Federal Motor Carrier Safety Regulation (FMCSR) 393
- FMCSR Appendix G, 49 CFR Subtitle B

CHAPTER 5: 2019 CVSA brake out-of-service criteria

Brake-related criteria for placing vehicles out of service at roadside safety inspections are developed by the Commercial Vehicle Safety Alliance. Out-of-service defects typically must be corrected at the inspection site. An inspector may require a vehicle to be towed, transported or escorted from the site to reduce a hazard to the public. To purchase detailed criteria, contact CVSA at www.cvsa.org.

DEFECTIVE BRAKES

A vehicle or combination of vehicles is out of service if 20 percent or more of its service brakes have one of the following defects:

Air drum, disc brakes, hydraulic and electric brakes (where applicable)

- Inoperative brake.
- Audible air leak at chamber.
- Missing brake on any axle required to have brakes.
- Evidence of oil, grease or brake fluid (hydraulic) contamination of the friction surface of the brake drum/rotor and the brake friction material.

Air drum brakes

- *Missing or broken brake components* such as: brake shoe, lining, return spring, anchor pin, spider, cam roller, camshaft, pushrod, yoke, clevis pin, cotter pin, brake adjuster, parking brake power spring or air chamber mounting bolt.
- Loose air chamber, spider or camshaft support bracket.
- Lining has crack/void, observable on edge, wider than 1⁄16 inch.
- Portion of lining is missing, to the extent that rivet/bolt is exposed.
- Lining has crack, observable on edge, that is longer than 1 1⁄2 inch.
- Loose lining segment, permitting about 1⁄16-inch movement.
- Entire segment of lining is missing.
- Lining thickness less than 1⁄4 inch or to wear indicator, if so marked, at shoe center.

Air disc brakes

- *Missing or broken brake components* such as: caliper, brake pad, pad retaining component, pushrod, yoke, clevis pin, brake adjuster, parking brake power spring or air chamber mounting bolt.
- Loose or missing brake chamber or caliper mounting bolt.
- Rotor has evidence of severe rusting or metal-to-metal contact over the rotor friction surface or on either side.
- Brake pad thickness is less than 1⁄16 inch or to wear indicator if pad is so marked.

Brake adjustment limits

- With engine off, reservoir between 90 to 100 psi (dump excess pressure) and brakes fully applied, pushrod stroke at 1⁄4 inch or more beyond adjustment limit is one defective brake; two brakes with pushrod stroke at 1/8 inch or more beyond adjustment limit equals one defective brake.

The Commercial Vehicle Safety Alliance has identified the most critical safety violations involving brakes.

- Clamp-type chamber adjustment limit:
  – Type 20 (6 25⁄32-inch O.D.) = 1 3⁄4-inch stroke
  – Type 24 (7 7⁄32-inch O.D.) = 1 3⁄4-inch stroke
  – Type 30 (8 3⁄32-inch O.D.) = 2-inch stroke
- Long-stroke, clamp-type chamber adjustment limit:
  – Type 20 (6 25⁄32-inch O.D.) = 2-inch stroke
  – Type 24 (7 7⁄32-inch O.D.) with less than 3-inch maximum stroke = 2-inch stroke
  – Type 24 (7 7⁄32-inch O.D.) with 3-inch maximum stroke = 2 1⁄2-inch stroke
  – Type 30 (8 3⁄32-inch O.D.) = 2 1⁄2-inch stroke
  Note: Brakes found at the adjustment limit are not a violation and not defective for the purposes of the 20 percent rule.

Hydraulic and electric brakes

- Missing or broken caliper, brake pad, shoe or lining.
- Movement of the caliper within the anchor plate, in the direction of wheel rotation, exceeds 1⁄8 inch.
- Rotor has evidence of severe rusting or metal-to-metal contact over the rotor friction surface on either side.
- Lining/pad thickness of 1⁄16 inch or less at the shoe center for disc or drum brakes.

Front steering axle brakes

Except for *Brake Adjustment Limits and Missing or Broken Brake Components*, all the defects listed above for Air Drum, Air Disc and Hydraulic Brakes found on the steering axle put the vehicle out of service automatically and are also included as one defective brake in the 20 percent criterion as well as:

- Any inoperative or missing brake the dolly and front axle of a full trailer and tractors required to have steering axle brakes.
- Mismatched air chamber sizes for drum air brakes and air disc brakes. This excludes long-stroke air chamber versus regular-stroke air chamber; and differences in design type, such as type 20 clamp versus type 20 rotochamber.) A mismatch on an air disc brake exists only when there is measurable difference in air chamber clamp sizes.
- Mismatched brake adjuster length for drum and air disc brakes.

Spring brake chambers

- Nonmanufactured hole/crack in spring brake housing.

Trailer/breakaway/emergency braking (all brakes)

- Missing or inoperable breakaway braking system on trailer or converter dolly.
- A breakaway system not directly attached to the towing vehicle.
- On any trailer equipped with spring brakes, more than 25 percent of the spring brakes are inoperative.

Parking brake

- No brakes are applied when parking brake control is actuated.

Brake smoke/fire

- Brake malfunction causing smoke or fire to emit from wheel end, not including overheating due to severe brake use.

Drum/rotor

- External crack that is visible or opens upon brake application.
- Rotor with a crack in length of more than 75 percent of the friction surface and passes through the rotor or has cracks in the vents.
- Portion of drum/rotor missing or in danger of falling off.
- A rotor surface is worn to or through center vents.

Hose/tubing

- Damage through outer reinforcing ply. Rubber impregnated fabric cover is not reinforcement ply.
- Thermoplastic nylon may have braid reinforcement or color difference between cover and inner tube. Exposure of second color is an out-of-service condition.
- Bulge/swelling when air applied.
- Audible leak at other than proper connection.
- Cracked, broken or crimped and restricting air flow.
- Improper splice (such as hose ends forced over piece of tubing and secured with hose clamps).
- Damaged by heat, broken or crimped, restricting air flow.

Air loss rate

- 80 to 90 psi reservoir pressure not maintained with governor cut in, with engine idling and with service brakes fully applied.

Tractor protection system

- Missing or inoperative components, including tractor-protection valve and/or trailer supply valve.

Low-air warning device

- Either the audible and visual warning devices fail to operate at the required pressure.

Air reservoir

- Separated from original attachment points moving more than an inch.

Air compressor

- Loose mounting bolts.
- Cracked/broken/loose pulley.
- Cracked/broken mounting bracket/brace/adapter.

Hydraulic

- Master cylinder below 1⁄4 full.
- Fluid line/connection is broken, restricted, crimped, improperly joined or cracked.
- Hose seeps or swells under pressure.
- Any observed brake fluid leak upon full brake application.
- No pedal reserve, engine running.
- Inoperative power assist.
- Hydraulic Power Brake (HPB) unit is inoperative.
- Hydraulic hose worn through outer cover to fabric layer.
- Failure/low-fluid warning light is actuated or inoperative.
- Brake backup system is inoperative.

Vacuum system

- Insufficient reserve for one full-brake application after engine stopped.
- Vacuum hose/line restricted; worn through the outer cover to cord ply; is crimped, cracked or broken; or collapses when vacuum is applied.

Performance-based brake tests (PBBTs)

- Failing to develop a total brake force as a percentage of gross vehicle or combination weight of 43.5 or more on an approved PBBT.

Commercial Vehicle Safety Alliance

Air Brake Pushrod Stroke

Why is it so important?

CVSA®

Air Brake Pushrod Stroke

Regulation Stroke Limits for Clamp-Type Brake Chambers

1. In a safe location, chock the wheels and release the spring brakes.
2. Bring the air pressure to 90 to 100 psi (620 to 690 kPa), then turn off the engine.
3. Identify the size and type of each brake chamber. *See Table 1.*
4. Scribe the pushrods.
5. Fully apply and hold the brakes.
6. Measure the pushrod stroke.
7. Confirm the pushrod stroke is within regulatory limits. Do not use rated stroke. *See Table 1.*

Use this table to determine the stroke limit in the regulation corresponding to the chamber size and type (standard or long stroke design) for each brake on the vehicle.

Table 1

TYPE SIZE	CHAMBER MARKING	SAE J2899 MARKING	OUTSIDE DIAMETER	MANUFACTURER RATED STROKE	REGULATION STROKE LIMIT
6	None	A	4 1/2" (115 mm)	1 1/2" (38 mm)	1 1/4" (32 mm)
9	None	B	5 1/4" (133 mm)	1 3/4" (44 mm)	1 3/8" (35 mm)
12	None	B	5 11/16" (144 mm)	1 3/4" (44 mm)	1 3/8" (35 mm)
16	None	D	6 3/8" (162 mm)	2 1/4" (57 mm)	1 3/4" (45 mm)
16LS	'L' and Stroke Tag	E	6 3/8" (162 mm)	2 1/2" (64 mm)	2" (51 mm)
20	None	D	6 25/32" (172 mm)	2 1/4" (57 mm)	1 3/4" (45 mm)
20LS	'L' and Stroke Tag	E	6 25/32" (172 mm)	2 1/2" (64 mm)	2" (51 mm)
20LS3	Square Ports, Tag and Marking	F	6 25/32" (172 mm)	3" (76 mm)	2 1/2" (64 mm)
24	None	D	7 7/32" (183 mm)	2 1/4" (57 mm)	1 3/4" (45 mm)
24L	'L' and Stroke Tag	E	7 7/32" (183 mm)	2 1/2" (64 mm)	2" (51 mm)
24LS	Square Ports, Tag and Marking	F	7 7/32" (183 mm)	3" (76 mm)	2 1/2" (64 mm)
30	None	E	8 3/32" (205 mm)	2 1/2" (64 mm)	2" (51 mm)
30	'DD3' (Bus/ Motorcoach)	N/A	8 1/8" (206 mm)	2 3/4" (70 mm)	2 1/4" (57 mm)
30LS	Square Ports, Tag and Marking	F	8 3/32" (205 mm)	3" (76 mm)	2 1/2" (64 mm)
36	None	2.75"	9" (228 mm)	2 3/4" (70 mm)	2 1/4" (57 mm)

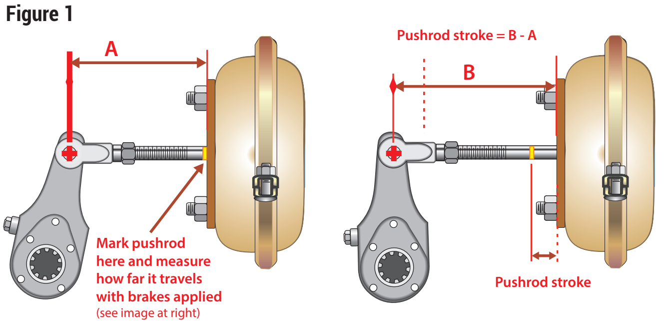
NOTES:

(1) Manufacturer's rated stroke, which is sometimes marked on chambers, should **never** be used as the adjustment limit. Brakes should be adjusted so pushrod travel does not exceed the respective stroke limit in the regulation.

(2) A drum brake with new linings that have not yet fully seated to the drum has the potential to exceed the stroke limit in the regulation upon a full brake application of 90 to 100 psi (620 to 690 kPa). Drum brakes with new linings should be checked regularly.

(3) SAE J2899 is a new alphanumeric marking option first implemented on some products in 2018.

Figure 1



Brake pedal released

Brake pedal fully applied at 90-100 psi (620-690 kPa)

Note: *It is normal for pressure to drop slightly as brakes are applied. If multiple brake applications cause the pressure to drop below 90 psi (620 kPa), pause the procedure to rebuild reservoir pressure to 90 to 100 psi (620 to 690 kPa), then resume with the engine off.*

Step Four – Compare your recorded pushrod stroke values with the stroke limits in the regulation for your brake chambers. *See Table 1*. If any chamber stroke measurement is near, at or beyond the prescribed regulatory stroke limit for your chamber type or size, the foundation brake, brake chamber, SABA, drum and wheel-end need to be inspected in more detail and serviced as soon as possible. If any pushrod stroke measurement exceeds the prescribed stroke limit, a violation exists. Any vehicle or combination of vehicles with 20 percent or more of the wheel ends containing brake violations is out of service per the CVSA North American Standard Out-of-Service Criteria.

What about free-stroke and slack?

Measuring chamber free-stroke or chamber pushrod slack, which is the distance you can pull the brake chamber pushrod by hand using a bar or lever without applying air pressure to the chamber, does not confirm a brake is working properly under all conditions. Chamber free-stroke longer than 3/8" to 3/4" (10 to 20 mm) may indicate a more serious issue. But shorter free-stroke does not confirm proper brake chamber stroke.

How can brake chamber stroke indicators help you?

Checking the stroke typically means getting under the vehicle to take measurements before and during a brake application. Brake chamber stroke indicators can be installed to help identify when the stroke reaches or exceeds regulatory limits. Stroke indicators can provide a visual aid to make stroke assessment easier, possibly without the need to go under the vehicle. It is recommended, however, that the previously mentioned four-step procedure be completed on a regular schedule.

What to do when the brake chamber stroke violates the regulations

When brake chamber pushrod stroke exceeds the regulatory stroke limit, what you do about it depends on whether your vehicle is equipped with manual or self-adjusting brake adjusters.

- **Self-adjusting brake adjusters –** SABAs should not be manually adjusted; they will do so automatically. If a chamber with a SABA has excessive stroke, there is a problem with the foundation brake, the drum, the SABA itself or other components. The entire wheel end (chamber, SABA, drum, hub and other hardware) should be inspected and serviced by an authorized brake technician as soon as possible. A manual readjustment may temporarily improve the stroke length, but it can cause damage and does not fix the underlying problem. The stroke violation may return within a few brake applications and, most importantly, stopping ability may be significantly impaired.
- **Manual brake adjusters –** Manual brake adjusters, permitted on older vehicles, must be readjusted by a qualified individual on a regular basis. If regulations require the vehicle to be equipped with SABAs based on its date of manufacture, installing and using a manual brake adjuster in place of the self-adjusting one is a violation.

Notes about self-adjusting brake adjusters

When SABAs exceed the regulation limit, consider the following before adjusting the brakes:

- Drivers may be legally prohibited from adjusting SABAs in some jurisdictions.
- The motor carrier may prohibit the driver from adjusting SABAs.
- Do not readjust a SABA unless you have been specially trained to do so.
- Manually adjusting a SABA improperly can damage it. The manufacturer's instructions must be precisely followed.
- The brake chamber will return to the excessive stroke condition until the cause of the problem is repaired. Excessive stroke can return quickly, in just a few brake applications.
- If the driver readjusts the brake chamber stroke, he or she must continue to monitor the brake chamber stroke and report any excessive stroke problems to the motor carrier or service provider.
- Be sure that any technician hired to correct an excessive brake chamber stroke is qualified and will fix the underlying cause.
- If a brake chamber with SABAs exhibits excessive stroke, some of the contributing causes could include worn or seized clevis pin connections, worn S-cam bushings, cracked chamber bracket or cam tube welds, worn rollers, cracked drums, worn linings, worn drums and/or loose mounting hardware. A trained brake technician should diagnose and correct the underlying problem(s).

The brake system on a commercial motor vehicle must work well every time, under all conditions. If not, the driver's life and the lives of others are at risk.

To stop effectively in every braking situation, all components in the air brake system, including the foundation brakes, must be properly installed, adjusted and maintained by qualified technicians. Stroke limits specified by Canadian and U.S. regulations help maintenance technicians and enforcement personnel inspect and identify brakes that may not be properly adjusting.

During day-to-day driving, a driver cannot tell how well the brakes will work during an extreme braking maneuver. The most effective way to confirm that S-cam drum brakes are within regulatory limits is to measure pushrod stroke. Pushrod stroke is the length in inches or millimeters that the pushrod travels when the brake is fully applied. If the pushrod stroke is beyond the limit in the regulation, the foundation brake may no longer be able to provide full braking force and the brake may need servicing.

Brake system violations represent the most common reason commercial motor vehicles are placed out of service during roadside inspections. When pushrod stroke exceeds the regulatory limit, a violation exists and something may be wrong in the foundation brake system or with the slack adjuster.

By following manufacturers' recommended foundation brake maintenance intervals (for lubrication, lining replacement, wear tolerances, etc.), regularly measuring the pushrod stroke and proactively addressing issues immediately, crash risk can be mitigated, safety ratings may improve, and the chances of a violation or out-of-service order can be reduced.

What is a brake chamber pushrod stroke violation?

A brake violation occurs when the brake chamber pushrod stroke exceeds the stroke limits set by regulations.

Keeping a brake chamber pushrod within regulatory stroke limits ensures there is sufficient pushrod travel to apply full force to the foundation brake under all operating conditions. The limits are based on the size of the brake chamber and whether the chamber is a standard or long-stroke design. *See Table 1.*

Pushrod stroke that exceeds regulatory limits not only violates federal, state, provincial or territorial regulations but, more importantly, results in a decline in the braking force – eventually to zero – provided by the foundation brake, which will increase the distance it takes to stop the vehicle.

Vehicles manufactured in the U.S. after Oct. 20, 1994, or in Canada after May 31, 1996, must be equipped with self-adjusting brake adjusters (SABAs) to automatically account for normal brake system wear. Manual brake adjusters are only permitted on legacy vehicles manufactured prior to the dates above and must be regularly adjusted by hand.

The use of SABAs has helped to significantly reduce the rate of out-of-service brake violations. However, even with properly working SABAs, abnormal or excessive wear or broken components can result in excessive pushrod stroke and must be properly serviced.

How to correctly measure the brake chamber stroke

To measure chamber pushrod stroke, you will need a ruler, chalk, flashlight, eye protection, pencil and paper. You will also need another person to apply the service brakes. The procedure is as follows:

Step One – Ensure the vehicle is in a safe location and make sure the wheels are properly chocked to prevent rolling. Release the spring brakes. Confirm your dash gauge indicates 90 to 100 psi (620 to 690 kPa) supply pressure in the air brake system reservoirs. Then, shut off the engine. ***Note:*** *Supply reservoir pressure exceeding 110 psi (758 kPa) will result in incorrect pushrod stroke assessments.*

Step Two – Visit each brake and confirm it is in the normal released position with nothing wrong or out of place. Mark each pushrod to establish a reference starting location. This should be level with where the pushrod exits the brake chamber or the chamber mounting bracket. Note where the pushrod mark started out and where it ends up, then measure the difference in the next step. *See Figure 1.*

Step Three – Have the other person press and hold the service brakes (pushing the brake pedal all the way down until it stops) while you measure and record the distance each pushrod mark moved (or "stroked").

Air Brake Pushrod Stroke

Consider Keeping a Chamber Stroke Measurement Record

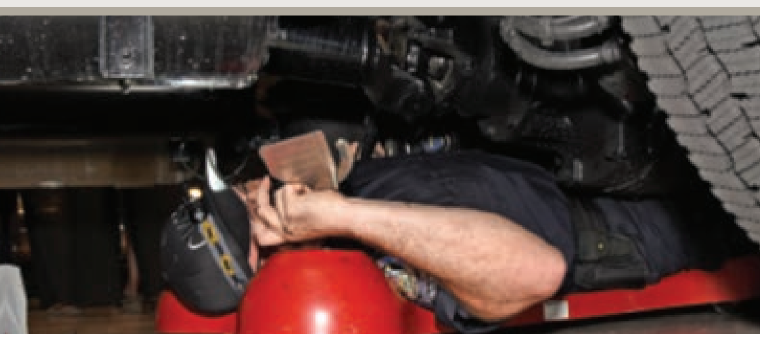
Many fleets and owner-operators have found success in preventing violations by tracking brake chamber stroke measurements at each wheel-end as part of their periodic maintenance programs. This involves recording pushrod stroke each time it is measured. *See Table 2.*

For example, consider a truck-tractor with Type 24L chambers on the steer axle and Type 30LS on the drive axles. Stroke limits in the regulation for Type 24L and Type 30LS are 2 inches and 2 1/2 inches, respectively.

The table below shows pushrod stroke measurements recorded on three occasions. Note the circled entries show one brake at the regulatory limit (it will need service soon) and another exceeding the regulatory limit (it is a violation and must be serviced). This table can be expanded to account for all axles in a vehicle or combination.

Table 2

	Chamber Size:	Type 24L	Type 24L	Type 30LS	Type 30LS	Type 30LS	Type 30LS
	Regulation Stroke Limit:	2"	2"	2 1/2"	2 1/2"	2 1/2"	2 1/2"
Date	**Odometer**	**L Steer**	**R Steer**	**LF Drive**	**RF Drive**	**LR Drive**	**RR Drive**
7/6	235,643 miles	1 1/2"	1 1/2"	1 1/4"	1 3/4"	1 1/2"	1"
7/26	243,355 miles	1 1/2"	1 3/4"	1 1/4"	1 3/4"	2 1/4"	1 1/4"
8/18	250,221 miles	1 1/2"	2"	1 1/2"	1 3/4"	2 3/4"	1 1/4"



The Commercial Vehicle Safety Alliance (CVSA) is a nonprofit association comprised of local, state, provincial, territorial and federal commercial motor vehicle safety officials and industry representatives. The Alliance aims to achieve uniformity, compatibility and reciprocity of commercial motor vehicle inspections and enforcement by certified inspectors dedicated to driver and vehicle safety. Our mission is to improve commercial motor vehicle safety and uniformity throughout Canada, Mexico and the United States by providing guidance and education to enforcement, industry and policy makers. For more information, visit www.cvsa.org.

