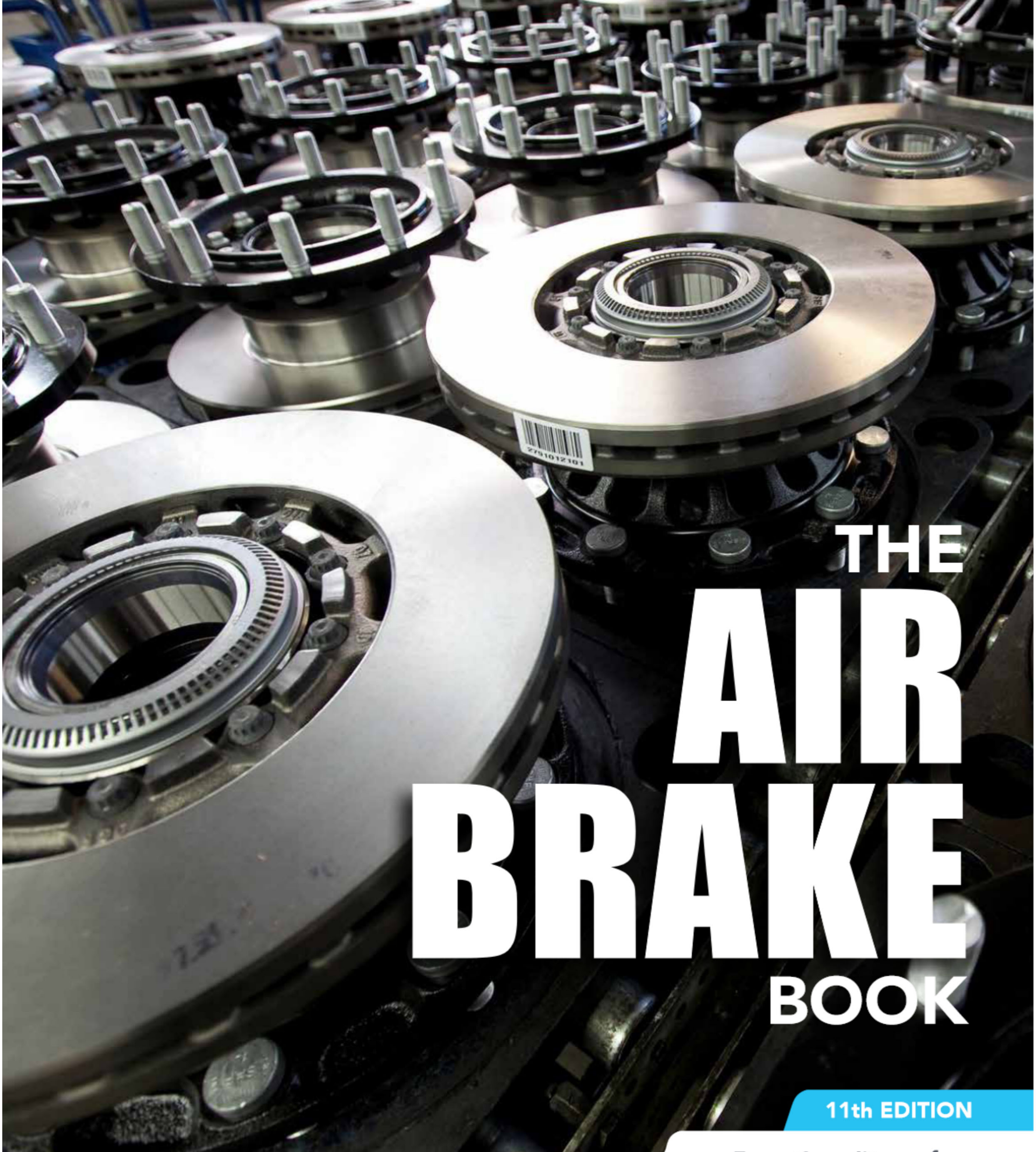

THE AIR BRAKE BOOK

11th EDITION

From the editors of CCJ COMMERCIAL CARRIER JOURNAL

RANDALL REILLY

WHICH SHOES ACTUALLY COST LESS?

SilverbackHD new lined shoes with ceramic friction run cooler, last longer and deliver quiet, safe stops. Buying a relined shoe may save a few dollars upfront, but if your brakes do not last as long, you just wasted your money.

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INTRODUCTION

AIR BRAKE BOOK, 11TH EDITION

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A GUIDE TO 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 11th edition. Since we published the last edition in 2019, industry suppliers and the truck maintenance community have improved performance and maintenance practices for commercial vehicle braking systems.

The 11th edition of *CCJ*'s Air Brake Book adds an important update on brake composition itself that might have sneaked by many maintenance pros and also various maintenance tips to seek drivers and fleets from suffering the consequences of out of service violations – like fines and downtime.

Thanks to the Commercial Vehicle Safety Alliance, we are able to provide a synopsis of the 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 2022 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*.

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

CHAPTER 1

BRAKE FRICTION MATERIAL GOES GREENER

By Jason Cannon

Electrification and hydrogen shoulder much of trucking's potential to become a more environmentally friendly industry, but many fleets have already taken a green leap and may not have even noticed.

As of 2021, brake manufacturers were required to reduce the amount of copper used in their friction material to meet the copper-free brake pad agreement reached in 2015 between the U.S. Environmental Protection Agency, California and Washington State and industry representatives.

The agreement calls for reducing the amount of copper used in brake pads to less than 5% by weight (B-Level) on Jan. 1, 2021, and 0.5% (N-Level) by Jan. 1, 2025. Copper, the EPA said, is a primary pollutant of concern found in highway stormwater runoff, impacting aquatic life and water quality. The initiative also reduces mercury, lead, cadmium, asbestiform fibers and chromium-six salts in brake pads.

"Copper provides good thermal conductivity and heat dissipation to brake pads," said Dhawal Dharaiya, engineering supervisor for Hendrickson Wheel End and Braking Systems. "In addition, copper plays an important role as a solid lubricant that helps generate a friction film during braking application to provide good wear characteristics. Materials that will eventually replace copper in brake pads must fulfill the complex properties that copper demonstrates in current formulations."

ZF Commercial Vehicle Controls Systems Division Engineering Director Dirk Wohltmann added that since copper wears and oxidizes at high temperatures, it helps provide for better overall pad wear.

Because copper generally is softer, it impacts rotor wear to a lesser degree than other metals, said Keith McComsey, director of Air Disc Brake & Systems for Bendix. "The reduction in copper for future pad formulations will have to be replaced with other materials that do a similar job without adversely affecting the pad friction performance," he said.

Joe Kay, director of Brake Engineering for Meritor, said a brake's friction formula has many compounds that make up a sophisticated recipe. Copper replacement in brake pads remains a topic of ongoing research, and many of the replacement materials and approaches to formulations are proprietary.

"There is actually one metal that can act as a substitute for copper, and that is silver," Wohltmann said, "but this is not a cost-effective solution."

The one constant that all manufacturers face is that stopping distance laws have not changed. New materials with reduced or no copper must meet current laws, and those updates will need to come without sacrificing component life.

"Wear and life of new pad materials will be dictated by new ingredients replacing copper," Dharaiya said. "Apart from formulations, wear life is always subject to a variety of factors, such as driving habits, environmental conditions, duty cycle and tractor-trailer brake combination, among others."

Copper is typically substituted by iron, Wohltmann said, as it is the cheapest metallic material available with reasonably comparable physical properties. However, he said it is not a direct one-to-one substitution, as simply replacing the copper with iron provides insufficient performance in wear rates and stopping distances.

"To try to maintain the level of performance of copper-based friction, the entire formulation of a low- or no-copper brake pad must evolve, for instance, by also utilizing a more complex group of materials for the lubricants and modifiers," he said. "In short, copper removal is a cocktail of complex problems and countermeasures."

McComsey said Bendix is working to ensure the continual optimization of the friction's performance "relative to both the stopping performance as well as the pad and friction wear performance to maximize the life of the friction/rotor interface."

Kay said Meritor spent more than two years developing a formula to meet the new standards, progressing from laboratory to FMVSS test tracks to fleets. The company conducted comprehensive lab testing and more than 2.4 million miles of field testing. "In the end, the MA9300 friction demonstrated superior pad wear and similar rotor life compared to Meritor's current offering," he said.

> **Drum brakes absorb and dissipate a much smaller amount of heat energy per unit area of available friction patch, which makes it more feasible for drum brake linings to be produced with little to no copper.**
>
> **Dhawal Dharaiya**, engineering supervisor, Hendrickson Wheel End and Braking Systems

Many commercial vehicle OEM formulations for drum brakes already meet 2025 requirements for reduced copper, Dharaiya said, adding that all Hendrickson drum brake offerings are copper-free.

"Drum brakes absorb and dissipate a much smaller amount of heat energy per unit area of available friction patch, which makes it more feasible for drum brake linings to be produced with little to no copper," he said.

Kay said Meritor's drum brake friction formulas already meet N-Level compliance, as drum brakes tend to operate at lower temperatures, which allowed non-copper formulas to be used.

"Drum frictions typically were classified as non-asbestos organic frictions (NAO), which came at a reduced copper level," McComsey added. "There are some semi-metallic frictions used to meet current levels, but [they] might need to be reformulated to meet the N-Level friction compliance for 2025."

Even though only two West Coast states are tied to the agreement, brake manufacturers rolled out compliant friction material nationwide to avoid having brakes that are compliant only in select states.

McComsey said Bendix air disc brake (ADB) pad offerings that meet the current mandate for B-Level friction are used in all ADB configurations in North America, adding that "we will also support the aftermarket in the same manner." The A-Level frictions that once were available prior to Jan. 1, 2021, were obsoleted and replaced with B-Level equivalent pads for both OES and AM replacement pad kits. The company also is actively developing friction material for its ADBs to meet N-Level friction by its implementation date three years from now.

Randy Petresh, vice president of technical services for Haldex, said the company similarly introduced its revised material formulations on a national basis, not state-specific, and would meet both B- and N-Level deadlines.

N-level friction for all Meritor disc brake products – EX+LS, EX+L, EX+H and Quadraulic – were 2025 copper-compliant by the end of 2020, including MA9300, MA9500 and MA704, for truck and trailer applications.

"Meritor will convert to N-Level formulas as the only offering," Kay said. "Formulas meeting the N-Level friction make it simpler for the vehicle OEMs and also aftermarket parts. We prefer to make it easier for our customers to keep them compliant no matter where their vehicle is purchased, used and service conducted on them."

CHAPTER 2

AIR BRAKE SYSTEM ANATOMY

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 design 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.