Brake-related CSA Vehicle Maintenance BASIC Violations

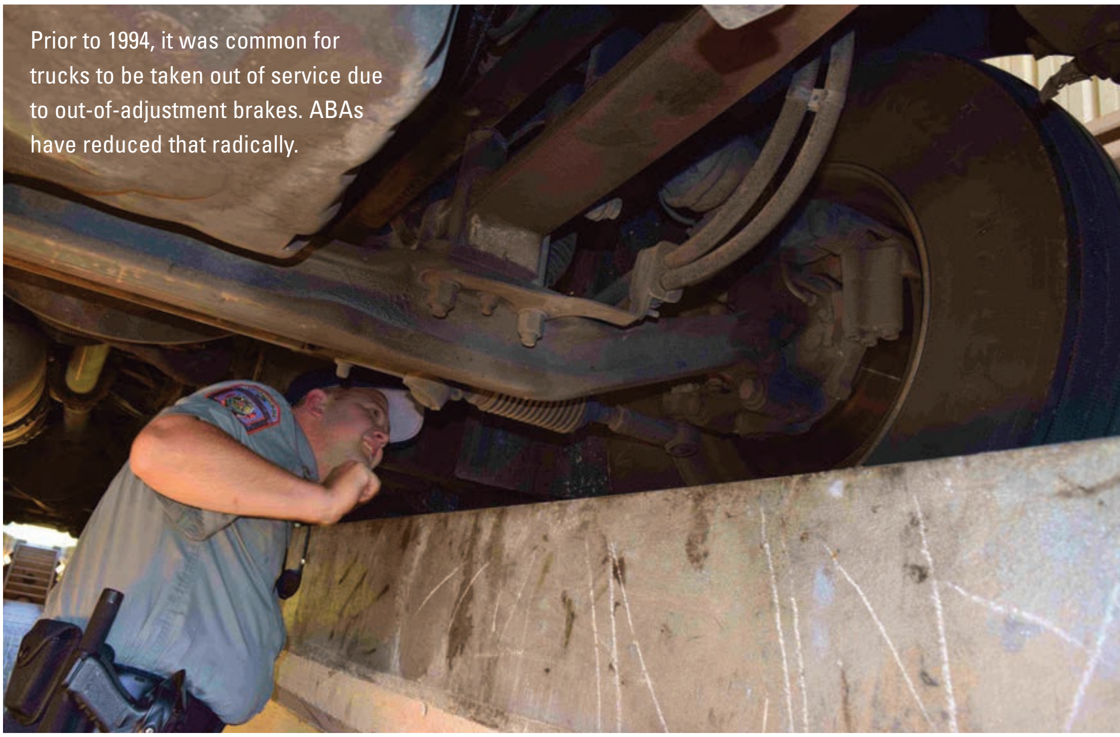
The following table contains a list of the brake-related violations and severity weights in the Vehicle Maintenance Behavior Analysis and Safety Improvement Category, part of the Federal Motor Carrier Safety Administration's Compliance Safety Accountability program (as of April 2018).

Section	Violation Description	Violation Severity Weight
Violation Group Description: Brakes, All Others		
393.40	Inadequate brake system on CMV	4
393.41	No or defective parking brake system on CMV	4
393.42	No brakes as required	4
393.42A-BM	Brake - missing required brake	4
393.42A-BMAW	Brake - all wheels not equipped with brakes as required	4
393.42A-BM-TSA	Brake - missing on a trailer steering axle	4
393.43	No/improper breakaway or emergency braking	4
393.43(a)	No/improper tractor protection valve	4
393.43(d)	No or defective automatic trailer brake	4
393.44	No/defective bus front brake line protection	4
393.45	Brake tubing and hose adequacy	4
393.45A-AJS	Inoperative brake lamps	4
393.45A-HJS	Hydraulic brake tubing improperly joined or spliced	4
393.45PC	Brake tubing and hose adequacy - connections to power unit	4
393.45UV	Brake tubing and hose adequacy - under vehicle	4
393.45(b)(2)	Brake hose or tubing chafing and/or kinking	4
393.45B2PC	Brake hose or tubing chafing and/ or kinking - connection to power unit	4
393.45B2UV	Brake hose or tubing chafing and/ or kinking - under vehicle	4
393.45(b)(3)	Brake hose or tubing contacting exhaust system	4
393.45(d)	Brake connections with leaks/constrictions	4
393.45DCPC	Brake connections with constrictions - connection to power unit	4
393.45DCUV	Brake connections with constrictions - under vehicle	4
393.45DLPC	Brake connections with leaks - connection to power unit	4
393.45DLUV	Brake connections with leaks - under vehicle	4
393.47(a)	Inadequate brakes for safe stopping	4
393.47(b)	Mismatched brake chambers on same axle	4
393.47(c)	Mismatched slack adjuster effective length	4
393.47(d)	Insufficient brake linings	4
393.47(g)	Insufficient drum/rotor thickness	4
393.48(a)	Inoperative/defective brakes	4
393.48A-BCM	Brakes - hydraulic brake caliper movement exceeds 1/8" (0.125") (3.175 mm)	4
393.48A-BMBC	Brakes - missing or broken components	4
393.48A-BRMMC	Brakes - rotor (disc) metal-to-metal contact	4
393.48A-BSRFS	Brakes - severe rusting of brake rotor (disc)	4
393.48(b)(1)	Defective brake limiting device	4
393.50	Inadequate reservoir for air/vacuum brakes	4
393.50(a)	Failing to have sufficient air/vacuum reserve	4
393.50(b)	Failing to equip vehicle air brake system with adequate reserve capacity or reservoir	4
393.50(c)	No means to ensure operable check valve	4
393.50(d)	No or defective air reservoir drain valve	4
393.51	No or defective brake warning device	4
393.52(a)(1)	Insufficient braking force as percent of GVW or GCW	4
393.53(a)	Automatic brake adjuster CMV manufactured on or after October 1993 - hydraulic brake	4
393.53(b)	Automatic brake adjuster CMV manufactured on or after October 1994 - air brake	4
393.53BMAN	CMV manufactured after October 1994 is not equipped with automatic air brake adjusters	4
393.53(c)	Brake adjustment indicator CMV manufactured on or after October 1994 - external automatic adjustment	4
393.55(a)	ABS - all CMVs manufactured on or after March 1999 with hydraulic brakes	4
393.55(b)	ABS - malfunctioning indicators for hydraulic brake system	4
393.55(c)(1)	ABS - all tractors manufactured on or after March 1997, air brake system	4
393.55(c)(2)	ABS - all other CMVs manufactured on or after March 1998, air brake system	4
393.55(d)(1)	ABS - malfunctioning circuit/signal - truck tractor manufactured on or after March 1997, single-unit CMV manufactured on or after March 1998	4
393.55(d)(2)	ABS - malfunctioning indicator to cab of towing CMV manufactured on or after March 2001	4
393.55(d)(3)	No or defective ABS malfunction indicator for towed vehicles on vehicles manufactured after February 2001	4
393.55(e)	ABS - malfunctioning lamps for towed CMV manufactured on or after March 1998	4
396.3A1B	Brakes (general)	4
396.3A1BC	Brake - air compressor violation	4
396.3A1BD	Brake - defective brake drum	4
396.3A1BL	Brake - reserve system pressure loss	4
396.3A1BOS	Brakes out of service when the number of defective brakes ≥ 20% of the service brakes on the vehicle or combination	4
Violation Group Description: Brakes Out of Adjustment		
393.47(e)	Clamp/roto-chamber type brake(s) out of adjustment	4
393.47(f)	Wedge type brake(s) out of adjustment	4
396.3A1BA	Brake out of adjustment	4

CHAPTER 6: Distinguishing the differences in automatic brake adjusters

Two main options exist for today's ABAs. Understanding their unique designs and how they function is key for proper selection and maintenance.

By *CCJ* staff


Prior to 1994, it was common for trucks to be taken out of service due to out-of-adjustment brakes. ABAs have reduced that radically.

Automatic brake adjusters – also called ABAs or automatic slack adjusters – have increased the safety of trucks and lowered maintenance concerns dramatically since they were made mandatory in 1994 on all new commercial vehicles with air brakes. As a result of the mandate, the percentage of vehicles taken out of service at roadside inspections due to out-of-adjustment brakes fell sharply.

There are two basic approaches to ABA technology. The majority of manufacturers, including Bendix Commercial Vehicle Systems, Gunite and Haldex, produce clearance-sensing ABAs, while Meritor produces stroke-sensing adjusters.

Stroke-sensing slack adjusters work by maintaining the total stroke of the air chamber. A clearance-sensing slack adjuster maintains the clearance between the shoe and the drum. The two systems work in a related fashion because the chamber moves out as the slack adjuster is turning, thereby maintaining proper brake adjustment. But how they function and their internal designs are based on two different principles. The stroke-sensing adjuster is designed to maintain the total stroke of the chamber, while the clearance-sensing adjuster is designed to maintain a specific gap between the linings and the drum.

All clearance-sensing slack adjusters have a clutch mechanism that allows a pressure differential slack. When the brake is applied, the system adjusts a small amount to keep the brakes at a constant set height built into the slack adjuster. Meritor's stroke-sensing design measures the amount of pushrod travel and says this adjusts for variances when the stroke is out of range. This maintains optimum chamber pushrod stroke.

Meritor ABAs sense the need for adjustment on the apply stroke and make any required adjustment during the end of the brake release stroke. Making adjustments at the end of the release stroke means the ABA adjustment mechanism does not see brake application loads, extending life by minimizing ABA internal wear. Stroke sensing designs typically also adjust faster. Reliability and cost are other advantages Meritor believes are conducive with stroke-sensing designs.

Regardless of adjustment philosophy, air chamber stroke is consumed in three ways:

- The chamber free stroke takes up between 1⁄2 to 5⁄8 inch of stroke on drum brakes and 3⁄4 to 7⁄8 inch on disc brakes.
- Stroke is required to account for system elasticity, which is the result of brake system deflections from the shoes, brake drum, camshaft friction material compression and air chamber mounting brackets.
- To counter dynamic changes that occur to a brake in service requiring more or less chamber pushrod stroke, such as lining or disc pad wear and brake drums or rotors heating and expanding, then cooling and contracting.

"We have a lot of years of experience with the stroke-sensing design and the interaction with the S-cam brake assembly," says Joe Kay, chief engineer, Brakes, Meritor. "The design of the S-cam profile is integral to the performance of the ABA."

One concern engineers face when designing any ABA type is maintaining running clearance throughout the life of the brake, as new unburnished brakes must allow for "green lining swell" – larger deflections due to the lining crown – in addition to lining wear and temperature changes brakes see in normal operation.

Most OE-quality replacement shoes and pads are designed in such a way to minimize green lining swell. Low-quality parts are not and may cause a dragging brake problem. All ABAs will adjust regardless of the application pressure applied by your treadle. Most brake applications are low, generally between 10 and 20 psi.

Air disc brakes also are equipped with ABAs. Although they function similarly to those found on drum brake systems, they do not have to compensate for drum expansion. In this application, an ABA's primary purpose is to keep running clearance at a certain level when the brake is cold to prevent brake drag at high temperatures.

"When the brake is hot, obviously the clearance gets less," explains Ron Plantan, principal engineer, Bendix's wheel end group. "Heat effects on running clearance in a disc brake are the opposite of a drum brake. The drum expansion with heat increases the running clearance and corresponding brake chamber stroke. On the other hand, the disc thickness grows with heat, reducing the running clearance and corresponding chamber stroke. The disc brake adjuster is designed to maintain enough running clearance in a cold brake to ensure sufficient running clearance in the worst-case hottest conditions. An inherent advantage of the disc brake is when it heats up under heavy braking; the brake stroke requirement is reduced, giving greater brake chamber reserve stroke along with improved performance.

"Basically, when an air disc ABA senses a larger clearance, it automatically adjusts to maintain to compensate for that amount," says Plantan. "If the brake then gets very hot, the ABA only has to expand over the width of the rotor as opposed to the diameter of the drum. Because of this, it's easier for an ABA to maintain brake adjustment than on a drum brake system."

Make proper adjustments

Certain features of stroke-sensing and clearance-sensing ABAs can affect fleet operations and should be considered during the spec'ing process. Proper brake adjustment can be affected adversely by overheated, expanding brake drums and rotors; cold, contracting ones; warped rotors and out-of-round drums; spongy friction materials; and distorted chamber brackets.

"The automatic adjuster doesn't really know what the temperature of the drum is, or how much it expands," says Plantan. "So if the driver pumps his brakes enough going down a long grade, it is possible to adjust the brake to a larger-sized drum."

Earlier adjusters adjusted in fairly large increments. "On a long grade, if the driver was snubbing his brakes like he's supposed to, the adjuster would overadjust to the thermally expanded drum," says Plantan.

Later, when the truck brakes had cooled down, a dragging brake was a possibility. "It was often described as an overadjustment situation," says a Bendix spokesperson. "It was a misunderstood phenomenon. The component isn't necessarily overadjusting. It's just responding to the high-temperature drum."

Manufacturers today have worked hard to design overcompensation flaws out of their ABA products.

Tips for spec'ing and maintaining ABAs

The following guidelines, gleaned from fleet managers and field service representatives, can help you make better-informed ABA maintenance and purchasing decisions:

When purchasing ABAs:

- Ask for evidence of a potential ABA's performance in different climates, applications, vocations and geographic regions similar to the ones where you operate. Remember that a manufacturer may have more than one ABA offering, including a unit better suited to your operation.
- Because internal contamination is an ABA's number-one enemy, check up on how the ABA you're considering is sealed to keep moisture and contaminants out.
- If your trucks operate in rough or mountainous terrain, pay extra attention to how the manufacturer has addressed overadjustment issues and how the design compensates for them.
- If you're retrofitting, don't buy on price alone. If you're not sure as to which ABA to go with, buy a few, install them, and track their performance before committing to a large purchase.
- Compare preventive maintenance requirements and field serviceability traits among several ABA brands before buying. Some ABAs may require special lubricants to perform properly. If you operate in tough conditions, units with easy field replacement characteristics may be preferred.
- If you're experiencing problems with camshaft corrosion, consider spec'ing an ABA with a lubrication system that sends grease to the splines whenever it is serviced.
- Consider visual stroke indicators to monitor the performance of your ABAs.

When maintaining ABAs:

- Make sure you incorporate ABA inspection procedures into your PM schedule, just like any other component.
- Although manual slack adjusters are becoming increasingly rare, remember that manual and automatic units should never be used together on the same vehicle. Also, some manufacturers caution against using ABAs from different manufacturers on the same vehicle. That being said, there is a general consensus they should never mix on the same axle.
- Improper factory ABA installation can be a problem on new vehicles. ABA inspection should be a part of your basic predelivery vehicle inspection procedure.
- If you are retrofitting from manual to automatic adjusters on older vehicles, make sure technicians receive thorough training and are familiar with each type of adjuster. Compare installation requirements and interchangeability with the manual adjusters on the vehicles and suspensions you're installing them on. Don't rely on installation diagrams that depict a "typical" vehicle.
- Remember that ABA housings are larger than manual adjuster housings, and make sure there's adequate suspension clearance when the adjuster body is rotated at maximum chamber stroke.
- Bear in mind that some ABAs fit under some suspensions better than others. Some require left- or right-handed versions with an offset clevis or offset arm in order to fit.
- Also remember that switching from manual adjusters to ABAs may reduce some brake maintenance expenses by lowering the incidence of human intervention in the brake adjustment process and by reducing uneven lining wear, wheel-to-wheel. But ABAs do not reduce the need to perform other brake maintenance. In fact, the use of ABAs actually increases the need of optimum brake system maintenance and performance since they tend to amplify weaknesses in brake maintenance practices and procedures. In short, for ABAs to work properly, brakes must be maintained at an optimum level. This may increase brake maintenance expenses in some fleets but pay dividends in safer vehicles and fewer incidences of unscheduled downtime.
- Always use the same slack type and brand on each axle to prevent side-to-side brake performance issues.

ABAs today adjust in increments small enough to allow a driver to snub brakes going down a grade without overadjusting.

"You can get brake drag for a whole variety of reasons," says Randy Petresh, vice president of technical services at Haldex. "The things that cause the most amount of problems as it relates to adjustment usually are not associated with ABAs. Brake adjusters will not compensate for poor maintenance practices."

Poor maintenance and general wear and tear can "trick" ABAs into overcompensating and lead to excessive stroke conditions. Wear at quick-connect collars, clevis pin bushings and S-cam splines are common problems. Anchor pin bushings wear. Return springs can lose their tension over time due to heat cycling in the brake, which causes them to weaken and eventually degrades how the shoe returns when the brake is released. As all of these items wear normally during braking operations, the ABA will compensate in small portions, as it is designed to do.

According to Petresh, it is this general wear and tear and degradation of all the other components in the brake wheel and the brake assembly that can be, over time, perceived by technicians as bad ABA adjustment or some sort of change to brake stroke on a particular axle or wheel end. "A lot of people just automatically assume that it's a brake adjuster, so one of the first cardinal sins they commit is they start manually adjusting it to correct the situation," he says. "That's why everybody – all the manufacturers, all the industry organizations such as Team CATA and CBSA – has had strong promotional programs over the last several years to discourage, prevent, train, teach technicians not to manually adjust ABAs."

This is important, Petresh says, because manual ABA adjustments do not solve the initial brake system problem, although doing so may disguise the true nature of the malfunction for a short period of time. But now, he says, on top of the original component problem, the technician has damaged the ABA's internal mechanism. "ABAs are not meant to be manually adjusted," he stresses. "So instead of looking for what's really causing the increase in brake stroke, all you've done is compensate for that condition. But the adjuster will very quickly thereafter revert back to its steady-state condition because it's reacting to how it's designed to react." As a result, Petresh says, the ABA goes back to a long stroke condition because of the other accumulation of wear and tear on the rest of the brake assembly that's causing the stroke to get longer in the first place.

ABA inspection and cleaning

Overall, ABAs are not maintenance-intensive components. However, as they age in normal service life, they are susceptible to wear and tear that can degrade performance. Wear on their tolerance-sensitive surfaces can increase the running clearance they are designed to maintain, resulting in a longer stroke requirement for the friction material to contact the brake drum effectively. In a worst-case scenario, at extended stroke, the amount of friction material coming into contact with the friction surface (the drum) may not be enough to generate adequate braking force.

Water and cold weather also can affect ABAs adversely. Even a small amount of water introduced into an ABA's adjustment mechanism – especially in winter – can allow corrosion to build up inside the component. Additionally, internal tolerance-sensitive surfaces can freeze up, preventing appropriate movement and adjustments until the ice thaws.

Good lubrication practices may be the biggest factor affecting the life of any type of ABA. While many technicians simply squirt ABAs with grease during service intervals, manufacturers recommend they actually lubricate the ABA in such a way that purges all the contamination out of its internal parts that may affect performance.

It's also important to remember that just because ABAs are touted as "automatic," they need to be inspected during preventive maintenance checks to ensure proper performance and long life. These checks should include verifying that the physical and operational characteristics of the ABA are in good working order. This includes inspecting its brackets and adjustment mechanisms for visual damage and automatically replacing any ABA that is suspect.

TMC Recommended Practice

RP 609C

VMRS 013-001, 013-002

SELF-ADJUSTING AND MANUAL BRAKE ADJUSTER REMOVAL, INSTALLATION AND MAINTENANCE

PREFACE

The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual*. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE

The purpose of this Recommended Practice (RP) is to provide information regarding the removal, installation, operation, maintenance, and selection of heavy-duty vehicle manual and self-adjusting brake adjusters.

INTRODUCTION

In an S-cam type foundation brake, the final link between the pneumatic system and the foundation brake is the brake adjuster. The arm of the brake adjuster is fastened to the push rod of the chamber with a clevis and the spline end is installed on the brake camshaft. Primarily, the brake adjuster is a lever that converts the linear force of the air chamber push rod into a torque which turns the brake camshaft and applies the brakes.

Two types of brake adjusters are in use: manual type brake adjusters, which periodically require a manual adjustment; and self-adjusting brake adjusters, which automatically adjust during normal service braking applications. All brake adjusters use the worm and gear principle and fundamentally differ only in their torque limit specification

NOTE: Manual and self-adjusting brake adjusters are for brake adjustment and will not compensate for normal wear characteristics and maintenance requirements associated with foundation brakes.

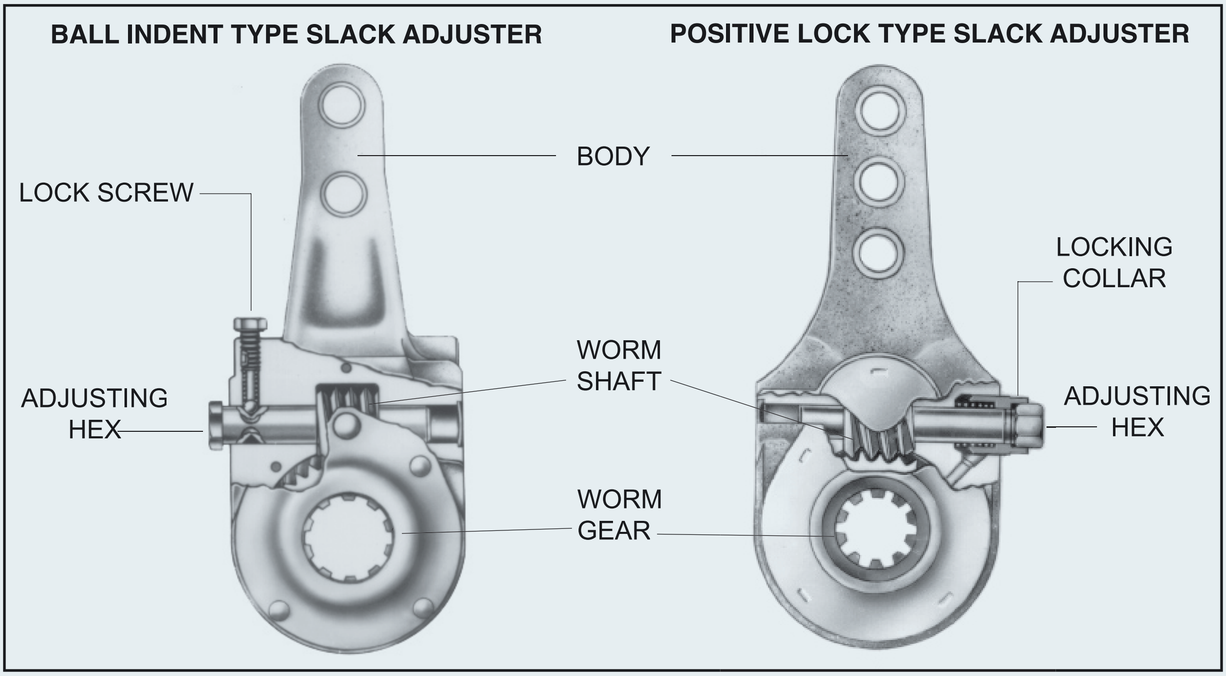


Fig. 1: Manual Brake Adjusters

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Revised 4/2011

MANUAL BRAKE ADJUSTERS

Manual brake adjusters contain four basic components: the body, worm gear, worm shaft, and locking screw or collar. See **Fig. 1.**

The worm shaft of a brake adjuster incorporates an external adjusting hex. Turning the adjusting hex rotates the worm shaft which turns the worm gear and brake cam shaft, thus spreading the brake shoes and reducing drum-to-lining clearance.