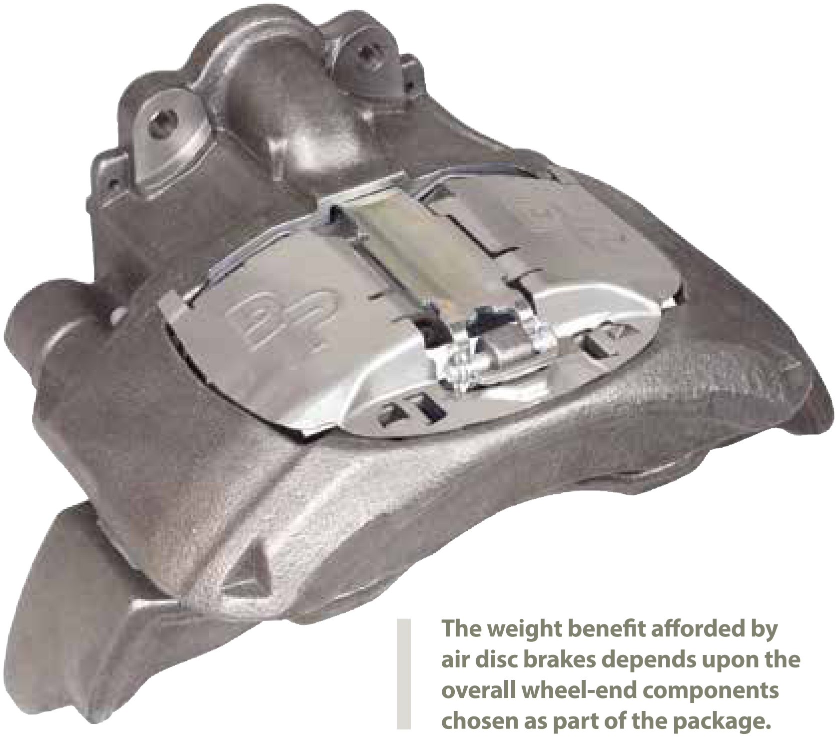
Supply system

The supply system provides pressurized air that actuates its components, and in many ways is the heart of the air brake system. An engine-powered air compressor supplies air to a governor, which controls compressor 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 of a problem.

Air in the system is stored in air reservoirs (usually three or more per tractor) until it is needed. Check valves keep 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.

The air reservoir nearest the compressor is often called



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

the supply tank (sometimes called a "wet" tank), because that is where atmospheric moisture condenses in the greatest quantities. Moisture is the biggest enemy of any air brake system, and great care must be taken to ensure a vehicle has the cleanest and 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. Alcohol will eat away at rubber components like seals.

Control system

Air in the reservoirs has to be routed to the various components in the system before any braking action can take place. The control system is a series of pneumatic valves that does just that – directing and controlling the air as it flows through the system to make sure it goes 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 highest 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.

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 time. 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), ABS valves are combined with relay valves on a trailer to supply modulated air to the anti-lock brake mechanism.

The delivery pressure of the relay valves is 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 significant 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

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

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 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 quick 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.

The tractor protection valve maintains air pressure in the lines that carry air to the trailer if one is being pulled behind the vehicle. "Gladhands" – quick-connect fittings at the rear of the tractor – 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.

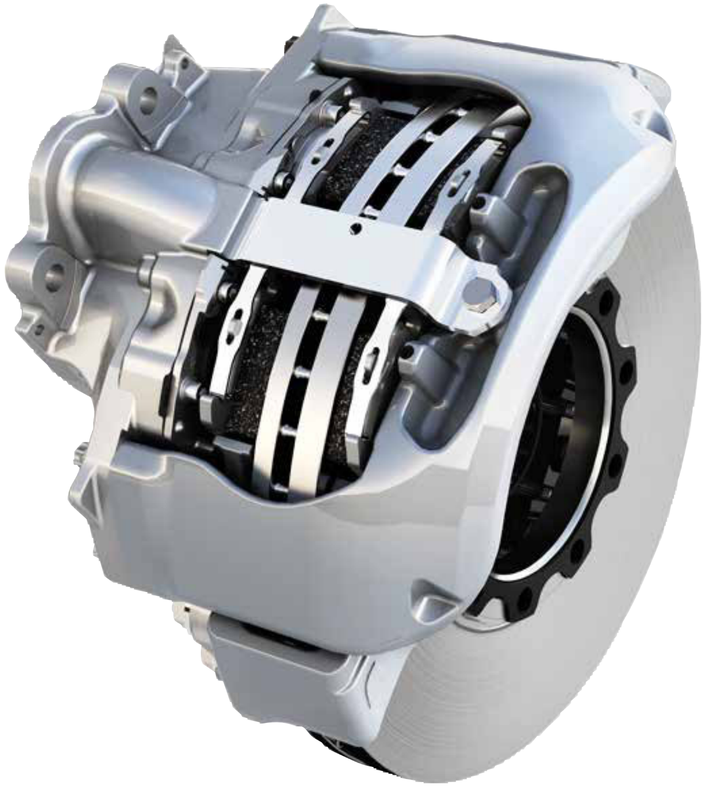
Foundation and parking brake systems

The systems mentioned above exist and work together to supply the proper amount of controlled air pressure to actuate the vehicle's foundation brakes, 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



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

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. Automatic Brake Adjustors (ABA) 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 back the spring brakes, 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.

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CHAPTER 3

SAFER DISC BRAKES CAN HELP WITH DRIVER RETENTION, EXPERTS SAY

By Tom Quimby

When it comes to weighing the pros and cons of drum and air disc brakes, experts point out several factors like maintenance requirements, brake performance, ROI and—perhaps more importantly than ever—driver preference.

"Along the lines of liability, certainly the shorter stopping distance helps prevent accidents," Bendix wheel end director of marketing Mark Holley said of air disc brakes, "but you've also got straighter or more controlled braking so that helps keep the truck in the lane, and so the side benefit is driver satisfaction and driver retention because if they know they've got a better performing brake, it gives them peace of mind."

> **Along the lines of liability, certainly the shorter stopping distance helps prevent accidents.**
>
> **Mark Holley**, Bendix wheel end director of marketing

Joe Kay, front drivetrain engineering director at Meritor, also noted the increased appeal of air disc brakes among drivers.

"Some fleets report that spec'ing air disc brakes can help with the crucial issue of retaining drivers," Kay said. "Reduced brake-to-brake variation and more linear torque output offers ride and handling characteristics that are closer to that of a passenger car. Plus, the improved ride and handling can instill increased driver confidence in the brake system."

Drivers, too, will feel the immediate response of air disc, compared to drum style brakes as air disc technology has consistently delivered brake applications with greater power and reduced stopping distances, said Hakan Sutluoglu, Silverback HD Marketing Manager.

"This results in safer vehicles with less stress for drivers," he said, "along with a work environment that is more comfortable and sustainable for these road warriors operating in today's high-volume traffic."

A Wabco Solution Center article pointing out the advantages of air disc brakes over drums states that, "Comfortable, confident drivers are the key to increasing uptime and improving safety. The confidence provided by shorter braking distances, and the 'car-like feel' that drivers report with ADBs can help reduce fatigue and improve driver response and performance."

When it comes to roadside inspections, drivers can breathe a little easier thanks to a major design difference between disc and drum brakes.

Commercial vehicle inspectors sidelined approximately 4,300 trucks across the U.S., Canada and Mexico for brake-related violations as part of the 2021 Commercial Vehicle Safety Alliance's Brake Safety Week. The out of service rate related to brakes in the U.S. was 13.5% out of the 28,694 commercial motor vehicles inspected.

"One of the chief violations is brakes being out of adjustment," Keith McComsey, Bendix's director of brake actuators and adjusters, said. "That's something that the inspector can see or witness on the vehicle. With air disc brakes, because the adjustment mechanism is internal to the caliper, that's not something that could be visually looked at by an inspector. Therefore, they typically are able to eliminate the brakes being out of adjustment."

While the overall impact of disc brakes on driver recruiting and retention is not crystal clear, James Burg, president of James Burg Trucking Company in Warren, Mich., can see some dividends helping with driver satisfaction.

Air disc brakes, like this Bendix ADB22X, can help lure drivers looking for safer and more comfortable rigs.

"I can't measure driver turn-over based on disc brakes," Burg said, "but, (2020) was our only roadside violation for disc brakes since 2008. Anytime we can reduce delays/downtime it must improve driver perception of their job at the company…until they take it for granted. I certainly see a benefit from a cost perspective, which allows me to pay my drivers more and reduces turn-over."

UPS Public Relations Manager Dan McMackin said while driver satisfaction regarding disc brakes is unclear, "anything that improves the driving experience should also improve driver satisfaction, although in the scheme of things, I don't see brake equipment being an impediment to retention."

Jeff Jackson, executive vice president of operations at Penske Logistics said disc brakes and other safety features on their trucks are part of an overall approach that has helped driver recruiting and retention.

"Disc brakes are just one part of our company's safety-focused environment," Jackson said.

Shorter braking distances with disc brakes are a big win for drivers and fleets alike especially at a time of nuclear verdicts when carriers can be forced to pay tens of millions of dollars following an accident. It's then that every extra foot of stopping power can make all the difference.

McComsey said during Bendix' 60mph to zero brake tests, it takes a fully loaded tractor-trailer about 225 feet to come to a full stop with drum brakes. Disc brakes show a 12% improvement by reducing stopping distance to roughly 200 feet.

"So, it's about 25 feet shorter," McComsey said, "which is a fairly significant amount, especially when a driver really needs it."

Stopping distances with disc brakes get even better when drums become susceptible to a phenomenon called brake fade, McComsey explained, where the drum heats up, "expands away from the friction material" and reduces stopping power. That shorter 25-foot advantage that disc brakes provide can expand roughly three-fold when drums fall victim to brake fade.

"Some of our testing shows up to almost 75 feet (difference) when you include brake fade," McComsey said.

Burg said he made the switch to disc brakes in 2008. A regional flatbed carrier with more than 100 trucks, Burg said he uses Meritor and Wabco disc brakes in "typical 5-axle equipment and specialized 11-axle combinations."

In addition to the benefits noted above, Burg said he discovered two other reasons for using disc brakes which can help increase driver satisfaction: one addresses a frustrating and costly challenge that can occur in freezing climates and the other deals with the critical topic of wheel retention.

"In the winter, water can puddle at the bottom of drum brakes, which freezes the pad to the drum when parking brakes are set," Burg said. "If the brake shoes are left frozen to the drum while moving the equipment, tires can flat spot or even blow out. This does not happen with disc brakes since the pads are higher up on the rotor. Water migrates lower than the pads and does not freeze the components.

"The second and more important safety benefit is a wheel cannot depart the axle in a wheel bearing failure situation since the caliper rests over the rotor and will not allow a wheel departure," Burg continued. "The latter is certainly worth the initial investment."

Less service time, lower costs, better ROI

For carriers concerned about scaling back shop hours, air disc brakes offer a strong advantage in reducing service time over drums. Wear points such as pads and rotors can be more quickly checked and serviced with disc brakes versus shoes and drums.

Wabco takes a closer look at the differences in their blog "On the Road: The Real-World Advantages of Air Disc Brakes vs. Drum Brakes":

During a regularly scheduled lubrication, a service technician can take a look at each brake for pad wear and rotor condition and do an adjustment test. Additionally, the caliper can be inspected *for loose or missing caps, plugs, and mounting bolts. Savings: More up-time.*

When it is time for brake service, installing new pads on a drum brake system is usually a 10-step procedure that takes an average of 90 minutes. Compare that to installing new pads on an ADB system – a nine-step procedure, that's usually substantially faster – as few as 30 minutes. Multiply the time saved by the number of wheels serviced, and the overall savings can be significant.

Savings through reduced service requirements can add up fast.

Many fleets have seen savings from extended air disc brake pad service intervals, compared to drum brake service intervals, and from eliminating the need to grease the brake system," Kay said. "There also is a marked advantage for the time it takes to service an air disc brake system. [For example] replacing brake pads on a vehicle with air disc brakes can be performed in less than half the time it takes to change brake shoes."

For fleets looking for a better idea on the cost differences between disc brakes and drums, Bendix recommends using their Value Calculator, an online reference tool that uses fleet data to show potential cost and ROI differences between discs and drums.

In a summary example, Bendix shows a fleet getting a 32% lifecycle cost decrease with discs over drums. Though disc brakes can incur higher upfront costs, the benefits of reduced maintenance costs have disc brakes coming out ahead.

Kay pointed out that ROI with disc brakes is coming faster as product costs continue to come down along with weight.

"Increasing demand, higher levels of manufacturing automation, and new brake designs targeted at the North American market are reducing air disc brake acquisition costs for fleets," Kay said.

"Meritor's newest air disc brake systems are 10 pounds lighter than its previous models and now weigh about the same as drum brakes, effectively negating the weight advantage of drum brakes," Kay continued.