Light to medium gross axle weight rating (GAWR) vehicles utilize either a spring-loaded locking sleeve or a lock ball indent adjustment lock to prevent the worm shaft from backing off.

Higher torque-rated brake adjusters use the lock ball or plunger and worm shaft indent principle adjustment lock. The lock ball or plunger must engage the worm shaft indent after the adjustment is completed. An audible metallic click can be heard when engagement is made.

SELF ADJUSTING BRAKE ADJUSTERS

While self-adjusting brake adjuster designs vary in the manner in which they are installed and operate, all are designed to automatically maintain a predetermined drum-to-lining clearance or brake chamber stroke. Some self-adjusting brake adjusters adjust upon the brake application stroke, others adjust upon release. Self-adjusting brake adjusters should not have to be manually adjusted while in service. However, manual adjustments can be made temporarily to get a vehicle to a maintenance facility for inspection and repair, if necessary.

⚠ CAUTION Self-adjusting brake adjusters do not eliminate or reduce the need for periodic inspection and maintenance of the adjuster components and attaching hardware. Self-adjusting brake adjusters should never be operated as a manual adjuster, if the self-adjusting function is not operating properly. Regular adjustment indicates adjuster malfunction; the cause needs to be identified and corrected

BRAKE ADJUSTER REPLACEMENT

When replacing a brake adjuster, it is recommended that the replacement be of the same size as the original equipment. All self-adjusting brake adjusters on a vehicle should be made by the same manufacturer. To identify the proper replacement, the following slack adjuster key dimensional checks are recommended.

- Arm length (center of spline to center of arm hole to be used).
- Type, width, number, and diameter of splines.
- Clevis pin diameter (do not drive out bushing to accommodate a larger clevis pin).
- Brake chamber push rod size (5/8" or 1/2").
- If offset configuration, determine the offset dimension (right or left side).

BRAKE ADJUSTER REMOVAL AND INSTALLATION

⚠ WARNING: To avoid possible injury, proper precautions must be taken to prevent automatic actuation of the brake chambers while removing or installing brake adjusters. Always block the wheels or mechanically secure the vehicle. Spring brakes must be mechanically caged. All brakes should be fully released.

A. Manual Brake Adjuster Removal—

1. Remove the brake chamber push rod clevis pin.
2. Remove the retaining mechanism from the end of the brake camshaft.
3. Rotate the adjusting hex to back the brake adjuster out of the clevis.
4. Remove the brake adjuster from the spline end of the brake cam shaft.

B. Manual Brake Adjuster Installation—

1. Lubricate the brake cam shaft. Install the brake adjuster on the cam shaft so the adjustment hex and grease fitting (if so equipped) are accessible for servicing.
2. Align the brake adjuster arm with center of the push rod clevis. Install the clevis pin and secure it with a new cotter pin.
3. Check to be sure the angle formed by the brake adjuster arm and the brake chamber push rod is greater than 90° when the brake adjuster is in the released position.
4. Install the brake adjuster retaining mechanism on the end of the brake cam shaft, being sure to shim it to less than 0.060 inch of end play.
5. Tighten the jam nut on the push-rod-to-clevis attachment (1/2 - 20 300-400 in. lbs. 5/8 - 18 400 in. lbs.).
6. After installation, make certain there is adequate clearance in both the fully applied and fully released positions. Check to ensure that all brake adjusters rotate freely and without binding.
7. Adjust the brakes by following the procedure in the section entitled BRAKE ADJUSTMENT PROCEDURE.

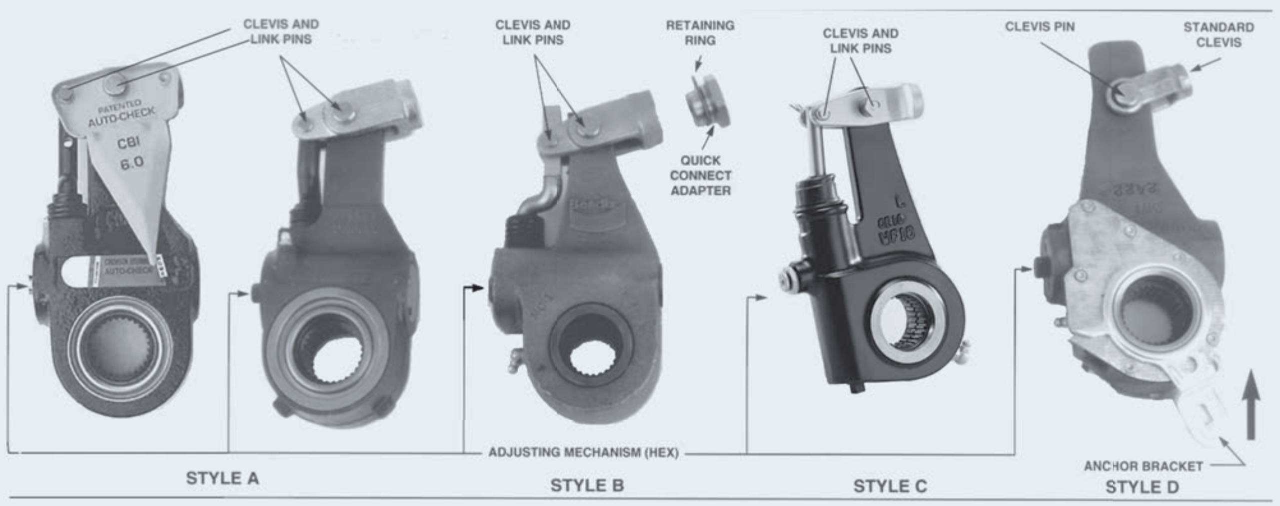


Fig. 2: Self-Adjusting Brake Adjuster Types

C. Self-Adjusting Brake Adjuster Removal—

1. Remove the clevis and link pins and the anchor bracket nut or pawl, if necessary (see **Fig. 2**).
   a. Style A—Remove the clevis and link pins.
   b. Style B—Remove the retaining ring quick connect yoke.
   c. Style C—Remove the pawl, clevis, and link pins.
   d. Style D—Remove the clevis pin and anchor bracket nuts.

2. Remove the retaining mechanism from the end of the brake cam shaft.
3. Rotate the adjusting mechanism to back the self-adjusting brake adjuster out of the clevis, if necessary.
4. Remove the self-adjusting brake adjuster from the spline end of the brake cam shaft.

   NOTE: If a manual brake adjuster is being removed to be replaced with a self-adjusting brake adjuster, the manual or threaded clevis must be removed from the brake chamber push rod (with Style D self-adjusting brake adjuster, the existing clevis is used and additional anchor bracket hardware is required). Leave the jam nut on the push rod.

D. Self-Adjusting Brake Adjuster Installation—

1. Ensure that the brake chamber is installed in the bracket holes appropriate for the self-adjusting brake adjuster arm length.
2. Clean the camshaft splines.
3. Coat the camshaft splines and the end of the brake chamber push rod with an anti-seize type product.
4. Install either a quick connect nut or threaded clevis on the brake chamber push rod per the manufacturer's recommendations. Some manufacturers offer both quick connect and threaded clevises.
5. Install the self-adjusting brake adjuster on the camshaft.
6. Install the self-adjusting brake adjuster retaining mechanism on the end of the brake cam shaft, being sure to shim it to less than 0.060 inch of end play.

7A. Rotate the adjusting mechanism to either install a clevis and link pin or to connect the clevis with a quick connect nut (see **Fig. 2**, Styles A, B, and C).

7B. For Style D, install the anchor bracket loosely and then rotate the adjusting mechanism to install the clevis pin.

8A. Using the correct gauge or template, (see **Fig. 2**, Styles A, B, and C) check for the proper mounting angle. Adjust the clevis for the correct angle, if necessary.

NOTE: The brake chamber push rod may require shortening or replacement to obtain the proper installation length.

8B. Make sure the control arm is bottomed out in the direction of the arrow or if the control arm has a pointer, align with the cut-out gap provided (see **Fig. 2**, Style D) and then secure all anchor bracket hardware.

9. Tighten the jam nut.

10. After installation, make a brake application to make certain there is no interference between the axle and the suspension components in both fully applied and fully released positions. Check to ensure that the brake adjusters rotate freely and without binding.

11. Adjust the brakes following the procedure in the section entitled BRAKE ADJUSTMENT PROCEDURE, below.

BRAKE ADJUSTMENT PROCEDURE

NOTE: All adjustments should be made with cold brake drums and the brakes fully released.

⚠ WARNING: To avoid possible injury, proper precautions must be taken to prevent automatic actuation of the brake chambers while adjusting brake adjusters. Always block the wheels or mechanically secure the vehicle. Spring brakes must be mechanically caged or released with air. All brakes should be released.

A. Manual Brake Adjuster Brake Adjustment Procedure—

1. **Brake adjusters with locking collar (positive lock type)—**Jack up the vehicle. Thoroughly clean the adjusting hex and locking sleeve area. Position a wrench or socket over the adjusting hex and disengage the locking sleeve by depressing it. With the locking sleeve fully depressed, adjust the brakes while rotating the tire and wheel. Use the wrench or socket to turn the adjusting hex until the shoes contact the drum. Then back off the adjusting hex until the tire and wheel turn freely. The actuator stroke should be as short as possible without the brakes dragging.

   If the vehicle cannot be jacked up, thoroughly clean the adjusting hex and locking sleeve area. Position a wrench or socket over the adjusting hex and disengage the locking sleeve by depressing it. With the locking sleeve fully depressed, use the wrench or socket to turn the adjusting hex until it will go no further indicating that either the shoes have contacted the drum or the adjusting hex has been turned in the wrong direction. Pull on the brake adjuster to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting hex must be turned in the opposite direction until it will go no further. After establishing solid shoe-to-drum contact, back off the adjusting hex 1/4 turn for worn linings and 1/2 turn when relining brakes. The actuator stroke should be as short as possible without the brakes dragging. Measure the chamber power stroke at 90-100 psi as described in subsection "B," "Self-Adjusting Brake Adjuster Brake Adjustment Procedure," below. Take a free stroke measurement as outlined in the section entitled FAILURE ANALYSIS. Ensure there is at least

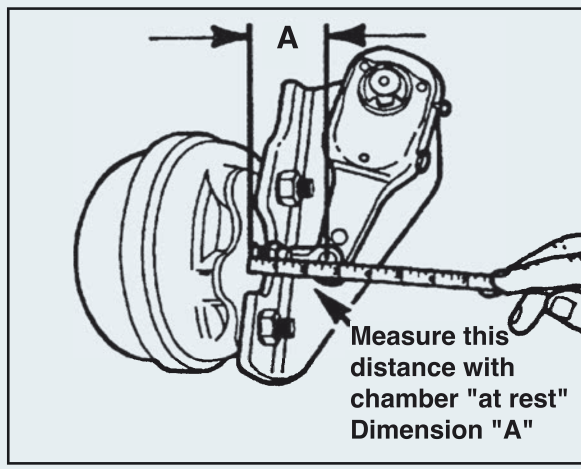


Fig. 3

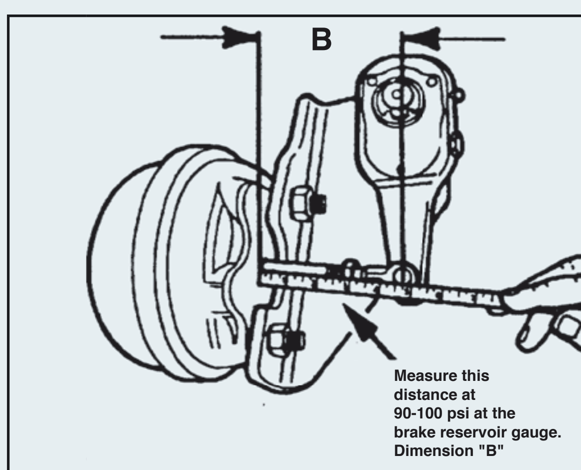


Fig. 4

TABLE 1

CHAMBER TYPE VS. MAXIMUM LEGAL STROKE AT 90-100 PSI BRAKE APPLICATION PRESSURE	
Chamber Type	**Maximum Legal Stroke**
12	1-3/8" or less
12 Long Stroke	1-3/4" or less
16	1-3/4" or less
16 Long Stroke	2.0" or less
20	1-3/4" or less
20 Long Stroke	2.0" or less
24	1-3/4" or less
24 Long Stroke	2.0" or less
24 Extra Long Stroke	2.5" or less
30	2.0" or less
30 Long Stroke	2.5" or less
36	2-1/4" or less

3/8" of free stroke. Free stroke less than 3/8" can cause brake drag. If you can't maintain maximum legal stroke and the free stroke is less than 3/8", contact the brake manufacturer for foundation or brake geometry problems.

⚠ **CAUTION**: When the manual brake adjuster brake adjustment is completed, the adjusting hex should be positioned so the locking sleeve engages it, thus locking it in place. If the locking sleeve does not engage the adjusting hex, the brake adjuster can back itself off.

2. **Brake adjuster with lock screw ball Indent type lock mechanism**—Back off (turn counterclockwise) the worm shaft lock screw (if applicable). Make the necessary adjustment by turning the adjusting hex as described in item number 1 of this section. Following brake adjustment, make certain that the lock ball or plunger engages the worm shaft indent. Without such engagement, the slack adjuster can back itself off.

B. Self-Adjusting Brake Adjuster Brake Adjustment Procedure—
A self-adjusting brake adjuster should not have to be manually adjusted except for initial installation and at brake reline. Instead of manually adjusting the adjuster, perform the following procedure during inspection:

Chamber Power Stroke: A power stroke at 90-100 psi brake application pressure will check both adjustment and foundation brake condition. Perform the following:

1. Measure from the brake chamber face to the center of the clevis pin at all wheel locations (see **Fig. 3).**
2. Make brake applications until the air reservoir gage reads 90-100 psi. Then have an assistant make a full brake application and hold it.
3. Measure from the brake chamber face to the center of the clevis pin (see **Fig. 4).**
4. The difference between the brakes released and applied measurements is the power stroke measurement. If the stroke is less than the maximum stroke for the chamber size (see **Table 1),** the inspection is complete. If the power stroke is more than the maximum stroke for the chamber size (see **Table 1**), refer to the section entitled FAILURE ANALYSIS.

SELF-ADJUSTING BRAKE ADJUSTER ADJUSTMENT PROCEDURE AT RELINE AND INSTALLATION
A self-adjusting brake adjuster should be manually adjusted after a brake reline and/or installation using the following procedure:

1. Position a wrench or socket over the adjusting mechanism.

   NOTE: If the self-adjusting brake adjuster is equipped with a pawl, remove the pawl for the brake adjustment and then properly reinstall the pawl (see **Fig. 2**, Style C) . Tighten the pawl to 15 - 20 ft.-lbs.

2. Rotate the adjusting mechanism until the brake shoes contact the drum. Pull on the brake adjuster by hand to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting hex must be turned in the opposite direction until it will go no further.
3. Reverse the rotation, backing the brake adjuster off one-half (1/2) turn.
4. Measure the chamber power stroke at 90-100 psi brake application pressure as described in the previous section.
5. Take a free stroke measurement as outlined in the section entitled FAILURE ANALYSIS. Make sure you have at least 3/8" free stroke. Free stroke of less than 3/8" can cause brake drag. If you cannot maintain the maximum legal stroke and the free stroke is less than 3/8", contact the brake manufacturer for foundation or brake geometry problems.

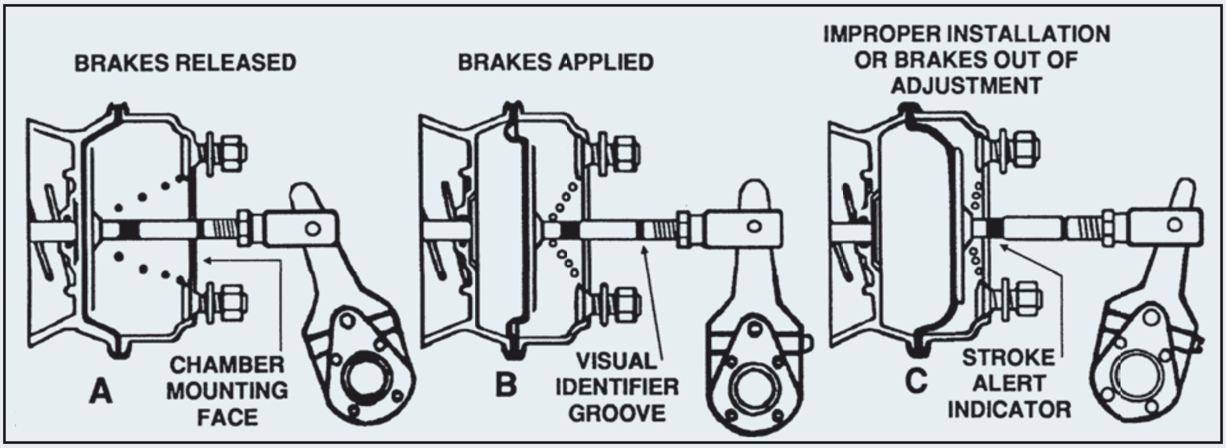


Fig. 5

ROADSIDE BRAKE ADJUSTMENT

If the driver has to adjust brakes on the road, the following procedure is recommended:

If the vehicle is equipped with an self-adjusting brake adjuster, use a pry bar to pull on the brake adjuster. If movement is more than 5/8", a manual adjustment should be made following the same procedure as described below for a manual brake adjuster. If the self-adjusting brake adjuster is equipped with a pawl remove the pawl for the brake adjustment and then properly reinstall the pawl. If the self-adjusting brake adjuster needs adjustment, inform maintenance personnel immediately.

1. Block the wheels or mechanically secure the vehicle. On the brakes to be adjusted, spring brakes must be mechanically caged or released with air.
2. Rotate the adjusting mechanism until the brake shoes contact the drum. Using a pry bar, pull on the brake adjuster by hand to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting mechanism must be turned in the opposite direction. Tap the brake drum with a wrench; you should hear a dull clunk indicating the brake linings are tight against the drum.
3. Back off the brake adjuster a small amount at a time, while tapping on the brake drum with a wrench in between adjustments. Stop backing off the adjuster when you hear a clear ringing sound from the brake drum when tapped with a wrench.
4. Using a pry bar, pull on the slack adjuster by hand. If movement is more than 5/8", adjustment was not done properly or there is a problem with the foundation brake.

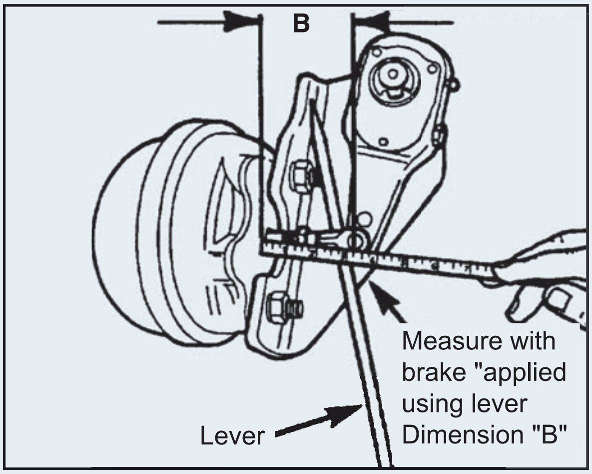


Fig. 6

NOTE: Some brake chamber push rods are marked to warn of an over-stroke condition. While the marking themselves may vary, the marking system has two basic features. They are: There is a mark on the brake chamber push rod near its clevis attachment to signal that it incorporates a stroke alert indicator (see **Fig. 5,** diagram B). There also is a mark on the brake chamber push rod opposite its clevis attachment end which is exposed from the brake chamber wherever over-stroke occurs (see **Fig. 5,** diagram C).

FAILURE ANALYSIS

Manual Brake Adjuster Failure Analysis—Manual slack adjusters should be inspected for gear set wear. To do this, back off the adjusting hex until all spring pressure is relieved from the clevis. Work the adjusting nut 1/4 turn back and forth while watching for cam rotation. If you have 1/8 to 1/4 turn of play without the cam rotating, the manual brake should be replaced. Repeat this procedure every 1/4 turn of the adjusting nut to check the whole gear set.

Self-Adjusting Brake Adjuster Failure Analysis—If the power stroke is at or more than the maximum stroke, measure free stroke and check/inspect the adjuster components and attaching hardware to determine if the brake adjuster is operational.