A good fit?

Depending on the application, some carriers may still want to opt for drum brakes like in cases where braking is less frequent.

"We really want as much adoption as possible to air disc brake because of the performance and everything we talked about, but there's still going to be some applications out there that are going to prefer drum and that's perfectly fine with us because we offer a full line of drum brakes," Holley said.

"An example might be intermodal chassis right where that upfront cost to those fleets is very important," Holley continued. "They want it very low cost. And these chassis tend to be flung out there across the country, and they have a hard time keeping track of them so they don't want to put a ton of investment into those chassis."

Meritor also offers a variety of brake systems to fit a wide range of fleet needs.

"We recommend that fleets evaluate their duty cycles and lifecycle costs in determining the right brake package for their fleets," Kay said. "Fleets should also make sure they are choosing the right brake for their operation from both maintenance and performance perspectives. As you know, air disc brakes are best suited for trucks and trailers and vocations making frequent stops."

"Since air disc brakes also have less brake-to-brake variation during emergency stops, when trucks are moving at fast speeds, the ability to stop quickly, maintain control and provide the operator confidence is key," Kay continued. "The primary benefit of air disc brakes is increased safety, so when you must rely on your brakes in tough situations, air disc brakes should always be considered."

Though the question occasionally comes up, particularly among owner-operators, brake manufacturers do not recommend swapping out drum brakes for discs. The increased cost and complexity, McComsey said, wouldn't be worth it. However, for fleets that hold onto to their trailers for years on end, the challenging swap may be worth it.

"The only time I could see that really being feasible is if they're refurbing the entire trailer," McComsey said. "Some of these trailers, like aluminum flatbeds and tankers, the fleets keep them for 15, 20 years. And so they'll go through a refurb where they replace the entire suspension bogey and they'll buy that new from somebody. That would be the time to say, 'I could make that switch and account for that and make my vehicles safer.'"

Bendix-Value-Calculator - The Bendix Value Calculator uses fleet data to show potential costs and ROI for air disc brakes versus drum brakes on tractors and trailers.

Drum vs. ADB Summary

Tractor Drum vs. Air Disc Brake Summary Costs				
Drum			ADB	
Unit Cost	Total Fleet Cost		Unit Cost	Total Fleet Cost
$ -	$ -	Initial Purchase Cost	$2,500.00	$2,500,000.00
$ -	$ -	Residual Value @ Trade-In	$500.00	$500,000.00
$ -	$ -	Estimated Impact on Safety	$126.00	$126,000.00
$1,560.00	$1,560,000.00	Estimated Replacement Maintenance Cost	$825.00	$825,000.00
$2,040.00	$2,040,000.00	Continuous Maintenance Cost	$ -	$ -
$185.25	$185,250.00	CSA Related Costs	$ -	$ -
$181.00	$181,000.00	Rust-Jacking Costs	$ -	$ -
$3,966.25	$3,966,250.00	Total	$2,699.00	$2,699,000.00

ROI	
ROI over Lifecycle (per Unit)	$1,267.25
ROI over Lifecycle ($)	$1,267,250.00

RP 652 **VMRS 013-013-000**

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.

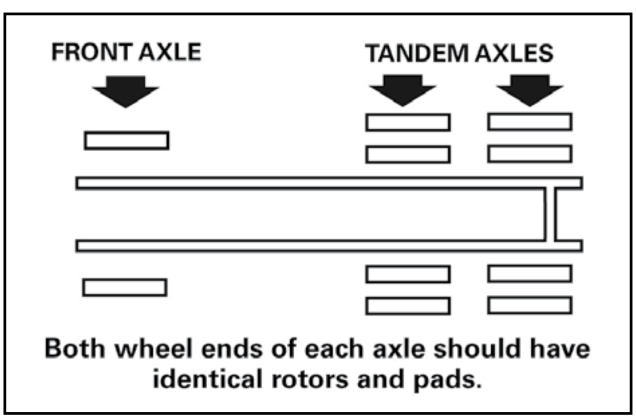


Figure 1

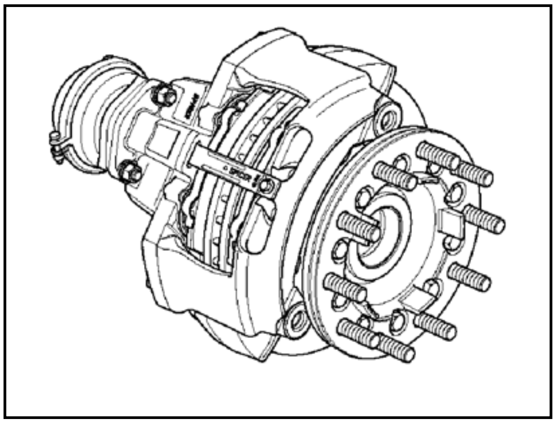
1.2 BRAKE PADS
⚠ **DANGER**: Although the majority of the brake linings used in the U.S. and Canada today are asbestos-free, the utmost precautions should be taken to eliminate unnecessary exposure to any brake dust from new or used lining materials. There is no easy way to visually identify asbestos-containing 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*.

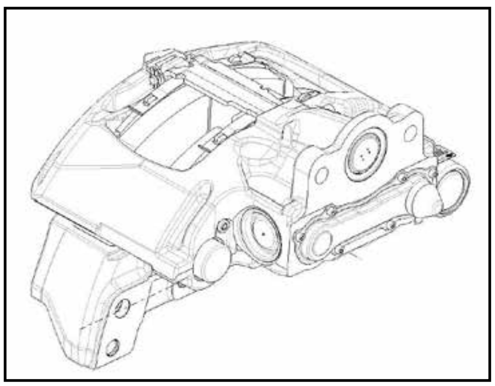
Pad thickness should be the same for each pad and on each side of the axle. Some consideration should be given to pads with various performance enhancing profiles.