FREE STROKE MEASUREMENT

Free stroke is the amount of brake arm movement required to move the brake shoes against the drum. To measure free stroke, perform the following:

1. With the brakes released, measure from the brake chamber face to the center of the clevis pin.
2. With a lever, pry the brake adjuster arm until the brake shoes contact the drum and measure the brake adjuster movement (see **Fig. 6**).
3. The difference between the brake released and applied measurements is the free stroke. The free stroke should be 3/8" - 5/8". If the free stroke is in the correct range, the out of spec stroke is due to a foundation brake problem. Check for missing or worn components, cracked brake drums, or improper lining-to-drum contact. If the free stroke is greater than recommended, a self-adjusting brake adjuster function test should be performed.

SELF-ADJUSTING BRAKE ADJUSTER FUNCTION TEST

1. Remove the pawl (if equipped), then rotate the adjusting mechanism at least one complete turn as if backing off the brake adjustment (see **Fig. 2**, Style C). The pawl must be installed properly and tightened to 15 - 20 ft-lbs after backing off the adjuster.
2. Apply the brakes several times and observe whether the adjustment mechanism is rotating in the direction needed to reduce brake chamber pushrod stroke. If the adjusting mechanism does not rotate, the brake adjuster should be replaced.
3. Check back-off torque by rotating the adjusting hex as follows (see **Fig. 2**):
   - Style A: Minimum 15 ft-lbs counter clockwise (CCW)
   - Style B: Minimum 15 ft-lbs CCW
   - Style C: Less than 45 in-lbs CCW (pawl removed)
   - Style D: Minimum 13 ft-lbs CCW

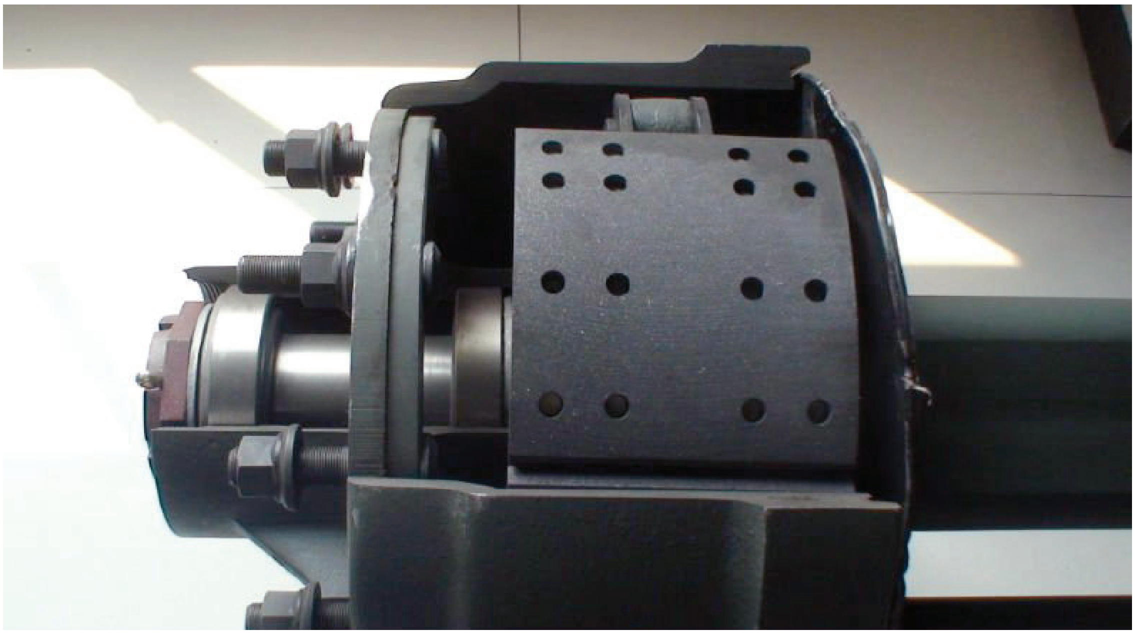
Consult the manufacturer for more information.

PREVENTIVE MAINTENANCE

Every month, 8,000 miles, or 300 operating hours, check brake chamber push rod travel; chamber stroke should be in compliance with the maximum allowable adjusted strokes indicated in Table 1, without the brakes dragging or the pushrod binding. Adjust manual adjuster if necessary. Due to different operating conditions, adjustments may be necessary at earlier intervals.

Every six months, 50,000 miles, or 1,800 operating hours, lubricate all brake adjusters and clevis pins with manufacturer's recommended lubricant. Check for worn clevises, clevis pins, clevis pin bushings, and worn or broken control arm/attaching brackets. Failure to replace worn, broken, or disconnected components will increase chamber stroke. Lubrication and inspection may be necessary at earlier, intervals due to different operating conditions.

CHAPTER 7: Selecting proper brake linings



Spec'ing the appropriate brake linings is key to optimizing brake performance and lowering maintenance costs.

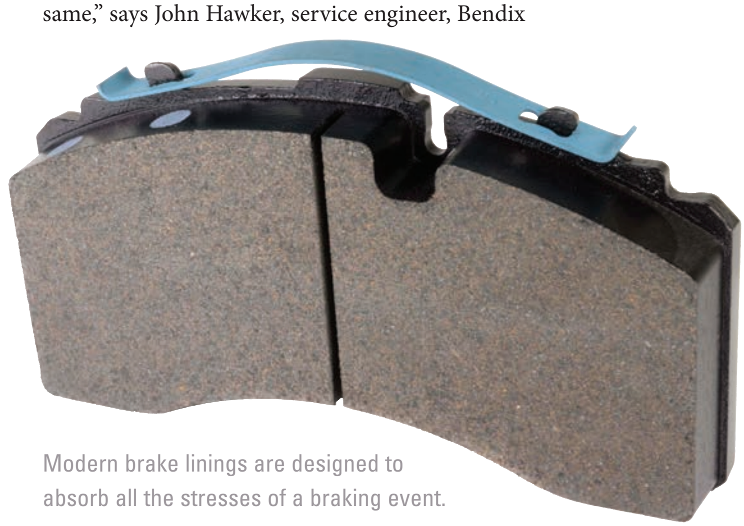
By *CCJ* staff

In trucking applications, friction is the force that slows a vehicle down. The brake system is the means by which that force is applied. But the actual component that has to bear the brunt of all the heat, weight, energy and force created during a braking operation? That would be the brake lining on the shoes and pads.

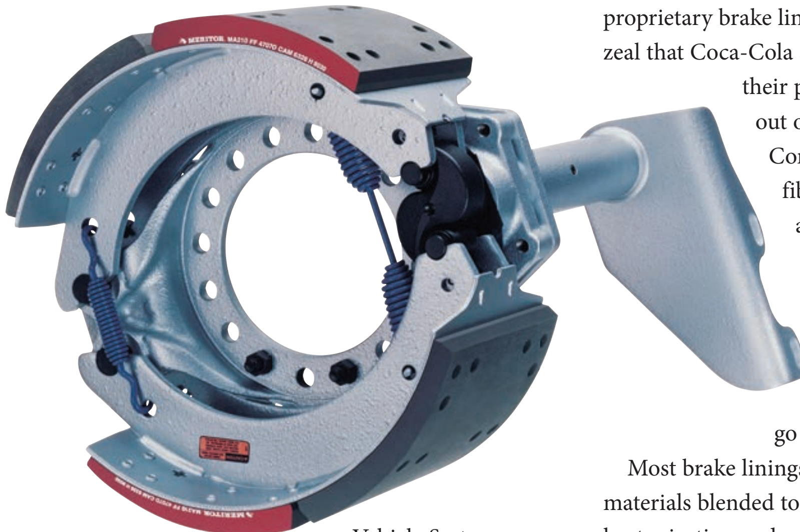
Clearly, brake linings work in a hellish environment. Yet they do so reliably, day in and day out, a testament to the ongoing research and development carried on by manufacturers.

Companies like Haldex carry out extensive laboratory testing to establish performance baselines for new linings. "Then we do field testing in addition to that to make sure they perform as intended, and that field testing can be several years," says Scott Corbett, director of technical service and warranty for Haldex. "Some of the linings have as many as 11 different tests to pass, evaluating factors such as fade, wear characteristics, overall component and material performance and high-temperature performance."

Additionally, Corbett says, tests are conducted on peripheral characteristics such as lining squeal and vibration. In all, he notes, it is not unusual for linings to undergo more than five years of extensive testing before being released into the marketplace. "Whether you're working on a motorcycle or you're working on a severe-duty off-highway vehicle, the concepts are basically the same," says John Hawker, service engineer, Bendix



Modern brake linings are designed to absorb all the stresses of a braking event.



Brake shoes are almost always sold in kits to ensure replacement of all worn components.

Vehicle Systems. "You're transferring energy and motion – kinetic energy – and converting it to heat. That's what the friction material in a brake pad or shoe does."

To understand exactly how a brake lining accomplishes this, think of the process of applying a brake pedal as a controlled burn. "Just like you burn fuel to make the vehicle go, you wear friction material to make the vehicle slow down," explains Hawker.

Because brake linings are designed to wear as they do their job, it makes sense for manufacturers to design linings to last as long as possible to keep maintenance costs down and assure solid braking performance even in abrasive or severe operating conditions.

Each manufacturer guards the ingredient list for its proprietary brake lining materials with the same sort of zeal that Coca-Cola and KFC guard the ingredients in their products. "Brake linings are made out of many different materials," Corbett notes. "You'll find carbon and fiberglass. And there used to be asbestos until we removed it. But all lining manufacturers have special materials they put in lining, and the higher grade or more expensive the lining is, the more premium materials go into that lining."

Most brake linings consist of different amounts of materials blended together in such a way to maximize heat rejection and component life. These include but are not limited to:

- Fiber materials, usually comprised of steel, carbon, fiberglass, synthetic or ceramics.
- Abrasives such as aluminum oxide, magnesium oxide, zinc oxide and silicon carbide.
- Friction modifiers.
- Fillers, including inorganic, metallic and organic materials.
- Binders, usually phenolic resins and rubber compounds.
- Carbonaceous compounds such as coke, carbon and graphite.

Each manufacturer blends these compounds in various amounts under computer control. The mix is pressure-cured in long slabs, then baked, cut and shaped. Rivet holes are drilled, and the lining is affixed to a shoe or pad. Samples are pulled and checked to ensure quality and durability, including analysis of moisture content, acidity, fiber size and ash content, among other tests.

Some states have their own specific requirements for brake materials. New OE and replacement brake blocks sold into California and Washington must feature reduced content of several metals, including

Experts stress the importance of always spec'ing brake linings manufactured by reputable OEMs to ensure the highest quality possible.

cadmium, chromium, lead, mercury and asbestiform fibers. Copper must be cut to 5 percent of material content by weight by Jan. 1, 2021. "Edge codes are specific to the corresponding formulation, so the edge codes will be unique to each formula," says Alesha Erving, commercial markets product manager for Federal Mogul.

Also, Erving says the industry has proposed requirements to designate compliance. There will be suffixes added to the edge code format. Environmental codes will be added (A, B, N), plus the year of manufacture. Each environmental hurdle is designated by the environmental code that will be applied to the edge code and label.

Gauging lining life

Choosing the proper replacement and knowing when to replace brake linings is critical for performance, so manufacturers and industry organizations such as the Technology and Maintenance Council and the Society of Automotive Engineers go to great lengths to simplify the selection process when selecting replacement linings. Common tools are friction thickness or lining thickness gauges built into a shoe or pad to enable technicians to determine at a glance how much useful life the component has left. Many brake wear gauges have a minimum thickness check, but also have a 50 percent checkpoint on them. So they not only will tell you when they need to be replaced, they also can allow you to project the remaining life left on the shoe or pad and schedule the brake maintenance for that vehicle in advance.

Another point worth noting is that the majority of brake shoes are sold in kit form, which typically consists of two shoes with all the applicable wheel-attaching hardware in the box so technicians will replace all of the wear components that are associated to that wheel end – such as anchor pins, springs, retaining springs and bushings – as well as check radial play in the camshaft and others items that are associated to that brake.

All quality brake shoes and pads will be marked with edge codes on the side of the friction material. These codes give crucial data about the part and help technicians ensure they are replacing it with one that will give comparable performance.

Most edge codes start out, typically, by identifying the brand of the material in the pad. Naturally, the manufacturer will be noted as well. If the friction material is designed for extended service, for example, other information such as FMSI identification will follow along with mounting information telling you if the shoe requires single or dual anchor pins. It also will have a coefficient of friction generated by the material; this alphabetical sequence designates the coefficient of friction for that particular lining material. Coefficient of friction can be identified as EE, FF or GG, for example. The higher the alphabet scale gets, the more aggressive the material.

"That coefficient of friction comes from testing in a lab, quality control tests of a 1-inch-square piece of friction at that particular point when coming off a manufacturing batch line," notes a spokesman for Bendix Commercial Vehicles. "It's considered more of a quality control test and was implemented as one of the only tests they had in the marketplace to define an aspect of a brake. Today we have much more in-depth detailed tests that we run, so although the coefficient of friction is still

Edge codes give a variety of important information, including the manufacturer's name, coefficient of friction, anchor pin requirements and service application.

labeled on the edge code of a friction lining material, it is a reference and not indicative of the performance of that particular friction. It's very important for technicians to bear that in mind when comparing edge codes."

A final piece of data on the edge code tells the batch – or specific manufacturing data – pertinent to that particular component. This is so that if there is a failure or performance issue with the material, it can be traced back to its manufacturing date, even down to the exact time of the manufacturing process.

According to Hawker, the most important thing about the edge code of any friction material is the manufacturer's name on it. "You need to know who manufactured that part so you know it's being backed by somebody," he stresses. "There are many 'will fit,' 'could fit,' 'might fit,' copycat and even counterfeit parts out there on the market today. One part may very well look like the one you've just pulled off a truck. But if there's no name on it, I sure wouldn't put it on a vehicle, because I wouldn't want the liability and responsibility that I installed something that's suspect."

Brake linings slowly wear every time a driver applies the brakes, but simply spec'ing more aggressive materials will not necessarily deliver longer pad or shoe life.

A fine line

The alphabetical codes found on the side of a brake pad or shoe also can help you select the appropriate lining material mix for the application at hand, says Corbett. "If you have a severe-duty cycle application, like cement mixers, you're going to need a different material grade than you would for a linehaul-type application," he notes. "But don't just depend on edge codes alone." All manufacturers provide weight charts that detail how a particular lining corresponds to the weight your vehicles are hauling. It's an easy way to make sure that you've done your homework and you put the appropriate lining on for the job the vehicle has to do.

But simply increasing the level of friction material aggressiveness to meet more severe duty cycles is not always the best course of action when optimizing brake linings. "It is a balancing act," Hawker stresses. "You have to take other factors beyond the friction material into account as well."

Those factors include air valves, drums, slack adjusters and chamber size. Naturally, different working environment or driving conditions may necessitate changes to vehicle brakes. But simply putting an aggressive brake lining on and assuming that will fix everything is a mistake.

One final piece of the puzzle is the driver. As Corbett notes, nothing affects lining wear like bad habits behind the wheel. "Excessive braking, running up on stoplights and hitting the brakes at the last minute – all of that takes a toll," he says.

Heat is another critical factor. "Drum-type brakes are effective up to a certain temperature, and then they start to fade away," says Corbett. "If a driver keeps his brakes cool and doesn't abuse them, he's always got that maximum amount of stopping power if he gets into an emergency. If a driver rides the brakes or overheats them and gets into an emergency situation, he may not have enough stopping power to do what he needs, so it's important to coach drivers and get them to help you get the most out of the brake linings on that vehicle."

TMC Recommended Practice

RP 628C **VMRS 013-001-015; -002-014**

AFTERMARKET BRAKE LINING CLASSIFICATION

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of TMC's *Recommended Maintenance Practices Manual*. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE
The purpose of this Recommended Practice (RP) is to provide information for judging the performance of aftermarket brake linings on air-actuated foundation brakes, when performing the dynamometer test and vehicle stopping distance procedures in Federal Motor Vehicle Safety Standard (FMVSS) No. 121, *Air Brake Systems*, and lining supplier qualification information. Such information will assist flee operators in choosing aftermarket brake linings that will perform adequately on typical combination (tractor/trailer) vehicles and single trucks.

BACKGROUND
While performance of original equipment (OE) brake linings is regulated by FMVSS 121,linings sold as replacement friction materials are effectively not required to meet any legal standard. **As a result, brakes relined with certain aftermarket materials can have reduced braking output, cause a shift of work to brakes on other axles, and reduce the overall stopping capability of the vehicle.**

FMVSS 121 testing for original equipment brake linings consists of two test procedures – a dynamometer laboratory test (including burnish, torque/retardation, fade, and recovery tests) and a vehicle stopping distance test (including burnish and stopping distance under various conditions). (See **Figure 1**.)

NOTE: Testing of small lining samples to SAE J661a, producing a two letter "friction identification code" (EE, FF, GH, etc.), is ***not*** considered accurate in determining performance on a full-size brake.

The **Appendix** to this RP lists aftermarket brake linings that have been voluntarily submitted by the manufacturer and have passed original equipment (OE) dynamometer testing conducted at qualified laboratories, and/or full vehicle stopping distance tests, and have been subsequently approved by an independent engineering committee of the Performance Review Institute (PRI), an affiliate of SAE International. The **Appendix** provides an example of the Aftermarket Brake Lining List. The most current list is available free through TMC's website *http://tmc.truckline.org* and PRI's website *http://www.p-r-i.org/other-programs/automotive-qpl/brake-lining/*.

This RP is updated to include four methods of determining aftermarket brake lining performance, based on Federal Motor Vehicle Safety Standard (FMVSS) No. 121, *Air Brake Systems*.

On July 27, 2009, NHTSA amended FMVSS 121 to require improved stopping distance performance for heavy truck tractors. This rule reduced the maximum

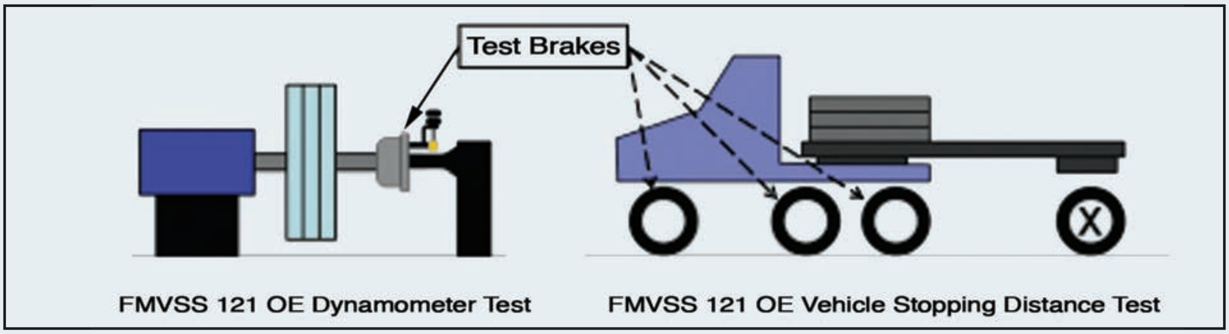


Figure 1

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Revised 5/2016

allowable stopping distance at 60 mph from 355 feet to 250 feet for the vast majority of heavy truck tractors when loaded to their gross vehicle weight rating (GVWR). For a small minority of very heavy tractors (when loaded to their GVWR), the maximum allowable stopping distance was reduced from 355 feet to 310 feet.

Accordingly, FMVSS 121 was revised to reduce stopping distance for high-volume 6x4 tractors built on or after August 1, 2011. Similar stopping distance requirements were implemented for 4x2 tractors built on or after August 1, 2013. Tractors built before these effective dates are often referred to by manufacturers as pre-reduced stopping distance (pre-RSD) tractors. Tractors built after these dates are called "post-RSD" tractors.

FOUR METHODS TO CHOOSE AFTERMARKET LININGS

Examples of how these methods can be used by a fleet are shown belo , and in **Table 4**.

NOTE: More than one test method can be used to select an aftermarket lining. The more tests a lining meets, the more confidence a fleet can have that the lining will perform adequately on their vehicles.

Method 1: FMVSS 121 Dynamometer Standard

The first original equipment test requirement for FMVSS 121 is to have a single brake assembly, mounted on a laboratory inertia dynamometer, where it passes a sequence of burnish, torque/retardation, fade, and recovery tests (see **Figure 1, left diagram**). This test applies to all commercial vehicle air brakes, including those on tractors, trailers, and trucks.

Aftermarket brake linings that appear in the current Aftermarket Brake Lining Listing have been confirme as meeting this FMVSS 121 dynamometer standard by PRI's Brake Lining Review Committee. By selecting linings from the current Aftermarket Brake Lining Listing, where a 'Yes' is indicated in the Method 1 column, a fleet can be assured that these linings meet, at a minimum, the dynamometer OE standard test. If a fleet uses a lining that is not on the list, it is possible that their vehicle will have reduced stopping capability, when compared to when it was equipped with OE linings.

The dynamometer data that was reviewed by the committee was supplied by the lining supplier, and run to strict test procedure standards. When using this method, fleet operators must identify the correct brake type, size, gross axle weight rating (GAWR), air chamber, and tire rolling radius for their vehicle as described in **Table A-3: Aftermarket Brake Lining List**.

Method 2: Vehicle Stopping Distance Standard—Estimated Performance

The second OE test requirement for FMVSS 121 is to have the tractor meet a stopping distance requirement (see **Figure 1**, **right diagram**). This RP has been updated to include recommendations for torque levels for tractor steer brakes and drive brakes to approximately meet these vehicle stopping distance requirements, for tractors manufactured both before and after the revised FMVSS 121 regulations took effect in August 2011 (6x4 tractors) and August 2013 (4x2 tractors). (See **Table 1**.) The revised FMVSS 121 regulation does not require trailers to meet a vehicle stopping distance test. Trailers and straight trucks are not covered by the Method 2 section of the RP.