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-



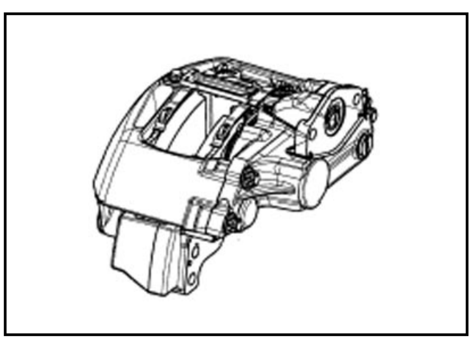
Type I—Internal Lever with Internal Automatic Adjustment (Bendix I - 2002 to present)

Figure 2



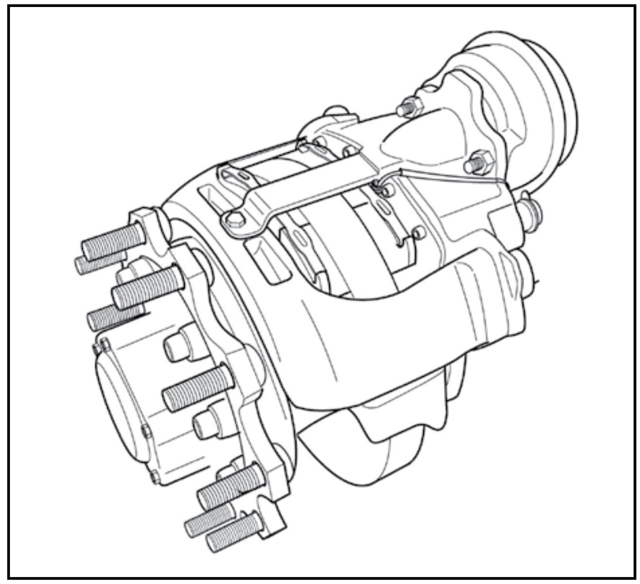
Type II—Internal Lever with Internal Automatic Adjustment (Dana & Bendix II -1994 to present)

Figure 3



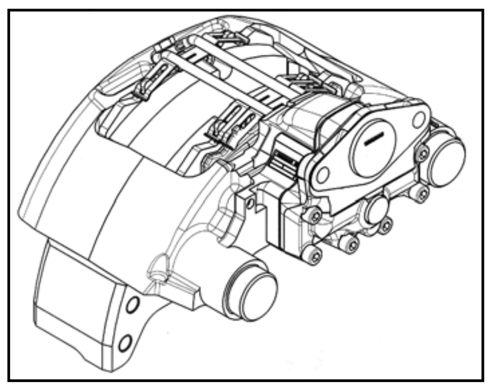
Type III—Internal Lever with Internal Automatic Adjustment (Haldex – 2002 to present)

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)

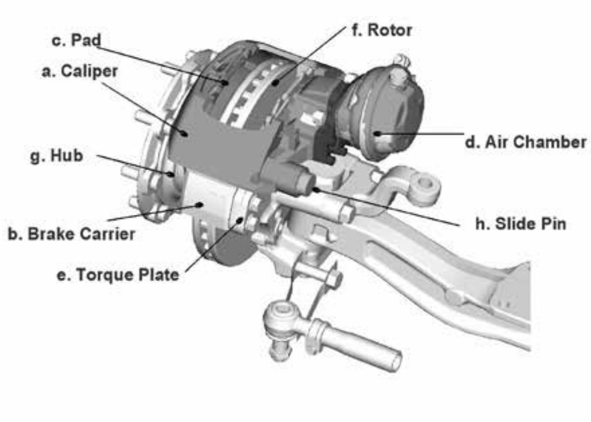
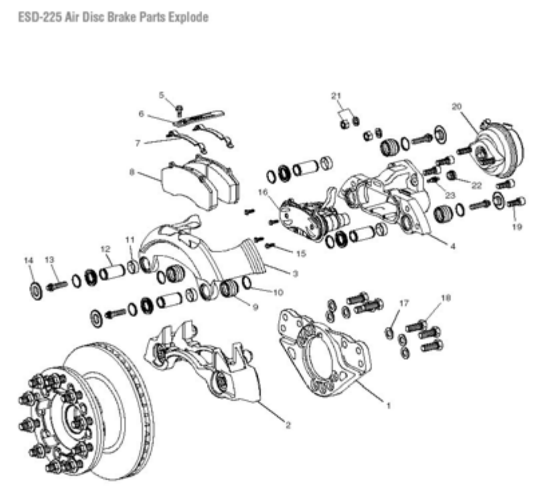


Figure 7

2.1 SPECIFIC AIR DISC BRAKE COMPONENTS FOR EACH BRAKE TYPE

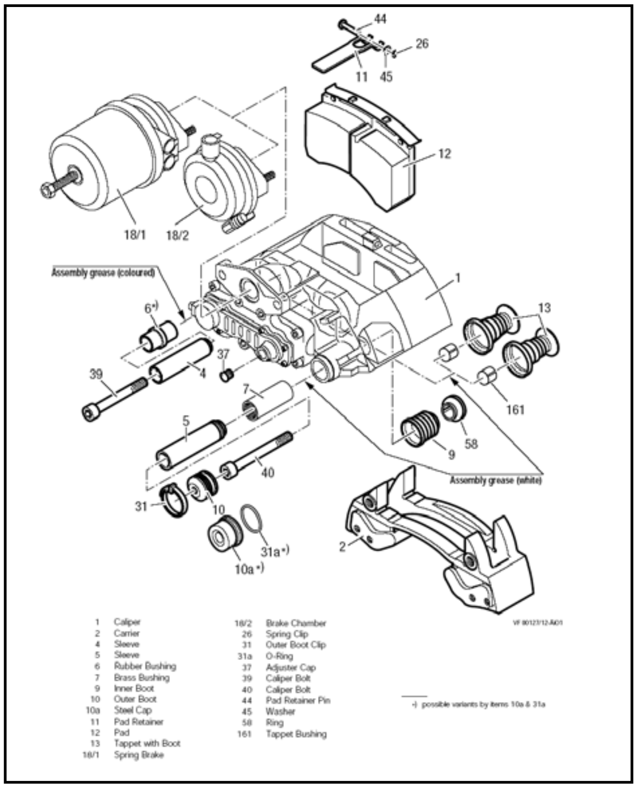
A detailed schematic is provided for air disc brake Types I-V in **Figures 8-13**.