Vehicle test results are influ nced by the vehicle's tire type and size, suspension reaction to dynamic weight changes, wheelbase and other factors. Because the vehicle is a complex system, and vehicle testing is more expensive, OE vehicle manufacturers generally perform actual vehicle tests on a limited number of vehicles, and then use computer modeling to extrapolate dynamometer test results to ensure all vehicles will meet the regulation.

For fleets that desire their tractors to continue to approximately meet original equipment stopping distance requirements, this RP identifies target torque minimums and maximums. Because these are "panic stop" requirements, these recommended torque ranges are measured at the 80 PSI brake application pressure. (See **Table 2**.) If the lining has been found to meet the target range for brake torque established in this RP, then a 'Yes' will be shown in the Method 2 column of the Aftermarket Brake Lining Report.

Aftermarket linings for both the steer axle and the drive axle brakes need to approximate the vehicle's OE braking performance according to the values listed in **Table A-3**. Because this process utilizes dynamometer results, and therefore only approximates the full OE vehicle stopping distance test, actual compliance to the vehicle stopping distance performance portion of FMVSS 121 cannot be guaranteed.

If a fleet uses linings with less torque, it is likely that its vehicles will have reduced stopping capability, when compared to when it was equipped with OE

TABLE 1 FMVSS 121 NEW TRACTOR REQUIREMENTS LESS THAN 70,000 lbs. GVWR			
Configuratio	GVWR	Tractor Build Date	FMVSS 121, 60 MPH Loaded Stopping Distance
Standard 6x4 Tractors	59,600 lbs.	Pre-8/1/2011	355 ft
		Post-8/1/2011	250 ft
4x2 Tractors	Any	Pre-8/1/2013	355 ft
		Post-8/1/2013	250 ft
"Heavy" Tractors	More than 59,600 lbs.	Pre-8/1/2013	355 ft
		Post-8/1/2013	250 ft

FMVSS 121 was revised in July 2009 to reduce stopping distance for high-volume 6x4 tractors built on or after August 1, 2011. Similar stopping distance requirements were implemented for 4x2 tractors built on or after August 1, 2013. The primary change to tractor brakes that resulted from these new stopping distance regulations was a significant increase in the retarding force (i.e., brake torque) of the steer axle brakes. To achieve this, most steer axle drum brake sizes were increased from 15x4 inches to 16.5x5 inches, along with higher friction linings and larger air chamber sizes. Some vehicle manufacturers also implemented air disc brakes as standard or optional on their tractors.

TABLE 2:
RECOMMENDED TRACTOR DRIVE AND STEER BRAKE TORQUES TO APPROXIMATELY MEET OE STOPPING DISTANCE REQUIREMENTS (FOR 80 PSI BRAKE APPLICATIONS)

OE Tractor Requirements			Recommended 80 PSI Brake Torque - Typical Axle Ratings					
Vehicle Configuration	GVWR	Tractor Build Date	12,000 lb. GAWR Steer Axle Brakes		17 - 20,000 lb. GAWR Drive Axle Brakes		22 - 23,000 lb. GAWR Drive Axle Brakes	
			Min. 80 PSI Torque	Max. 80 PSI Torque	Min. 80 PSI Torque	Max. 80 PSI Torque	Min. 80 PSI Torque	Max. 80 PSI Torque
Standard 6x4 Tractor	59,600 lbs. or less	Pre - 8/1/2011	59,300 in-lbs.	80,200 in-lbs.	85,500 in-lbs.	128,200 in-lbs.	113,900 in-lbs.	139,300 in-lbs.
		Post - 8/1/2011	104,000 in-lbs.	142,500 in-lbs.				
4x2 Tractor	Any	Pre - 8/1/2013	59,300 in-lbs.	80,200 in-lbs.				
		Post - 8/1/2013	104,000 in-lbs.	142,500 in-lbs.				

linings. A fleet desiring actual certification to a full FMVSS 121 vehicle test should reference **Method 3**, or directly contact the supplier providing his aftermarket linings.

Method 3: Vehicle Stopping Distance Standard—Actual Vehicle Testing
The "complete" vehicle stopping distance requirement is conducted on a test track. When a tractor is being tested, a trailer without brakes is used as a load bed (see **Figure 1, right diagram**). This RP has been updated to include full tractor stopping distance tests, as submitted by suppliers to PRI. Results found to meet FMVSS 121 vehicle stopping distance requirements are included in the current Aftermarket Brake Lining Listing, as indicated in the Method 3 column.

If a supplier has submitted test results, and the vehicle passed the stopping distance requirement, this is indicated by a 'Yes' in the Method 3 column. If test results have not been submitted, 'N.T.' (not tested) will be shown. Information may not be available in this new category, as suppliers will not have had a chance to provide data, or may choose not to provide this information.

NOTE: These results are unique to a particular vehicle's brake system, including brake size and type, tire size, air system, ABS system, and the build date of the vehicle that applies to the braking system. This includes tractors manufactured before and after the effective dates of the FMVSS 121 RSD revision. In addition, the lining formulas supplied on each test vehicle's axle (e.g., steer, drive, tag, etc.) must be used exactly as configured on the test vehicle, if an in-service vehicle is to have a stopping distance equivalent to the FMVSS 121 test.

Method 4: Lining Torque Values For Brake Balance
To provide guidelines for fleets who desire improved brake balance between their tractor drive and trailer brakes, target torque ranges have been identified in this RP. Because steer axle brakes are typically smaller than the drive and trailer brakes, steer brakes are not included in this part of the recommendation.

Because the vast majority of normal highway braking is done at or below 20 psi, these recommended torque ranges are established at a 20 PSI brake application pressure. See **Table 3**. If a lining meets these recommended ranges, it will be indicated by a 'Yes' in the Method 4 column of the Aftermarket Brake Lining Listing.

TABLE 3: RECOMMENDED DRIVE AND TRAILER AXLE BRAKE TORQUES FOR IMPROVED BRAKE BALANCE (FOR 20 PSI APPLICATIONS)

	Axle GAWR, lbs.	
	17 - 20,000 lbs.	22 - 23,000 lbs.
Minimum Torque at 20 PSI	17,800 in-lbs.	26,900 in-lbs.
Maximum Torque at 20 PSI	27,500 in-lbs.	32,800 in.-lbs.

NOTE: The desired effect is to have tractor drive and trailer brakes produce the same torque levels at low pressures. Fleets should attempt to have these torques as close as possible.

NOTE: These recommended torque levels can be applied to any type of brake (e.g., drum, disc, wedge). However, they are intended only for use with tire sizes that are approximately the same size on the tractor drive axles and trailer axles, and for brakes that are used with 22.5 or 24.5 inch wheel rims. If significantly different tire or wheel sizes are present on the tractor drives versus the trailer axles (e.g., 22.5 inch wheels vs 17.5 inch wheels), the recommended torque levels in **Table 3** should not be used to determine brake balance.

EXAMPLES OF METHODS 1, 2, 3 & 4 (Also See Table 4)

Method 1 Example:
A fleet desires that its trucks, tractors and/or trailers be fitted with aftermarket linings that meet the minimum OE dynamometer requirement for drive axles. The operator checks the vehicle sticker and determines the axles are rated at 23,000 lbs. GAWR. The brake size is 16.5x7 inches, the air chamber is Type 30, the brake adjuster length is 5.5 inches, and the tire size is a typical 11R22.5 with an approximate rolling radius of 19.9 inches. The operator goes to the TMC or PRI website to get the latest approved Aftermarket Brake Lining Listing. The operator finds the linings that match the above vehicle specific -tions and have a 'Yes' in the Method 1 column. The operator then selects one of these linings to install on his/her vehicles.

Method 2 Example:
A fleet desires that its 6x4 tractors be fitted with aftermarket linings that approximately meet the minimum OE vehicle stopping distance requirements. The operator checks the vehicle sticker and finds his GVWR is 52,000 lbs., and the build date was after August 1, 2011 making this vehicle a "post-RSD" vehicle. (See **Table 1**.)

The operator also determines:

- The steer axle is rated at 12,000 lbs. GAWR, and is equipped with 16.5x5 inch brakes, Type 24 air chambers, 5.5 inch brake adjusters, and the tire rolling radius is approximately 20 inches.
- The drive axles are rated at 20,000 lbs. GAWR each, and are equipped with 16.5x7 inch brakes, Type 30 air chambers, 5.5 inch brake adjusters, and a tire rolling radius of approximately 19.8 inches.

The operator then goes to the TMC or PRI website to obtain the latest approved Aftermarket Brake Lining Listing. The operator finds the steer and drive linings that match the above vehicle specifications and show a 'Yes' in the Method 2 column. The operator selects from these linings, one steer lining and one drive lining to install on his vehicles.

Method 3 Example:
A fleet desires its 6x4 tractors be fitted with aftermarket linings that have been tested to the "full vehicle" stopping OE vehicle stopping distance requirements. The operator checks the vehicle sticker and determines the vehicle build date, and steer and drive specifications, similar to **Method 2**. The operator then matches these specific tions to a full vehicle stopping distance test in the current Aftermarket Brake Lining Listing, and have a 'Yes' indicated in the Method 3 column. The operator then purchases both the steer and drive linings used in the full vehicle test and installs them on his/her vehicles.

Method 4 Example:
A fleet desires to improve the brake balance between its tractors and trailers, including both drum brake and disc brake equipped units. The operator inspects his vehicles and determines:

- The drive axle brakes on the different tractors are all rated at 20,000 lbs. GAWR, have a tire rolling radius of approximately 19.8 inches, and are equipped with both:

TABLE 4:
LININGS THAT MEET RP 628C CRITERIA (EXAMPLE)

				Steer	Drives	Trailer
6x4 Tractor Built Before 8/1/2011 (Pre-RSD) & Tandem Trailer	Method	GAWRs, lbs.		12,000	34 - 40,000	34 - 40,000
		Brake Type, Size, Actuation		Disc 225, T18	Drum 16.5x7, 30x5.5	Drum 16.5x7, 30x5.5
		Tire Size, Rolling Radius, inches		18.5 - 21.0	18.5 - 21.0	18.5 - 21.0
	1	Dynamometer Testing - Linings That Meet FMVSS 121	Retardation, Fade, Recovery	NA	Textar T5000, Armada AR1, Armada AR20P	Textar T5000, Armada AR1, Armada AR20P
	2	Vehicle Stopping Distance - Linings That Meet Recommended Torques	Torque Targets @ 80 PSI, in-lbs.	59,300 - 80,200	85,500 - 128,200	Trailers are not required to meet FMVSS 121 stopping distance test
			Approved Linings	NA	Textar T5000, Armada AR1, Armada AR20P	
	3	Vehicle Stopping Distance - Linings That Have Been Tested to FMVSS 121 Full Load Vehicle Test	Vehicle Stopping Distance	355 feet		
			Approved Linings	NA	NA	
	4	Brake Balance - Linings That Meet Recommended Torques	Torque Targets @ 20 PSI, in-lbs.	Steer axles not considered in tractor/trailer brake balance	17,800 - 27,500	22,500 - 27,500
			Approved Linings		Textar T5000, Armada AR1, Armada AR20P	Textar T5000, Armada AR1, Armada AR20P

N/A—No linings have yet been supplied to RP 628C for this criteria.

- Drum brakes; 16.5x7 inch, Type 30 air chambers, and 5.5 inch brake adjusters
- Type 225 air disc brakes; Type 24 air chambers

- The trailer axle brakes are rated at 17,000 lbs. GAWR, have a tire rolling radius of approximately 19.2 inches, and are equipped with drum brakes—16.5x7 inch, Type 30 air chambers, and 5.5 inch brake adjusters.

The operator then goes to the TMC or PRI website to get the latest approved Aftermarket Brake Lining Listing. The operator finds the linings that match the above vehicle specifications and selects those linings with a 'Yes' indicated in the column for Method 4. The operator then selects from these linings, one drum brake lining and one disc brake lining to install on his/her vehicles.

OTHER INFORMATION

Brake Fade Index

Fade is a characteristic of brakes in which braking torque is reduced as brake temperature increases. Fade can be a concern for vehicle operations in which high brake temperatures are experienced, such as during mountainous operation or heavy brake usage in cities.

The RP 628C Brake Fade Index (see **Brake Fade Index** column in the **Appendix**) uses the brake power portion of the FMVSS 121 dynamometer test. In this test, a brake is required to complete 10 snubs from 50 MPH over a period of 12 minutes, this simulating a long mountainous decent, where the brake temperature can rise several hundred degrees. The RP 628C Brake Fade Index is the change in maximum braking force effectiveness from Snub 1 to Snub 10 during this test. A higher brake fade index number indicates a lining with more fade (i.e., reduced torque at high temperatures).

Lining Manufacturer Information

To further assist fleet operators in selecting aftermarket linings, the following information is also provided for each manufacturer and lining formula:

- Whether or not the manufacturer of the lining has certified the specific lining formula as "asbestos free."
- What quality certification is held by the manufacturing plant(s) that produce the specific lining formula.
- Whether or not the lining has been tested to the FMVSS 121 stopping distance vehicle test.

Discussions With Lining Suppliers

In certain cases, a fleet operator who desires to use FMVSS 121 as a standard for aftermarket linings may not find a lining that matches the brake type, brake size, GAWR, air chamber size or other parameters in the **Appendix** to this RP. In this event, the operator can still request confirmatio from a lining supplier that a specific lining formula will meet FMVSS 121 for the vehicle's parameters. In addition, the operator can request confirmation that the specific lining meets the recommended torque at an 80 PSI application pressure for estimated stopping distance (see **Table 2**) and torque at a 20 PSI application pressure for brake balance (see **Table 3**).

Tire Sizes and Slack Lengths

Because tires come in a range of rolling radii, this RP is based on industry average tire sizes, and ranges (e.g., for 22.5 inch rims, a range of 18.5 - 21.0 inches, see **Table A-1** in **Appendix**). Small variations in tire sizes should not signific ntly change the recommendations within this RP. In addition, standard drum brakes typically use 5.5-inch self-adjusting brake adjusters. A slightly longer six-inch adjuster should not significantly change the recommendation within this RP.

APPENDIX

AFTERMARKET BRAKE LININGS WHICH MEET FMVSS 121 CRITERIA FOR ORIGINAL EQUIPMENT LININGS AND APPROXIMATE OUTPUT TORQUE VALUES DURING A BRAKE APPLICATION

The Performance Review Institute (PRI), an affiliate of SAE International, Brake Lining Performance Review Committee has complied this list of aftermarket brake linings that meet the brake dynamometer requirements specified in FMVSS 121. All original equipment foundation brakes must meet these requirements.

Three torque values are listed for each lining at application pressures of 20, 40, and 80 psi. Most vehicle brake applications are typically non-panic stops at low pressures—usually 20 psi or less. Medium braking occurs around 40 psi, while heavy or panic stops can be at 80 psi or higher. Historically, the 40 psi value has been used to match brake torques of aftermarket linings. The 20 and 80 psi values are also now reported for additional fleet operator information

The aftermarket brake lining list is intended to help fleets replace worn OEM linings with replacement linings of similar torque value to help ensure torque balance. The higher the torque value the more aggressive the brake lining.

PRI and TMC stress that the review of this information does not constitute PRI or TMC approval, certification endorsement, or recommendation of the products; it simply verifies that the brake lining material, as represented by the data presented to the PRI Brake Lining Performance Review Committee, has demonstrated its ability to meet certain FMVSS 121 requirements, when installed on the indicated brake and operated in a configuration specified in TMC RP 628C, *Aftermarket Brake Lining Classificatio* .

NOTE: Vehicle compliance indicated in a lining's listing does not guarantee vehicle certification under all vehicle configurations. Brake lining products that are not on the list either were not tested, or did not pass. Only successfully tested linings are listed.

TMC permits distribution of this **Appendix**. However, the preceding preamble must appear in its entirety with any publication of the brake lining list.

Any friction material or foundation brake supplier who wishes to submit lining formulas for review and addition to the RP628C list should visit the website *www.pri-network*.org — *http://www.pri-network.org/other-programs/automotive-qpl/brake-lining/*— Brake Lining Program or contact PRI for information on how to submit test results. PRI may be reached at 161 Thorn Hill Road, Warrendale, PA 15086; phone: (724) 772-1616.

NOTICE: The material manufacturers provided the information contained in this report. The Performance Review Institute has not tested this material nor verified the manufacturers' test results. The review of this information does not constitute an approval by SAE. The listing of these products on the Performance Review Institute Brake Lining Qualified Products List only verifies that the brake lining material, as represented by the data presented by the manufacturer, has demonstrated its ability to meet the established test criteria. It is incumbent upon the user to determine whether the material is or is not suitable for a particular application.

An aftermarket lining's torque output should approximately match that of the original equipment lining it is replacing. The vehicle manufacturer should be able to supply the original equipment lining formulation when supplied with the vehicle identification numbe . Brake lining output torque, by itself, should not be used to measure total brake system performance. Due to variability in testing and lining composition, torques shown in the aftermarket lining classification list are approximations onl .

(NEXT PAGE)

TABLE A-1 : LINING TEST CONDITIONS AND THE VEHICLE CONFIGURATIONS THEY REPRESENT

Rim Size		Drive/Trailer					Steer		
22.5 In.	Brake Size (Drum - Dia./Width, in., Disc - Rim Size, in.)	16.5x7 Drum	16.5x7 Drum	16.5x7 Drum	22.5 Disc	22.5 Disc	15x4 Drum	16.5x5 Drum	22.5 Disc
	GAWR (lbs.)	20,000	20,000	23,000	20,000	23,000	12,000	14,600	14,600
	Air Chamber Size (type)	30	24	30	Various	Various	20	24	Various
	Cam Brake Slack Adjuster Size (in.) -	5.5	5.5	5.5	Not Req'd.	Not Req'd.	5.5	5.5	Not Req'd.
	Tire Size for Test, Rolling Radius (in.)	19.6	19.6	19.6	19.6	19.6	19.6	19.6	19.6
	Range of Tire Sizes on Vehicle	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0	18.5 - 21.0
19.5 In.	Brake Size (Drum - Dia./Width, in., Disc - Rim Size, in.)	15x8.625 Drum	15x8.625 Drum	19.5 Disc	Additional brake sizes, linings, axle ratings, etc. can be supplied as special configurations for any wheel size.				
	GAWR (lbs.)	14,500	14,500	14,500					
	Air Chamber Size (type)	30	24	Various					
	Cam Brake Slack Adjuster Size (in.) -	5.5	5.5	Not Req'd.					
	Tire Size, Rolling Radius (in.)	15.3	15.3	15.3					
	Range of Tire Sizes on Vehicle	15.1 - 16.3	15.1 - 16.3	15.1 - 16.3					
17.5 In.	Brake Size (Drum - Dia./Width, in., Disc - Rim Size, in.)	12.25x7.5 Drum	12.25x7.5 Drum	17.5 Disc					
	GAWR (lbs.)	19,200	19,200	19,200					
	Air Chamber Size (type)	30	24	Various					
	Cam Brake Slack Adjuster Size (in.) -	5.5	5.5	Not Req'd.					
	Tire Size, Rolling Radius (in.)	14.6	14.6	14.6					
	Range of Tire Sizes on Vehicle	14.1 - 17.0	14.1 - 17.0	14.1 - 17.0					

The sets of FMVSS 121 test conditions listed above—which depend on gross axle weight rating (GAWR) and air chamber size—can be used to test and evaluate brake lining friction materials. The test conditions simulate vehicle configurations which are commonly used in on-highway tractor-trailer operations.

TABLE A-2 (METHOD 3): FULL VEHICLE STOPPING DISTANCE TEST LININGS

Supplier Company Name	------	**Compressor Cut-Out, PSI**	------
Address	------	**ABS System Specifications**	------
Vehicle Type (Tractor, Truck, other)	------	**Lining is Asbestos Free**	------
Vehicle Configuration (4x2, 6x4, other)	------	**Quality Certification of**	------
Wheelbase, In.	------	**Review Expiration Date**	------

Axle 1							Axle 2							Axle 3						
Lining Brand Name	Brake Type	Brake Size	GAWR, lbs.	Chamber Type/ Size	Slack Adjuster Length	Tire Rolling Radius	Lining Brand Name	Brake Type	Brake Size	GAWR, lbs.	Chamber Type/ Size	Slack Adjuster Length	Tire Rolling Radius	Lining Brand Name	Brake Type	Brake Size	GAWR, lbs.	Chamber Type/ Size	Slack Adjuster Length	Tire Rolling Radius
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

NOTE: No full vehicle stopping distance tests have yet been supplied for approval to RP 628C.

TABLE A-3: AFTERMARKET BRAKE LINING LIST (PAGE 1 OF 2)

List current as of May 2016

NOTICE: The material manufacturers provided the information contained in this report. The Performance Review Institute has not tested this material nor verified the manufacturers' test results. The review of this information does not constitute an approval by SAE. The listing of these products on the Performance Review Institute Brake Lining Qualified Products List only verifies that the brake lining material, as represented by the data presented by the manufacturer, has demonstrated its ability to meet the established test criteria. It is incumbent upon the user to determine whether the material is or is not suitable for a particular application. The torque of an aftermarket lining should approximately match that of the original equipment lining it is replacing. The vehicle manufacturer should be able to supply the original equipment lining formulation when supplied with the vehicle identification numbe . Brake lining output torque, by itself, should not be used to measure total brake system performance. Due to variability in testing and lining composition, torque shown in the aftermarket lining classificat on list is approximate only.