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

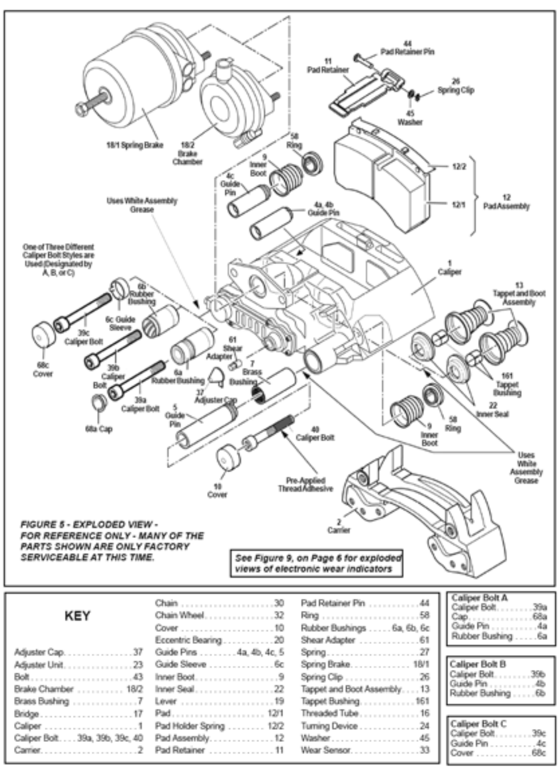
Item	Description Number
1	Torque Plate
2	Frame
3	Caliper Bridge
4	Caliper Housing
5	Retaining Bar Screw
6	Pad Retaining Bar
7	Pad Retaining Spring
8	Pad (Lining)
9	Slider Boot
10	Boot Retaining Ring
11	Slider Bushing
12	Slider Pin
13	Slider Pin Bolt
14	Slider Pin Cap
15	Adjuster Mounting Screw
16	Actuator 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



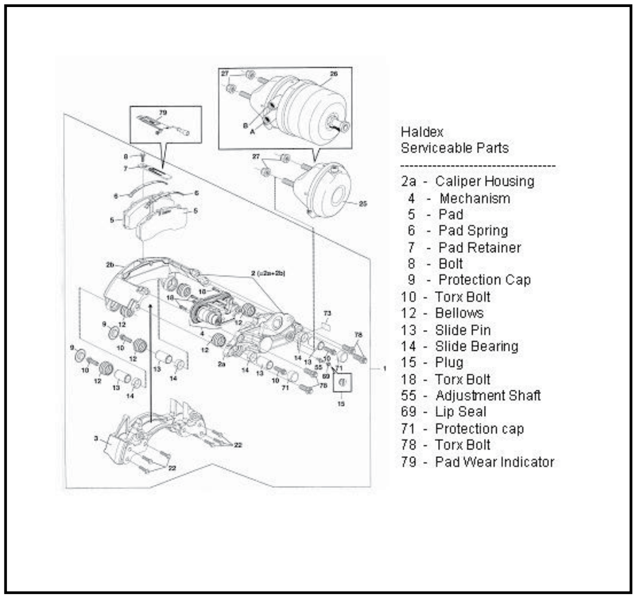
Type IIa: Bendix SB-Series Air Disc Brake

Figure 9



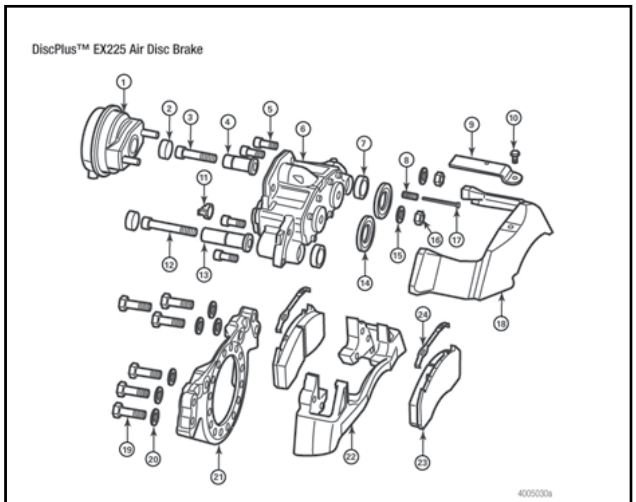
Type IIb: Bendix SN & ADB225™ Air Disc Brake

Figure 10



Type III: Haldex Air Disc Brake

Figure 11



Item	Description	Item	Description
1	Air Chamber	13	Long Slide Pin
2	Slide Pin Cap (2)	14	Piston Boot (2)
3	Short Slide Pin Bolt	15	Air Chamber Washer (2)
4	Short Slide Pin	16	Air Chamber Nut (2)
5	Bridge Bolt (4)	17	Visual Wear Indicator
6	Caliper Housing Assembly	18	Bridge
7	Slide Pin Boot (2)	19	Carrier Bolt — EX225L (4), EX225H (5-6)
8	Visual Wear Indicator Spring	20	Washer — EX225L (4), EX225H (5-6)
9	Pad Retainer	21	Torque Plate
10	Pad Retainer Bolt	22	Carrier
11	Adjuster Cover	23	Brake Pad (2)
12	Long Slide Pin Bolt	24	Pad Spring (2)

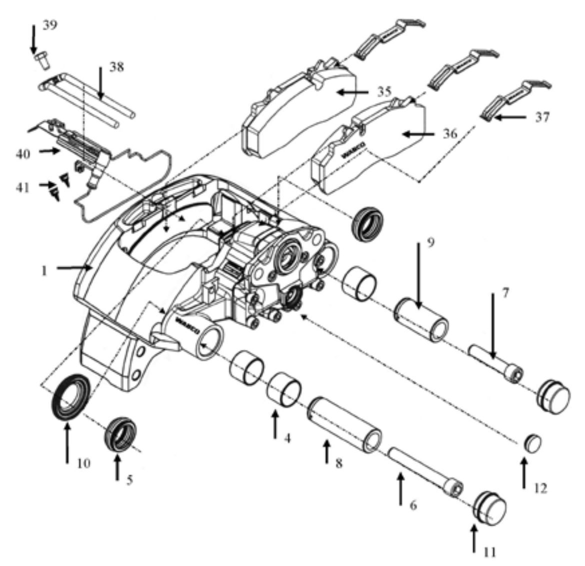
Type IV: Meritor Air Disc Brake

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**.