Lining Supplier Company Name	Lining Brand Name	Performance of Brake and Lining to RP 628C and the Identified Vehicle Specifications (See Veh. Specs. to right and notes below)						Vehicle Specifications (should approximately match your vehicle's specifications)					
		Method 1	Method 2		Method 3		Method 4						
		Meets FMVSS 121 O.E. Dyno Test	Meets Estimated FMVSS 121 O.E. Tractor Stopping Distance		Meets Actual FMVSS 121 O.E. Tractor Stopping Distance		Meets RP628C Brake Balance Targets						
			Pre-RSD (note 4)	Post- RSD (note 5)	Pre-RSD (note 4)	Post- RSD (note 5)		Brake Type	Brake Size	GAWR, lbs.	Chamber Type/ Size	Slack Adjuster Length	Tire Rolling Radius
Commercial Vehicle Components, LLC	CVC HD 119	Yes	No	No	N.T. (note 1)	N.T. (note 1)	Yes	Disc	17.08 x 1.76	22-23000	24	N. R. (note 3)	20.7"
Commercial Vehicle Components, LLC	CVC 6032	Yes	No	No	N.T. (note 1)	N.T. (note 1)	Yes	Disc	17.07 x 1.77	22-23000	24	N. R. (note 3)	20.7"
TMD Friction, Inc.	Textar T5000	Yes	Yes	Yes	N.T. (note 1)	N.T. (note 1)	Yes	Drum	16.5 x7	17-20000	30	5.5"	19.6"
TruckPro, Inc.	Armada AR1	Yes	Yes	Yes	N.T. (note 1)	N.T. (note 1)	Yes	Drum	16.5 x 7	17-20000	30	5.5"	19.6"
TruckPro, Inc.	Armada AR23P	Yes	Yes	Yes	N.T. (note 1)	N.T. (note 1)	Yes	Drum	16.5 x 7	22-23000	30	5.5"	19.6"
TruckPro, Inc.	AR20P	Yes	Yes	Yes	N.T. (note 1)	N.T. (note 1)	Yes	Drum	16.5 x 7	17-20000	30	5.5"	19.6"
TruckPro, Inc.	AR2	Yes	Yes	Yes	N.T. (note 1)	N.T. (note 1)	Yes	Drum	16.5 x 7	22-23000	30	5.5"	19.6"

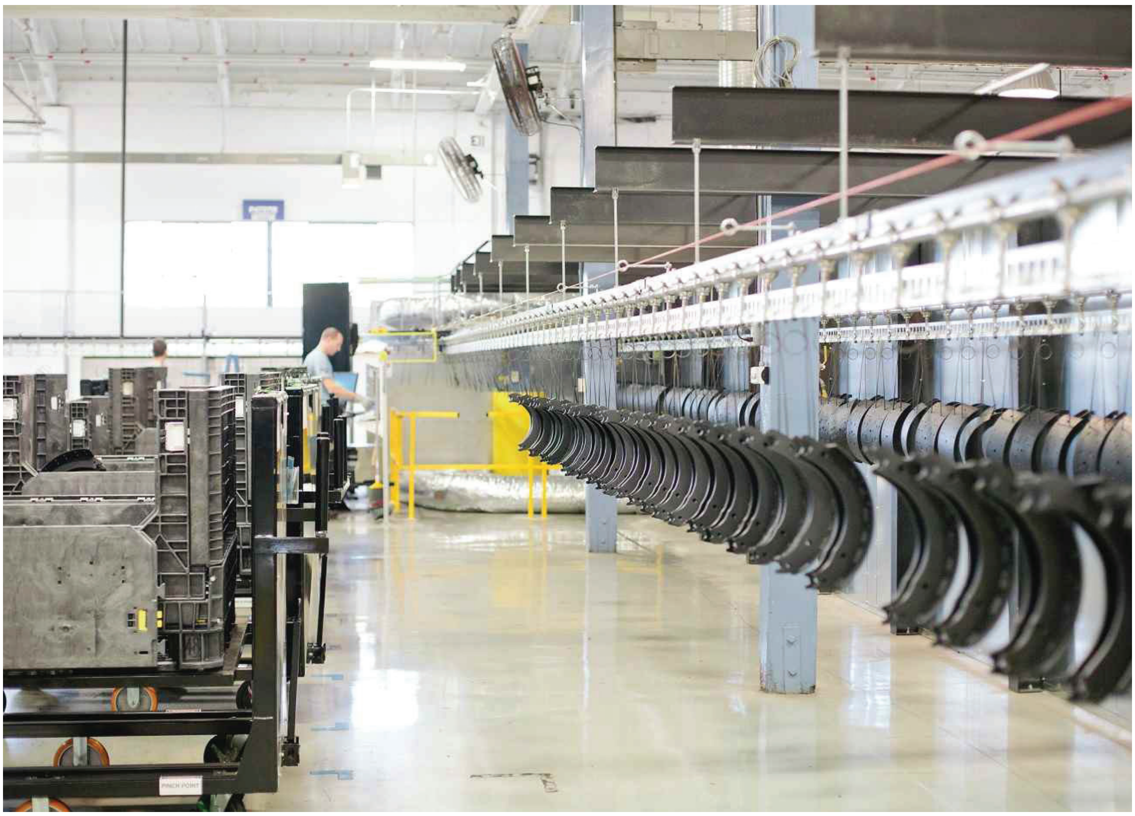
Note 1	N.T. - Not Tested (Lining was not specifically tested to this standard)
Note 2	N.A. - Test Procedure is Not Applicable (e.g. brake and lining are not typically used on tractor drive axles or trailers)
Note 3	N.R. - Not Required (e.g. an air disc brake does not utilize a slack adjuster)
Note 4	Pre-RSD - Standard configuration tractors typically built BEFORE August, 2011, that are NOT REQUIRED to meet a newer "Reduced Stopping Distance" requirement (see the explanation in RP 628C for details
Note 5	Post-RSD - Standard configuration tractors typically built AFTER August, 2011, that ARE REQUIRED to meet a newer "Reduced Stopping Distance" requirement (see the explanation in RP 628C for details

TABLE A-3: AFTERMARKET BRAKE LINING LIST (PAGE 2 OF 2)

List current as of May 2016

Lining Supplier Company Name	Lining Brand Name	Brake Torque Output, in-lbs. (should approximately match that of the O.E.M. lining being replaced)			Brake Fade Index	Lining is Asbestos Free	Quality Certification of Manufacturing Plant	Lining has been Tested to FMVSS 121 Vehicle Test	Review Expiration Date	Company Address
		Primary Torque to Match	Normal Stopping Pressure	Panic Stop Pressure	Lower % = Less Fade, Higher % = More Fade					
		40 PSI Value	20 PSI Value	80 PSI Value						
Commercial Vehicle Components, LLC	CVC HD 119	76,372	27,100	164,258	11.40%	Yes	ISO 9001:2008	Unknown	31-Mar-2019	9688-28 Puxing Road Haiwan, Fengxian, Shanghai, 201419 P.R. China
Commercial Vehicle Components, LLC	CVC 6032	66,942	27,428	155,571	11.10%	Yes	ISO 9001:2008	Unknown	31-May-2020	9688-28 Puxing Road Haiwan, Fengxian, Shanghai, 201419 P.R. China
TMD Friction, Inc.	Textar T5000	53,537	26,114	108,215	24.80%	Yes	ISO/TS 16949:2009	Yes	28-Feb-2017	1035 Crooks Road Troy, Michigan 48084
TruckPro, Inc.	Armada AR1	56,880	25,508	117,044	32.50%	Yes	ISO/TS 16949:2009	No	31-Jan-2018	8110 Cordova Road, Suite 116 Cordova, Tennessee 38018
TruckPro, Inc.	Armada AR23P	64,920	29,604	131,896	73.50%	Yes	ISO/TS 16949:2009	No	31-Jan-2018	8110 Cordova Road, Suite 116 Cordova, Tennessee 38018
TruckPro, Inc.	AR20P	47,912	20,212	102,951	28.30%	No	ISO/TS 16949:2009	No	31-Oct-2019	1610 Century Center Parkway Suite 107 Memphis, Tennessee 38134 USA
TruckPro, Inc.	AR2	61,166	27,793	122,161	64.30%	No	ISO/TS 16949:2009	No	31-Oct-2019	1610 Century Center Parkway Suite 107 Memphis, Tennessee 38134 USA

CHAPTER 8: Brake relining and restoration



Taking time to thoroughly inspect and repair brake components when relining brakes can save money in the long run.

By *CCJ* staff

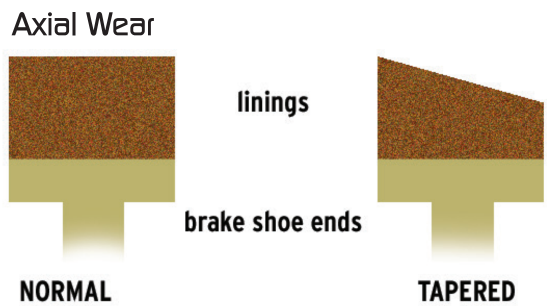
Brake linings should be replaced before they completely wear away, resulting in metal-on-metal contact between the brake shoe and the brake drum, causing potentially catastrophic component failures and expensive replacement costs. Replacing linings in a timely fashion also will prevent the possibility of S-cam turnover.

It is widely accepted that brake linings worn down to 1⁄4-inch thickness are in need of replacement. Carefully measuring lining thickness is recommended, but if you are performing a visual inspection, look for lining thickness that is slightly higher than the rivet heads that secure it to the brake shoe.

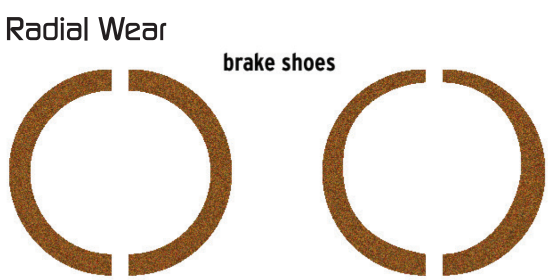
But don't simply slap new shoes on and put the vehicle back in service. Relining time is an excellent opportunity to tune up the entire brake system and ensure safe, efficient stopping power for many miles to come.

Inspecting foundation brakes

It's easy to check over the foundation brakes when the wheel is off an axle. Keep an eye out for excessive deflection or loose and broken parts. You also want to look for excessive component wear – most notably on the cam splines, which can allow lost motion between the automatic brake adjuster and S-cam. Replace the camshaft and the slack adjuster if there is more than .020 inch of free movement between the adjustor and the S-cam. This is also a good time to check the clearance between the slack clevis pin and its bushing. Once again, clearance between the two components should not exceed .020 inch. If the slack adjuster has to



Axial tapered wear results from worn anchor pins, holes or bushings, or worn outer S-cam bushings. These allow force to push shoes to one side.



Radial tapered lining wear between the leading and trailing ends of a shoe may mean a weak return spring, a worn S-cam bushing or an out-of-arc shoe.

be removed, use an anti-seize compound on the camshaft splines to make it easier to remove next time service work is performed.

Once removed, closely examine the old brake shoes before you toss them in the core bin. They can tell you a lot about what's going on with the foundation brakes out on the highway. Are any linings cracked? That's a sure sign of additional problems, most likely a shoe that's out of arc, rust buildup on the shoe surface, improper riveting or duty cycle.

Lining wear should be even around the circumference of both brake shoes, from inboard to outboard. Tapered wear patterns – where both shoes show accelerated wear at the top or bottom, or inboard or outboard side – is an indication that peripheral brake hardware is worn. As a result, the brake cannot be adjusted properly. Ideally, you should see uniform wear patterns all the way around the brake linings.

Worn anchor pins, holes and bushings or outer S-cam bushings can allow applied force to push the brake shoes to one side. This not only results in tapered lining wear, but also can cause outer edge abrasion on the brake shoes. (This condition also can be caused by drum deflection at the open side). For those reasons, reusing shoe rollers and anchor pins is not recommended.

Don't confuse a designed-in taper with one caused by unbalanced brake wear. Many brake shoes feature a cam end that is thicker than the anchor end to allow geometry optimization in an effort to gain full contact to the drum. Also don't confuse tapered lining wear with a high ridge on the inside edge of the linings. This actually is beneficial, as it prevents a lip being etched into the drum and makes drum removal easier while keeping water and contaminants out of the brake assembly.

If you do find uneven lining wear between the leading and trailing ends of a shoe, you'll need to check several components to pinpoint the cause. Such wear may be the result of a weak return spring, a worn outer S-cam bushing, an out-of-arc shoe or a high-energy duty cycle. Attempting to adjust a brake with any of these conditions will result in dragging and high contact pressure at one spot of the lining, leading to rapid lining wear and heat damage to the drum.

Brake disassembly and repair

If lining wear is unacceptable, it's time to remove the worn brake shoes and replace them. It's also a good time to replace any associated components and check for leaks to ensure safe and reliable braking characteristics.

When removing anchor pins, don't heat the spider and try to hammer them out. Heating removes the metal's temper, and hammering a hot spider will cause permanent distortion, reduced brake performance and abnormal wear. If the anchor pins are stubborn and don't want to come out easily, douse them with a light, penetrating oil and give it time to work in before tapping them out as gently as possible. You also can use a puller specifically designed for that purpose.

Once you've got it out, clean the spider with a solvent and wire brush, and inspect it for broken welds or cracks in the camshaft and anchor pin areas. Check tightness of the spider securing bolts, and be sure the spider is not bent; the anchor pin holes must be parallel to the centerline of the axle. Otherwise, the shoes won't track in the drum properly, and tapered wear will result.

If the old liners are covered with oil or grease, you need to identify and correct the cause before putting new shoes on. The problem is almost always a leaking oil seal, too much grease on a grease-type wheel bearing or camshaft bushing or from careless handling. If there is some grease or oil on the old lining — an area no larger than 10 percent of the total lining area – then the spot can be cleaned with brake cleaning solvent (not gasoline or another substitute). However, this isn't the safest option, as it could lead to a brake imbalance condition if done improperly.

Check the cam bearing surfaces for wear before installing the new brake shoes. Replace any cam if wear exceeds .010 inch. You can reuse a cam that's within tolerance but has deep grooves caused by the seals, although Meritor recommends no more than 0.030 inch of total radial play since at that point the seal lip may no longer be effective at keeping contaminants out, resulting in accelerated bearing and cam wear. The cam bearing itself should be replaced each time the brakes are relined.

Carefully examine the S-cam and rollers for flat spots and irregularities. An irregular surface on these parts will cause brake noise and cause brake "grab" and slower release times. It is best to replace the S-cam if you have any doubts about its condition. Return springs are inexpensive, and there's almost no excuse for reusing them. If you must, be sure they're not stretched, broken or corroded. Be sure to lube the cam bearing and seals, and anchor pin bores and bushings when reassembling.

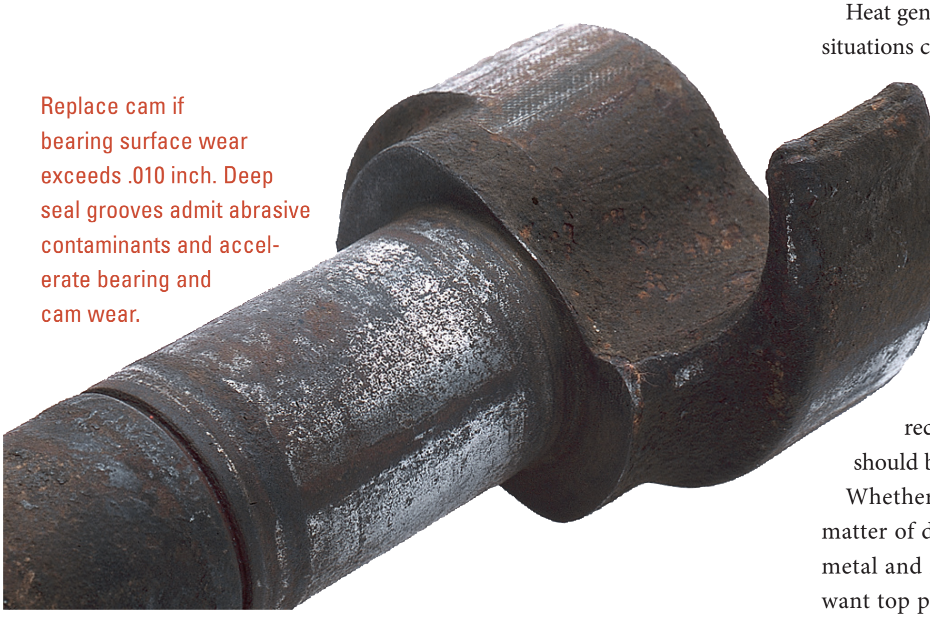
Now you're ready to install new brake shoes. First, make sure the lining is tight and follows the contour of the new shoe. Always check a replacement shoe's dimensions – don't assume it's OK just because it has new lining.

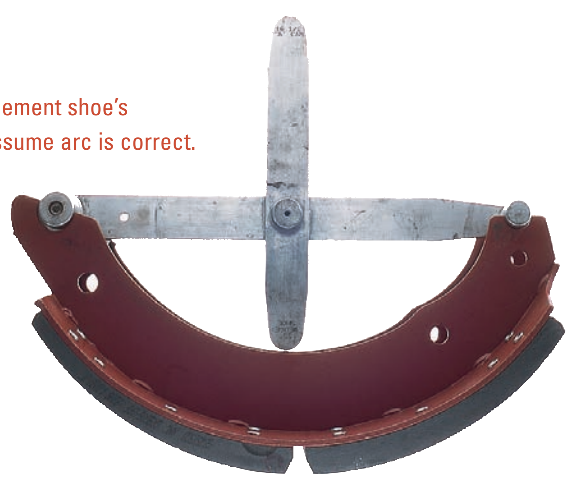
Cracked linings likely were loose on the shoe. This is caused by a shoe that's out of arc, rust buildup on the shoe surface or improper riveting.

Tiny marks around the spring retainer hole (center of photo) are from removing retainer for reline. Three marks likely mean three relines — cause to suspect dimensions and hole sizes.

Clean spider with solvent and a wire brush, and inspect for broken welds or cracks in camshaft and anchor pin areas. Check tightness of spider securing bolts, and be sure the spider is not bent. Anchor pin holes must be parallel to axle centerline to avoid uneven lining wear.

Most experts stress the importance of using known name-brand replacement linings and brake components. A rash of counterfeit and "look-alike" will-fit parts from overseas are readily available today, often at discount prices. But they rarely perform up to the standards of the original parts and may be unsafe to install and use. Worse, they can be a tremendous liability for your fleet if a jury finds you or your technicians knowingly installed counterfeit or substandard parts on a commercial vehicle involved in an accident. (For more on brake lining selection, see Chapter 7: Selecting proper brake linings, page 73.)


Replace cam if bearing surface wear exceeds .010 inch. Deep seal grooves admit abrasive contaminants and accelerate bearing and cam wear.


Always check a replacement shoe's dimensions — don't assume arc is correct.

Inspect the brake drum before you put it back on over the foundation brakes. No matter how good a reline job you've done, the linings must have a smooth, round drum to rub against, or the brakes aren't going to perform properly. Some light scoring and abrasions are OK as long as they haven't cut any deeper than .010 inch into the drum. A drum with surface heat checks should be inspected periodically, as the checks may wear away over time. If it's obvious that they are getting worse, discard the drum. Needless to say, any crack through the drum's thickness means the drum should be scrapped.

Heat generated in intense (downgrade) braking situations can distort drums quickly, so it's important to check and make sure the drum's circumference is within tolerances. Use a dial indicator to measure a mounted drum's diameter in the center of the rubbing path. Take another measurement 90 degrees from the first one, again in the center of the rubbing path. If the two measurements are not within .010 inch of each other, the drum can be cut or rotated one bolt hole and rechecked. If severely out of round, the drum should be discarded.

Whether a drum should be cut (turned) is a matter of debate. Turning a drum removes valuable metal and reduces the drum's effectiveness. If you want top performance, replace drums as wear approaches .080 inch.

The key to a good reline is to remember that brakes are a system of components working together to get the job done. For that reason, it is vitally important to replace linings by axle sets rather than individual wheel ends to avoid performance differences. If any part of the system isn't right, the brakes are not right, and the vehicle is unsafe. Wheel seals, bearings, axles or anything else you touch during a brake job should be treated with the same respect given the brake components. Bring everything as close as possible to original condition, and you won't be sorry. It costs more upfront, but a thorough job will pay for itself in longer life and trouble-free operation.

CHAPTER 9 : Troubleshooting brake imbalance

A rolling dynamometer (brake tester) can be invaluable when diagnosing brake imbalance, easily exposing left-to-right and steer-versus-drive imbalances.

Diagnosing and correcting brake imbalance issues is critical for vehicle performance and safety over the road.

By *CCJ* staff

A balanced brake system is one in which all the vehicle's brakes apply and release at about the same time, with each brake developing the appropriate braking force for its respective load.

Visualizing this concept, it's not hard to imagine the safety and maintenance problems that imbalanced brakes can cause for a commercial vehicle. If a tractor, for example, brakes more aggressively than the trailer it is towing, uneven brake wear will be the most obvious consequence as the linings on the hardest-working brakes will wear faster than the brakes not doing their fair share of the work. Worse, this condition could lead to a trailer bumping into the braking tractor, jackknifing or unintended panic stops as brakes lock up.

The frequency of brake imbalance situations has decreased somewhat thanks to improved brake technology. Today's brake systems are comprised of a myriad of components that must all work properly and in the correct sequence in order to guarantee safe, efficient stops day in and day out. But if one of those components fails to perform, the vehicle's brake system will begin applying in an unsynchronized manner.

Brake imbalance is an early warning sign that a brake system is not functioning like it's supposed to. Torque imbalance, pressure imbalance and different tire sizes are all common problems that can lead to a brake imbalance problem. Each of those circumstances can be complicated further by the temperature extremes foundation brakes are subjected to during an normal workday. For many technicians, tracking down the source of a brake imbalance problem can be like a forensic investigator trying to figure out a crime scene: Many possibilities have to be examined and discarded before the culprit is identified.

When examining brake imbalance causes, it's worth noting that stopping distances on a vehicle equipped with drum brakes will increase when all brakes on a heavily laden combination vehicle are cool but maladjusted. When these maladjusted brakes become hot, their drums naturally expand, which causes linings to fade and brake-chamber stroke to increase. In these instances, it can take the vehicle up to 75 percent more stopping distance to come to a complete halt. Automatic slack adjusters are supposed to combat this problem, but don't always respond correctly due to worn parts.

Maintaining torque balance

One of the most common brake imbalance scenarios is caused by torque imbalance, a lack of uniform friction material coming into contact with the vehicle's brake drum or rotor. This is common sense: A brake shoe or pad with thicker friction material on it will engage sooner and more aggressively than a shoe or pad on another wheel end with a thinner layer of material.

Other factors can degrade the friction material's stopping power as well. These include oil or grease on the pad or shoe, glazed friction material, polished drums or rotors or linings and pads with mixed friction capabilities at one or more wheels. Out-of-spec drums or rotors, incorrectly adjusted brakes, different size brake chambers, improperly installed automatic brake adjusters, inoperative or improperly adjusted antilock brake wheel sensors and incorrectly spec'd axle gross vehicle weight rating all can cause brake imbalance problems as well.

Differences between linings are most likely to sneak up and present you with a nasty surprise when you least expect it. That's because lining friction, fade and recovery characteristics at various temperatures can vary widely. In the early days of nonasbestos linings, some friction materials would swell excessively when exposed to high temperatures. Because of this, the swelled linings often caused tightly adjusted brakes to drag after the treadle was released. However, after the lining cooled down, it could not always be counted on to shrink back to its previous dimensions. In extreme cases, this permanent lining growth required slacks to be backed-off before the brakes could be released.

Other friction-induced imbalance problems remain with us. Consider edge codes, as a prime example, which offer easy identification of a lining's aggressiveness. (For more information on brake lining selection, see Chapter 7, page 73). But edge-code markings often wear off as friction material is worn down during the braking process. That's no great loss, however, because even within the same edge code, friction can vary by as much as 40 percent.

To maintain some degree of consistency, always spec the same brand and type of lining on tractors and trailers, and use the same material for relining. A good guide is TMC's RP 628C "Aftermarket Brake Lining Classification," (see page 77) which provides an ever-changing laundry list of various brands and types of FMVSS-121-compliance linings and their torque ratings.

Understanding torque degradation

Even if tractors and trailers initially are well-matched, torque balance can degrade over time. Friction material can be contaminated by leaky, improperly installed wheel oil seals or ill-advised and overgenerous greasing of the cam assembly on drum brakes. Leaking oil seals on new equipment demands a spot check of other units on the tractor or trailer, since assembly line errors could be responsible. Leaking seals on older vehicles and equipment could indicate a need to spec higher-quality seals or retrain technicians in proper lubrication procedures. Another option is to consider spec'ing "unitized" (sealed) hubs on new equipment.

Over time, brake drums can become deeply scored or bell-mouthed, and disc brake rotors can become "dished" and prevent even contact with the friction material at one or more wheels. Never assume new or replacement drums are automatically good to go, either. They can come from the manufacturer with flaws, like being bell-mouthed or eccentric, requiring that they be turned true in a lathe. In some cases, radius grinding of linings may be required for a good fit. While mild heat checking is acceptable, any drum or rotor with deep cracks should be scrapped out of hand.

Remember that brake shoe return springs can stretch or even break over time. That's why it's a good idea to replace springs every time brakes are relined, even if they look good. The same rule should apply to rollers that have become flat-spotted.

S-cams can wear down to the point that brake torque is severely affected as well. Likewise, worn camshafts and their splines and bushings also can degrade stopping performance. Pay special attention to the condition of the bushing, as it's responsible for centering the cam and shoe assembly in the drum. Just like springs, bushings should be replaced every time the brakes are relined.

More than one anchor pin has been removed over the years with heat and hammer. But doing so may warp the spider, and bent spiders degrade lining-to-drum contact. Use only light taps, or better yet, use specially designed pullers to remove anchor pins when servicing brakes.

Sliding disc brake calipers can seize, causing accelerated wear of the inner disc brake pad. To combat this problem, make sure caliper pins and sliding surfaces are lubricated properly to assure proper function of the disc caliper.

Gum and carbon buildup from air contaminated with oil and water can, over time, clog valves, causing them to slow down or fail altogether. There's an easy way to avoid this malady: Make sure air tanks are drained routinely, and spec an air dryer if you're not using one already.

Retrofitting brake chambers or slack adjusters of the wrong size will change performance and compatibility. Mixing two brands of automatic slack adjusters on the same axle also is not recommended because they will not perform identically and will create uneven brake wear. And although they are highly reliable components, automatic slack adjusters can malfunction or wear out over time. Lubricate them properly, and measure for excessive push rod stroke as brakes are applied. Inspecting the assembly for excessively worn holes in the yolk and slack adjuster, worn clevis pins and general looseness should be a standard maintenance procedure as well. To ensure proper performance, ABAs must be mounted at the correct angle, as determined by use of installation templates that vary by application and brand of slack. In the real world, however, the mounting angle may be compromised by clearance problems experienced by the OEM. For that reason, clearance should be checked before making a change in mounting position. (See Chapter 6, page 62.)

Low-profile tires can save you money at the fuel pump. But not matching low-profile tires on a tractor and trailer can cause brake compatibility issues. And retrofitting tires without reconfiguring the vehicle's brake system is a mistake. A vehicle or tractor with low-profile tires having a radius 18 percent smaller than original-equipment tires can cause a vehicle to be overbraked. In fact, an 18 percent reduction in rolling radius can result in an 18 percent increase in braking force, resulting in the lockup of lightly laden non-ABS-equipped trailers in the course of normal braking. And because smaller tires rotate faster at a given road speed, linings will engage the drums at higher rpm and run hotter, especially when braking on downgrades. If you want to spec low-profile tires, consider spec'ing the next smallest chamber on the vehicle, which will reduce torque by about 20 percent. And changing to a less aggressive lining – or, with engineering approval, placing some sort of pressure modifier in the system – will help resolve an overbraking issue as well.

Consistent overheating, localized wear from lack of uniform friction material contact or exposure to abrasive material all can damage drums and rotors. Always inspect rotors and drums during relining jobs. Any friction surfaces with a mirror-like finish should be roughed up with 80-grit emery cloth and, if accompanied by a glazing on the shoes or pads, should trigger a quest for a more suitable friction material.

Foreign abrasive materials also can cause excessive wear along the edges of the trailer lining contact area, or in areas coinciding with lining rivet holes. If this is happening, remove the lower dust shield (if equipped) to provide an exit for the foreign material. Remember when checking a drum for excessive wear that its inner diameter shouldn't be more than .12-inch more than the original spec.

When resurfacing drums, the finished ID shouldn't be over .08 inch beyond original spec. And runout shouldn't exceed .01 inch. The same goes for disc brake rotors. When checking rotor thickness, they shouldn't be more than .12 inch less than the original spec, and don't resurface more than .08 inch less than the original spec. Lateral runout shouldn't exceed .01 inch. In any event, it is important to follow individual manufacturer turning and finish requirements.

Pneumatic imbalance

Pneumatic or air pressure imbalance occurs when a tractor-trailer's air system delivers air pressure to the vehicle's brake chambers improperly. This is often caused by incorrectly spec'd or malfunctioning relay valves, although quick-release valves also can upset air pressure balance. Other common air pressure imbalance causes include air leaks, air system contamination, a front-axle-limiting valve and excessive use of the trailer hand control valve. (Refer to SAE J1505 and 1860 for further information.)

Timing imbalance occurs when some brakes receive air faster than others. Common causes include oversized control lines (found on pre-1991 trailers), which impede brake application; poor plumbing design or improper installation; and failure to use booster valves where appropriate.

Most manufacturers say that maintaining good pneumatic balance is crucial in improving brake response. Ideal pneumatic balance is achieved when the air delivered to each axle doesn't vary by more than 2 psi during a 10- to 40-psi application. (An exception to this rule would be the ill-advised mating of an S-cam-equipped tractor with a wedge-braked trailer. Because wedge brakes have smaller chambers and require more psi than S-cams to make linings contact the drum, the wedge-braked trailer would require higher air pressure than the tractor for balanced braking during low-pressure applications.)

Low-pressure imbalance

Brake system engineers say about 95 percent of braking involves application pressures for linehaul applications below 20 psi. And approximately 84 percent of braking is done at application pressures of 15 psi or less. When Federal Motor Vehicle Safety Standard 121 took effect in 1975, it required trailers to be compatible with a tractor simulator delivering a massive slug of air. To achieve timing requirements, trailers needed 1⁄2-inch OD (3⁄8-inch ID) control lines instead of the 3⁄8-inch OD (1⁄4-inch ID) lines. But during normal braking procedures, a tractor doesn't deliver enough air to fill a trailer's oversized control line. As a result, trailer braking is delayed, and the problem is magnified on multiple-trailer combinations.

In some cases, this delayed air delivery gives drivers a noticeable thump from behind as the trailer pushes the power unit forward. In extreme cases, that bump quickly can become a full-blown shove when braking in slippery conditions or in a curve, causing a jackknife.

Seeking to eliminate the delay, the National Highway Traffic Safety Administration modified the tractor simulator and changed maximum application/release times for trailers built on or after May 3, 1991, and has specified air-delivery times for control-line gladhands at the rear of tractors, trailers and dollies built on or after May 3, 1991, and should, theoretically, be a rare occurrence today. But if you're working with older tractors and trailers, trailer bumping can be eliminated by retrofitting a smaller control line to the trailer and by making changes to the tractor that would speed gladhand timing. This causes trailer brakes to apply faster during normal brake applications without any degradation of stopping distance during panic stops.

High-pressure imbalance

Conversely, if a tractor's brakes are doing most of the work, a combination vehicle can't slow down quickly without the driver applying heavy pressure on the brake pedal.

And while ABS prevents overbraked wheels from locking up, it's not a substitute for a properly balanced brake system. Sustained high-pressure braking of an ABS-equipped tractor is not advisable since a non-ABS-equipped trailer (or one with nonfunctional ABS) may receive enough air to lock its brakes, perhaps causing it to swing rapidly out of its traffic lane. Worse, a tractor with a nonfunctioning ABS is likely to jackknife during full and sustained braking. For those reasons, NHTSA advises drivers not to change their normal braking habits when driving ABS-equipped combination vehicles.

Air disc brakes provide more efficient braking on tractors, which could be a problem when paired with trailers still equipped with drum brakes. Trailer drum brakes have a tendency to develop heat fade faster when paired with tractor air disc brakes. As a result, the tractor brakes work harder to slow the rig down, resulting in imbalanced brakes.

The key to solving this high-pressure imbalance lies with the crack pressure on the trailer. Crack pressure, expressed in psi, is the air required to force a valve open when air brakes are applied. Some tractors fire air quickly to their own brakes before passing it along to the trailer(s) behind them. But some trailers resist accepting air from a tractor because they have a relay valve set with a relatively high crack pressure.

As a general rule, valve character, including crack pressure, has minimal effect on high-pressure braking and primarily influences low-pressure braking and wear.

Remember that retrofitting remanufactured or aftermarket air valves can destroy pneumatic balance because the crack pressure of relay or quick-release valves fitted with aftermarket springs can vary considerably. Just because a valve "looks right" or "will fit" doesn't mean it's a suitable replacement for original equipment. Even where valves of the same make and model are used as replacements, crack pressures and pressure differentials may vary because of differences in bore size and manufacturing tolerances. (Refer to SAE 1860 for more information.)

Correcting overspec'd brakes

A final yet relatively simple problem causing brake imbalance is a tractor with axles that have been overspec'd for the loads it usually carries. Some fleets do this to boost the tractor's resale value or to extend axle life by using larger gearsets and bearings. But the safety aspects far outweigh any payload or durability gains because the tractor always will overbrake if axle loading is substantially less than its rated capacity. The same rule applies to trailers with overspec'd axles. This can lead to compatibility, wear and maintenance issues.

One option to resolve an overspec'd tractor or trailer is to switch to less-aggressive brake linings. Another option (not always possible) is to attach chamber pushrods to a different slack adjuster hole, thereby reducing braking force. Keep in mind, though, that spacing between slack adjuster holes varies by make. So it's wise to ask your vehicle OEM or brake component supplier for technical advice before making changes.

It's also a good idea to conduct an onsite brake-torque-balance test before making any fleetwide modifications. A suitable procedure is offered by Recommended Practice (RP) 613 "Brake System Torque Balance Test Procedure," which is offered by the Technology and Maintenance Council of the American Trucking Associations.

CHAPTER 10: Resources

The following are selected original equipment and aftermarket suppliers of air brake system parts and components.

AIR COMPRESSORS, BRAKING

Bendix Commercial Vehicle Systems
www.bendix.com

Bepco Inc.
www.bepco.biz

Brake Systems Inc.
www.brakesystemsinc.com

FleetPride Inc.
www.fleetpride.com

Haldex
www.haldex.com

HDA Truck Pride
www.hdatruckpride.com

Meritor Inc.
www.meritor.com

Precision Rebuilders
www.precisionrebuilders.com

S & S Truck Parts Inc.
NewStar Parts Component Group
www.sandstruck.com

Transaxle LLC
www.transaxle.com

Vipar Heavy Duty
www.vipar.com

Wabco
www.wabco-na.com

AIR DRYERS

Alliance Truck Parts
www.alliancetruckparts.com

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bepco Inc.
www.bepco.biz

Brake Systems Inc.
www.brakesystemsinc.com

D&D Instruments
www.ddinstruments.com

Haldex
www.haldex.com

HDA Truck Pride
www.hdatruckpride.com

Meritor Inc.
www.meritor.com

PDC Power Products
www.partsdistributing.com

Precision Rebuilders
www.precisionrebuilders.com

S & S Truck Parts Inc.
NewStar Parts Component Group
www.sandstruck.com

SKF Vehicle Aftermarket
www.vsm.skf.com

Torque Parts
www.torqueusa.com

Vipar Heavy Duty
www.vipar.com

Wabco
www.wabco-na.com

ANTILOCK BRAKING SYSTEMS

Bendix Commercial Vehicle Systems
www.bendix.com

Haldex
www.haldex.com

Meritor Inc.
www.meritor.com

Mico Inc.
www.mico.com

Road Equipment Parts Center
www.roadparts.com

Robert Bosch Corp.
www.bosch.com

Wabco
www.wabco-na.com

BRAKE ADJUSTERS

Accuride Corp.
www.accuridecorp.com

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Haldex
www.haldex.com

Meritor Inc.
www.meritor.com

PDC Power Products
www.partsdistributing.com

S & S Truck Parts Inc.
NewStar Parts Component Group
www.sandstruck.com

Sirco Industries Inc.
www.sircoind.com

Torque Parts
www.torqueusa.com

Transaxle LLC
www.transaxle.com

Vipar Heavy Duty
www.vipar.com

Wabco
www.wabco-na.com

Wanxiang America Corp.
www.wanxiang.com

BRAKE DRUMS AND ROTORS

Accuride Corp.
www.accuridecorp.com

Alliance Truck Parts
www.alliancetruckparts.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Brake Systems Inc.
www.brakesystemsinc.com

Consolidated Metco (ConMet)
www.conmet.com

DuraBrake Co.
www.durabrake.com

East Coast Brake Rebuilders
www.eastcoastbrake.com

Extreme Manufacturing
www.extremebrake.com

Federal Mogul Corp.
www.federalmogul.com

FleetPride Inc.
www.fleetpride.com

HDA Truck Pride
www.hdatruckpride.com

Meritor Inc.
www.meritor.com

NeoBrake Systems Inc.
www.neobrake.com

New Life Transport Parts Center
www.newlifeparts.com

Raybestos
www.raybestos.com

SAF-Holland
www.safholland.us

Stemco
www.stemco.com

Transaxle LLC
www.transaxle.com

Webb Wheel Products Inc.
www.webbwheel.com

BRAKE LINING & BLOCK

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Carlisle Industrial Brake & Friction
www.carlislebrake.com

DuraBrake Co.
www.durabrake.com

East Coast Brake Rebuilders
www.eastcoastbrake.com

Federal-Mogul Corp.
Abex Friction
www.fmheavydutyparts.com

Fras-Le North America
www.fras-le.com

Gorilla Brake & Components Inc.
www.gorillabrake.com

Haldex
www.haldex.com

HDA Truck Pride
www.hdatruckpride.com

I.M.T. Corp.
www.imtcorporation.com

Marathon Brake Systems
www.marathonbrake.com

Meritor Inc.
www.meritor.com

NeoBrake Systems Inc.
www.neobrake.com

Raybestos
www.raybestos.com

Roadranger Parts Marketing
www.roadranger.com

Southwest Trailers & Equipment
www.swtrailer.com

Stemco Duroline
www.stemco.com

TMD Friction Inc.
www.tmdfriction.com

Vipar Heavy Duty
www.vipar.com

BRAKE SERVICE EQUIPMENT

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Brake Machinery Sales
www.brakemachinery.com

Brake Tech Tools
www.braketechtools.com

Central Tools Inc.
www.centraltools.com

Equipment Supply Co.
www.esco.net

Hennessy Industries Inc.
www.ammcoats.com

Hommer Tool & Mfg. Inc.
www.hommer.com

Hunter Engineering Co.
www.hunter.com

Innovative Products of America
www.ipatools.com

Kiene Diesel Accessories
www.kienediesel.com

Kwik-Way Products
www.kwik-way.com

LS Industries
www.lsindustries.com

MotorVac Technologies Inc.
www.motorvac.com

Safe Shop Tools
www.safeshop.com

SPX Service Solutions
www.spx.com

Tiger Tool International Inc.
www.tigertool.com

Unique Truck Equipment
www.uniquetruck.com

Van Norman
www.van-norman.com

Vehicle Inspection Systems
www.vischeck.net

BRAKE SHOES

American Isuzu Motors
www.isuzucv.com

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Carlisle Industrial Brake & Friction
www.carlislebrake.com

East Coast Brake Rebuilders
www.eastcoastbrake.com

Extreme Manufacturing
www.extremebrake.com

Federal-Mogul Corp.
www.federalmogul.com

FleetPride Inc.
www.fleetpride.com

Gorilla Brake & Components Inc.
www.gorillabrake.com

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Marathon Brake Systems
www.marathonbrake.com

Meritor Inc.
www.meritor.com

NeoBrake Systems Inc.
www.neobrake.com

Napa Truck Parts
www.napaonline.com

Raybestos
www.raybestos.com

Road Equipment Parts Center
www.roadparts.com

Roadranger Parts Marketing
www.roadranger.com

Stemco Rome Heavy Duty
www.stemco.com

TMD Friction Inc.
www.tmdfriction.com

Vipar Heavy Duty
www.vipar.com

BRAKE VALVES

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bepco Inc.
www.bepco.biz

Brake Systems Inc.
www.brakesystemsinc.com

D&D Instruments
www.ddinstruments.com

Di-Pro Inc.
www.di-pro.com

FleetPride Inc.
www.fleetpride.com

Fontaine PartSource
www.fontainepartsource.com

Haldex
www.haldex.com

HDA Truck Pride
www.hdatruckpride.com

Meritor Inc.
www.meritor.com

Parker Hannifin
www.parker.com

PDC Power Products
www.partsdistributing.com

Precision Rebuilders
www.precisionrebuilders.com

S & S Truck Parts Inc.
NewStar Parts Component Group
www.sandstruck.com

Tectran Mfg. Inc.
www.tectran.com

Torque Parts
www.torqueusa.com

Tramec Sloan
www.tramecsloan.com

Velvac Inc.
www.velvac.com

Vipar Heavy Duty
www.vipar.com

Wabco
www.wabco-na.com

BRAKES, AIR SYSTEM PARTS

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bepco Inc.
www.bepco.biz

Brake Systems Inc.
www.brakesystemsinc.com

Brass Craft Industrial Products
www.brasscraft.com

Coronet Parts Mfg. Co. Inc.
www.coronetparts.com

Dayton Parts LLC
www.daytonparts.com

Di-Pro Inc.
www.di-pro.com

DuraBrake Co.
www.durabrake.com

East Coast Brake Rebuilders
www.eastcoastbrake.com

Fairview Fittings
www.fairviewfittings.com

Gates Corp.
www.gates.com

HDA Truck Pride
www.hdatruckpride.com

Hendrickson
Trailer Suspension Systems
www.hendrickson-intl.com

Meritor Inc.
www.meritor.com

MGM Brakes
www.mgmbrakes.com

Napa Truck Parts
www.napaonline.com

PDC Power Products
www.partsdistributing.com

Philatron International
www.philatron.com

Phillips Industries
www.phillipsind.com

Precision Rebuilders
www.precisionrebuilders.com

S & S Truck Parts Inc.
NewStar Parts Component Group
www.sandstruck.com

Tectran Mfg. Inc.
www.tectran.com

Tramec Sloan
www.tramecsloan.com

TSE Brakes Inc.
www.tsebrakes.com

U.S. Trailer Parts & Supply
www.ustrailerparts.com

Vipar Heavy Duty
www.vipar.com

Wabco
www.wabco-na.com

BRAKES, DISC

Accuride Corp.
www.accuridecorp.com

Automann Inc.
www.automann.com

Bendix Commercial Vehicle Systems
www.bendix.com

Bendix Spicer Foundation Brake
www.foundationbrakes.com

Bepco Inc.
www.bepco.biz

Brake Systems Inc.
www.brakesystemsinc.com

Carlisle Industrial Brake & Friction
www.carlislebrake.com

Consolidated Metco (ConMet)
www.conmet.com

DuraBrake Co.
www.durabrake.com

Federal-Mogul Corp.
www.federalmogul.com

Fras-Le North America
www.fras-le.com

Haldex
www.haldex.com

Hendrickson
Trailer Suspension Systems
www.hendrickson-intl.com

Marathon Brake Systems
www.marathonbrake.com

Meritor Inc.
www.meritor.com

Midwest Remanufacturing
www.pwrsteering.com

Performance Friction Corp.
www.pfcbrakes.com

Precision Rebuilders
www.precisionrebuilders.com

Robert Bosch Corp.
www.bosch.com

Ryder Fleet Products
www.RyderFleetProducts.com

SAF-Holland
www.safholland.us

TMD Friction Inc.
www.tmdfriction.com

Webb Wheel Products Inc.
www.webbwheel.com

Wabco
www.wabco-na.com

CHAPTER 11: Glossary

ABA: The abbreviation for automatic brake adjuster. Also called an automatic slack adjuster (ASA), this is a lever connecting the brake chamber pushrod with the foundation brake camshaft. It provides torque to rotate the brake camshaft when the brake treadle is depressed. It also provides a means of adjusting clearance between brake shoes and the drum to compensate for lining wear. Some brake adjusters require manual adjustment.

ABS: The abbreviation for "antilock braking system." ABS electronically monitors wheel speed and prevents wheel lockup by rapidly cycling the brakes during panic stops and when stopping on low-friction surfaces.

ABS control valves: Control valves that are actuated by the ABS electronic control unit (ECU) to ensure wheels are optimally braked. On a tractor, they are called ABS modulator valves. On a trailer, they're called ABS relay valves.

Actuate: To initiate mechanical motion of a brake system component.

Actuator: A device which physically initiates mechanical motion of a brake system component.

Aftercooler: Optional device that condenses and eliminates water from air pressurized by the compressor.

Aggressiveness (pertaining to brake linings): The brake output torque developed based on the friction coefficient and the input pressure. Brake torque output can be increased with higher friction coefficients. Typically the friction coefficient is varied by the friction block or pad material rather than the rotor or drum. Changing friction coefficients changes the energy distribution proportionally. The vehicle needs to be balanced to avoid creating overly aggressive stopping performance that may occur when a vehicle is lightly loaded.

Air buildup: Process of compressor building (increasing) pressure to a predetermined maximum level (usually 100-120 psi) within the brake system air tanks.

Air compressor: Engine-driven via a belt or direct gear, the compressor pressurizes the air tank.

Air compressor cut-out: Predetermined point at which the air governor halts compression of air by the compressor.

Air disc brakes: Air-actuated brakes which, upon application, employ a caliper to clamp two brake pads against a rotor. Air discs, compared with drum-type brakes, have superior ability to resist fade.

Air dryer: A filter, typically containing a desiccant, which is installed between the compressor and service reservoir to remove water and vapor plus oil blow-by from the compressor.

Air gauge: Dash-mounted gauge indicating air pressure in terms of pounds per square inch (psi).

Air governor: Controls the compressor unloader mechanism and also maintains system air pressure between predetermined minimum and maximum levels (usually between 90-120 psi).

Air tank: A reservoir for compressed air. Typically, a combination vehicle has several tanks: three in the tractor and one per trailer. The tractor's supply air tank (formerly "wet tank") receives air from the compressor and delivers it to the primary and secondary air tanks in the tractor. A check valve on each tank prevents total air loss in the event of a leak.

Alcohol evaporator: Optional device, installed in compressor discharge line between the compressor and supply air tank, which injects alcohol mist into the air flow to reduce the risk of freezeup. It's not normally used in a vehicle with an air dryer.

AL factor: A mathematical expression of the brake adjuster and brake chamber combination. "A" equals the effective area, in square inches, of the brake chamber (e.g., Type 30 chamber has effective area of 30 square-inches). "L" equals the effective length, in inches, of the slack adjuster. For example, 30 x 6 inches = 180 AL factor.

Analog processing: A method of processing information used in older ABS control units. Today's electronic control units (ECUs) use digital processing, which is many times faster and more reliable.

Anchor pin: A pin or pins used to retain brake shoes within the brake assembly.

Anti-compounding: Basically, an optional system that prevents application of service brakes from compounding (adding to) the force exerted by parking brakes. Functionally, this guards against brake cracking and lining damage.

Antilock: A safety-oriented system which senses wheel rotation (at one or more axles) during braking and cycles the brakes to prevent locking those wheels.

Application time: Time elapsed between depression of the brake treadle and engagement of the linings with the drums (or, per FMVSS 121, the point at which all service chambers reach 60 psi).

Application valve: Air valve, such as foot valve or trailer control valve, which controls the pressure delivered to brake chambers.

Automatic slack adjuster: See **ABA.**

Automatic traction control (ATC): Also called ASR, it's an optional system that is available on 4- and 6-channel ABS systems. Automatic traction control minimizes wheel slipping during acceleration by controlling both the engine throttle and brake pressures. Can also be used to enhance vehicle roll stability.

Bell-mouthed drum: Drum with variation of inner diameter (i.e., greater at open end), preventing full contact with brake lining.

Blue drum: Brake drum with friction surface blued from high temperature. High temperature may result, for example, from dragging of brakes caused by weak return springs. Blue drum also may result from lack of brake balance.

Brake adjuster: See **ABA.**

Brake balance: Is achieved when all brakes on all axles do their fair share of the work. It is an optimized timing when all the vehicles' brakes (including trailers) turn on and turn off. Brake balance is desirable to assure good wear, proper energy distribution during braking and stable vehicle handling.

Brake block: Friction material or lining attached to a brake shoe. Disc brakes use pads with friction material.

Brake chamber: Device inside which a diaphragm converts air pressure to mechanical force, via a push rod, for brake actuation.

Brake chamber diaphragm: Bellows-type device within brake chamber that converts air pressure to mechanical force via a push rod.

Brake drag: Failure of one or more brakes to release immediately or completely after a driver removes his foot from the brake treadle. (See **Quick release valve.**) Constant drag, unrelated to a brake application, also can exist.

Brake fade: There are many types and causes of braking fade. Fade may result, for example, from a reduction in friction between linings and drums caused by exposure to water. Most typically, however, fade involves a reduction in braking force experienced when dragging brakes on a long grade. If brakes are maladjusted, an overheated drum may expand to the degree that pushrod travel is insufficient to fully actuate the brakes. This is one example of mechanical fade, which also may result from various mechanical defects (e.g., scored drums) within the foundation brake system. In contrast, heat fade occurs when linings overheat and become less aggressive. Gradual and predictable fade is desirable as a warning.

Brake proportioning: Optional safety-oriented system, often called "bobtail proportioning," for limiting drive-axle brakes while a tractor is operated without a trailer. Also, a system that varies individual axle braking effort in response to weight or other variable.

Brake treadle: Functionally, the brake pedal; a mechanical lever attached to the foot brake valve.

Breakaway valve: Upon accidental separation of trailer(s), a tractor protection system which prevents air loss from the power unit. (See **Tractor protection valve.**)

Burnish: The conditioning or "seasoning" of a brake lining by wear and temperature via a test procedure or in-service operation.

Caliper: In an air disc brake system, the clamping device containing friction material mounted to pads. When actuated, the caliper applies braking force to both sides of the rotor.

Channel/ABS: The number of channels in an ABS system refers to the number of valves its electronic control unit (ECU) is capable of independently controlling.

1-Channel ABS: A system design that uses two wheel-speed sensors and one control valve (2S/1M). This is the most popular system for most trailers. It is called tandem control.

2-Channel ABS: A system design that uses two or four wheel-speed sensors and two control valves (2S/2M or 4S/2M). The ABS monitors wheel speed and avoids wheel lockup on one axle while braking on low-friction surfaces or in emergency situations by rapidly cycling the brakes on the wheel ends of two axles. Commonly used on trailers.

4-Channel ABS: A system design that uses four wheel-speed sensors and four ABS control valves (4S/4M) on a two-axle truck or tractor. A 4-channel system can also be used on a three-axle vehicle, controlling the left- and right-side drive axle wheels in pairs. This popular system, which offers an optimum blend of performance and economy, is the most common system on trucks, tractors and buses.

6-Channel ABS: A system design that features six wheel-speed sensors and six ABS control valves (6S/6M) to individually monitor and control all six wheels of a three-axle truck or tractor. This type of system provides the highest available level of ABS control. It's commonly used on vehicles with lift or tag axles.

Check valve: A one-way check valve is used, for example, to prevent air from bleeding back out of a reservoir. A two-way check valve activates selectively: for instance, by drawing air for brake application from the most-highly-pressurized reservoir (primary or secondary).

Clevis pin: Pin connecting the arm of a slack adjuster to a brake chamber push rod yoke.

Connectors/ABS: Sealed, corrosion-resistant plugs that link the ABS wiring system to the electronic control unit (ECU), wheel-speed sensors and modulator or relay valves using a shielded wiring harness.

Control algorithm: The computer commands programmed into the electronic control unit (ECU) to control brake actuation under impending wheel lockup.

Crack pressure: Minimum air pressure, expressed in pounds per square inch (psi), required to open an air valve.

Cracked drum: Brake drum cracked all the way through by excessive heat buildup (perhaps signifying inadequate drum weight, driver abuse or resurfacing of a drum beyond the manufacturer's limit).

Diagnostics/ARS: A component-by-component self-check performed each time the truck's ignition is turned on. An independent microprocessor also checks the system continuously during vehicle operation.

Diagonal system/ABS: A brake system design that divides the ABS into two circuits (front wheel on one side with rear on the other side, and vice versa) to allow partial system function should one diagonal malfunction.

Digital processing/ABS: The latest processing technology that is many times faster and more reliable than analog processing.

Drain valve: Used to drain oil and water from air reservoirs. Valve may be manual or automatic in operation. Automatic versions, which may be heated electrically to prevent the valve freezing open, often are referred to as spitter valves.

Dual brake system: A redundant air system (primary and secondary) designed to retain braking ability in the event one system fails.

Duplex gauge: Essentially, a diagnostic device incorporating two separate air gauges with a common housing and utilizing indicator needles of different colors. Device is used to diagnose brake system imbalance within a combination vehicle via simultaneous connection to two points (such as the tractor gladhand and a trailer brake chamber). It's also used as a dash gauge for dual reservoirs.

Dust shield: Plate made of metal or polyethylene that's mounted behind a brake drum to minimize entry of dirt and road splash.

EBS: Electronic braking system, or brake-by-wire. A system in which the control signal is sent electronically, rather than pneumatically, although the actual service application is still made by air pressure.

ECU/ABS: Electric control unit is a microprocessor that evaluates how fast a wheel is rotating. The electrical signals generated by the inductive sensors pick up impulses from toothed rings that spin with the wheel.

Edge codes: Developed by Friction Materials Standards Institute, a double letter code (e.g., EE, FF, GG, FG) printed on the edge of a brake block to designate its range of aggressiveness.

Emergency brake system: Not a separate system, emergency braking (in the event of air loss) involves various portions of the parking and service brake systems. (See **Spring brake.**)

Engine brake: One type of retarder. An optional device that converts a diesel engine into a power-absorbing air compressor to slow a vehicle on downgrades.

Exhaust brake: One type of retarder. An optional device that uses engine exhaust back pressure to slow a vehicle on downgrades.

Fail-safe/ABS: If antilock brake system should fail during vehicle operation, a dash light warns driver that ABS is disengaged. Meanwhile, the tractor's pneumatic system returns to normal relay valve functions and maintains standard air brake performance.

Fault codes/ABS: A series of codes displayed by the self-diagnostic portion of the ABS unit, isolating the section of the system that has malfunctioned.

Foot valve: A foot-operated valve controlling air pressure delivered to the brake chambers.

Foundation brake system: Term inclusive of mechanical components involved in providing braking force (i.e., brake chambers, slack adjusters, brake drums and brake linings).

Front axle limiting valve: See **Ratio limiting valve.**

GCWR: Gross combination weight rating is the total weight capacity of a combination vehicle (tractor and trailer) as determined by axle ratings. It includes the weight of the vehicle and payload.

Gladhand: Mechanical connector used to attach a tractor's or converter dolly's service (i.e., control) and emergency (i.e., supply) air lines to those on a trailer.

Greased-stained drum: A brake drum with discoloration of friction surface caused by, for example, improper greasing of brake camshaft.

GVWR: Gross vehicle weight rating is the total weight capacity of a single vehicle, as determined by axle ratings.

Hand valve: See **Trailer control valve.**

Heat-checked drum: Brake drum with hairline cracks on friction surface caused by thermal cycling. Mild checking normally does not require drum replacement.

Heat-spotted drum: Brake drum with a pattern of hard, slightly raised dark spots of martinsite on its friction surface. Caused by localized overheating and sudden cooling, those spots should be ground off to prevent drum cracking, uneven lining wear and loss of braking efficiency. If spots cannot be removed, the drum should be discarded. Heat spotting is promoted by light and steady braking on downgrades.

Hold-off spring: A spring within a relay valve or quick release valve designed to retard valve operation until a predetermined amount of air pressure is exerted. (See **Crack pressure.**)

Hysteresis: Difference between the amount of pressure needed to open a valve and the pressure drop needed to close it.

Inversion valve: Valve used on trucks to release air from the parking brake chambers and apply the rear brakes if the rear air reservoir fails.

Jackknife: Uncontrollable articulation of a tractor-trailer typically resulting from lockup or spinning of tractor drive axles. The risk of jackknife is greatest on a slippery road with an empty or lightly-laden trailer in tow.

Jake Brake: Trademark of engine brakes by the Vehicle Equipment Division of The Jacobs Manufacturing Co.

Leak-down test: A common method of checking for air leaks. With the engine off, vehicle stationary, the air system at maximum governed pressure and all service brakes fully applied, there should be no more than a 3 psi/minute air loss noted on the dash-mounted pressure gauge for straight trucks; 4 psi/minute for combination vehicles.

Lining growth: Permanent swelling of brake lining resulting from heat exposure.

Long-stroke chamber: A brake chamber designed to permit longer-than-normal pushrod travel without exceeding its readjustment limit. For example, a regular, clamp-type, Type 30 chamber has a readjustment limit of 2 inches. A long-stroke version of that chamber has a readjustment limit of 2½ inches.

Low pressure warning device: Pressure-sensitive electrical switch that actuates an in-cab buzzer and warning light when air pressure falls below a predetermined level (typically, 60 psi).

Multiplexing: A means of sending discreet electrical signals to multiple devices along a common pair of wires.

Out-of-round drum: Brake drum with variations in its inner diameter, causing reduced braking efficiency. An out-of-round drum often can be machined, within manufacturer's limits, to restore concentricity.

Oversized drum: Refers to a brake drum having an inner diameter greater than the discard diameter marked on the drum by its manufacturer.

Parking brake: See **Spring brake.**

Parking brake priority: A type of trailer brake control valve which prioritizes delivery of air for quick release of a trailer's parking brakes after being hooked to a tractor. Charging a trailer's service reservoirs, to provide braking ability, is a secondary concern.

Pawl: A mechanical device allowing rotation in only one direction. One type consists of a hinged tongue, the tip of which engages the notches of a cogwheel, preventing backward motion.

PLC: Power-line carrier; a form of multiplexing wherein a discreet electrical signal is sent along a wire already carrying power for another purpose. PLC technology is used in tractor/trailer communications, allowing more utility than the standard J-560 7-pin connector could otherwise afford.

Pneumatic balance: Achieved when individual air chambers receive the air pressure required for each brake in the system to do its fair share of the work. Lack of pneumatic balance is most likely at low brake application pressures, rarely during panic stops.

Pneumatic timing balance: Achieved when individual air chambers sequentially receive air within a timeframe that ensures each brake in the system will do its fair share of the work. In a combination vehicle, lack of proper timing is likely to occur because tractor brakes receive air faster than trailer brakes. (See **Trailer push.**)

Polished drums: A brake drum with a friction surface polished to a mirror-like finish by unsuitable brake linings. Remove gloss from drum with 80-grit emery cloth.

Pop-oil valve: Jargon for a pressure-relief valve, installed in the service reservoir or wet tanks as insurance against over-pressurization.

Pressure differential: Difference between the inlet and outlet air pressure of an open brake valve. Also, difference in air pressure between any two points within a brake system.

Pumping the brakes: Phrase denoting a rapid series of brake applications (a.k.a. fanning) used to avoid locking brakes on axles during sudden stops. Phrase also may apply to a slower series of heavy brake applications (a.k.a. snubbing) used in an attempt to prevent brake overheating and resultant fade on long downgrades.

Pushrod: A rod, protruding from a brake chamber, which is connected to the arm of a slack adjuster via a clevis pin.

Quick release valve: Designed to reduce the chance of brake drag, a valve that speeds the process of exhausting air from brake chambers when driver releases the brake treadle.

Radio frequency interference (RFI): External interference or false signals from such sources as radar, citizens band radio, other types of radio transmissions and television signals. While the effects of this interference on ABS was a concern during the 1970s, today's technology has virtually eliminated the problem.

Ratio limiting valve: Prevents locking of front brakes by automatically limiting application pressure to steer axle during normal braking. Progressively harder braking, however, will progressively increase steer-axle braking until maximum torque is applied.

Relay valve: Valve located near a reservoir that is activated by a control signal from another valve that usually is farther away. It's used to speed the application of brakes on drive and trailer axles.

Release time: Time between release of brake treadle and total disengagement of brake linings and brake drums. Or, per FMVSS 121, that time required to reduce pressure to 5 psi from 95 psi within all service chambers.

Retarder: Auxiliary braking device such as engine brake, exhaust brake, hydraulic retarder or electric retarder.

Return springs: Springs which retract brake shoes upon release of the brake treadle.

Roll-over: Jargon denoting that an S-cam has traveled beyond its designed stopping position during brake application.

S-cam brake: Type of brake where mechanically-induced rotation of an S-shaped cam forces brake linings against the brake drum.

Scored drum: Brake drum with a grooved friction surface, resulting in excessive lining wear. Severe scoring requires that a drum be machined, within manufacturer's limits, before replacing the linings.

Service brake priority: A type of trailer brake control valve which prioritizes delivery of air to a trailer's service reservoirs, to provide braking ability, after being hooked to a tractor. Releasing a trailer's parking brakes is a secondary concern.

Service brakes: As opposed to parking brakes, that portion of the brake system used for normal brake applications.

Slack adjuster: Also called a brake adjuster, this is a lever connecting the brake chamber push rod with the foundation brake camshaft. It provides torque to rotate the brake camshaft when the brake treadle is depressed. It also provides a means of adjusting clearance between brake shoes and the drum to compensate for lining wear. Some models are automatic, while others require manual adjustment. (See **ABA.**)

Speed sensor/ABS: An electromagnetic device that, in conjunction with a rotating toothed wheel, generates an electrical signal proportional to the wheel speed and transmits the information to the ABS electronic control unit (ECU).

Spider (on a brake shoe): Foundation component that attaches all the drum brake components such as brake shoes, camshaft, etc. to the axle. It transfers brake torque from the wheel end to the axle/suspension.

Spitter valve: Slang for automatic drain valve. (See **Drain valve.**)

Split-coefficient surface: Also called split-Mu, a road condition where one side of a lane has low friction and the other has high friction (example, the left side of the lane is ice-covered, the right side is dry). A 2-, 4- or 6-channel ABS system (antilock brake system) with individual wheel control will provide optimum stability and stopping-distance performance under these conditions.

Spring brake: Generally refers to a tandem-chamber brake actuator that incorporates an air-applied service brake chamber and an air-release/spring-applied parking or emergency brake chamber. Spring brakes apply upon sudden air loss (emergency mode) or activation of a dash-mounted parking brake control. Spring brakes remain applied until that chamber is recharged with air or the spring is manually compressed or caged. DISASSEMBLY OF A SPRING BRAKE IS DANGEROUS. ONLY TRAINED MECHANICS SHOULD ATTEMPT THE PROCEDURE. The spring portion often is referred to as the piggy-back.

Stopping distance: The distance traveled by a vehicle on a road between the initial brake pedal movement and a full stop.

Stopping time: The time elapsed between the initial brake pedal movement and a full stop.

Stroke: Refers to a total distance traveled by a brake chamber pushrod or slack adjuster arm during brake application.

Supply air tank: The air reservoir immediately downstream of the air compressor. (See **Wet tank.**)

Threaded drum: Brake drum improperly resurfaced on a lathe, resulting in a friction surface akin to that of a scored drum.

Tire loaded rolling radius: Distance, expressed in inches, from the center of a tire/wheel assembly to the pavement, measured when mounted on a vehicle and loaded to its maximum rated capacity.

Torque balance: Achieved when individual brakes exert the degree of braking force required for each brake in the system to do its fair share of the overall work.

Tractor protection valve: Isolates tractor air system in event of a trailer breakaway or dangerous decrease in the tractor's reserve air, but is typically applied (via dash-mounted control) before disconnecting a trailer.

Trailer control valve: Hand-operated valve, located on (or adjacent to) the steering column, which permits independent control of the trailer brakes. Also known as the trolley valve or the hand valve.

Trailer push: Caused by the tractor braking prior to the trailer and/or with greater torque. Even with "perfect" brake balance, the trailer pushes the tractor to some extent since the tractor brakes will absorb part of the trailer's load.

Trailer swing: Articulation of the trailer caused by locking the trailer brakes.

Treadle valve: Foot-operated brake actuation valve.

Trolley valve: See **Trailer control valve.**

Turned drum : A brake drum that has been resurfaced on a lathe to remove scoring or other defects. Stay within manufacturer's limits.

Warning light/ABS: An indicator light on the truck or tractor instrument panel that illuminates to indicate the status of the ABS system. On trailer ABS, the indicator light may be located on the trailer body where the driver or maintenance personnel can easily see it.

Wedge brakes: As opposed to a brake applied by an S-cam, this type of brake is applied by a single or double wedge-type mechanism. This type of brake is self-adjusting and, as such, does not utilize a slack adjuster.

Wet tank: Also known as the supply air tank, that reservoir nearest to the air compressor where water and oil are most likely to accumulate (assuming the lack of a functional air dryer).

Worm gear: Component of slack adjuster. The worm and worm gear provide for adjusting lining-to-drum clearance.