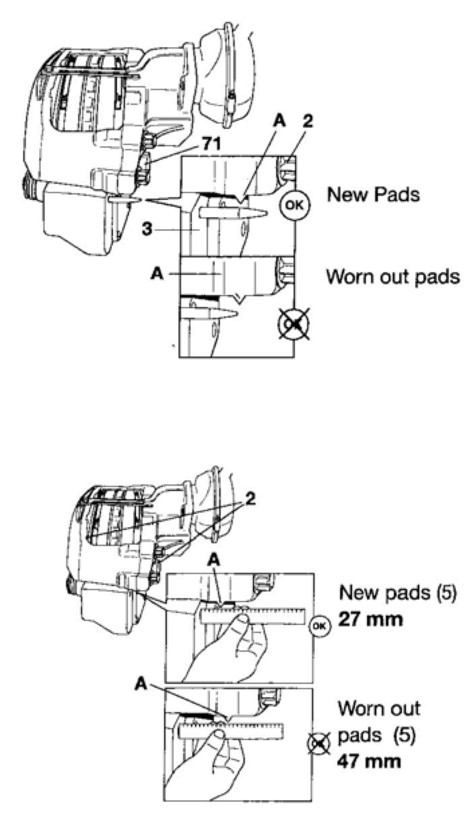


Figure 14

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**.
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.

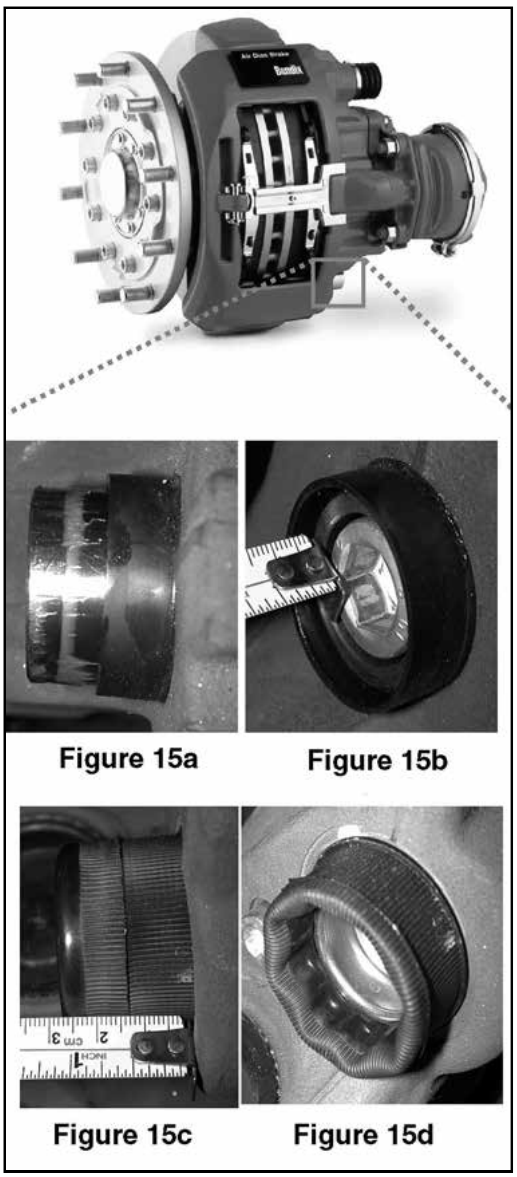


Figure 15

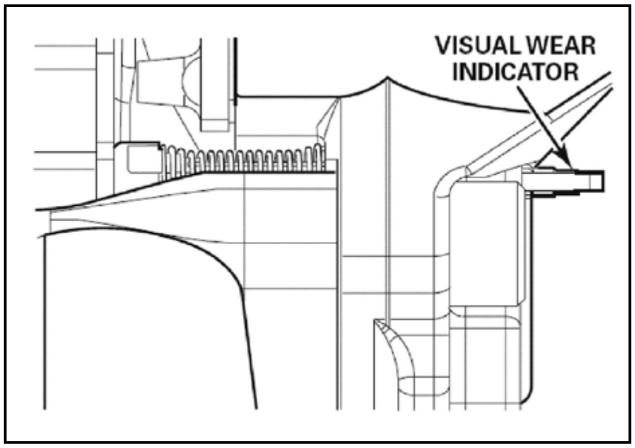


Figure 16

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.

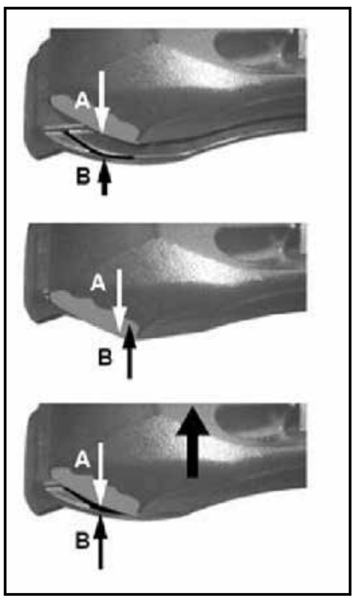


Figure 17

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

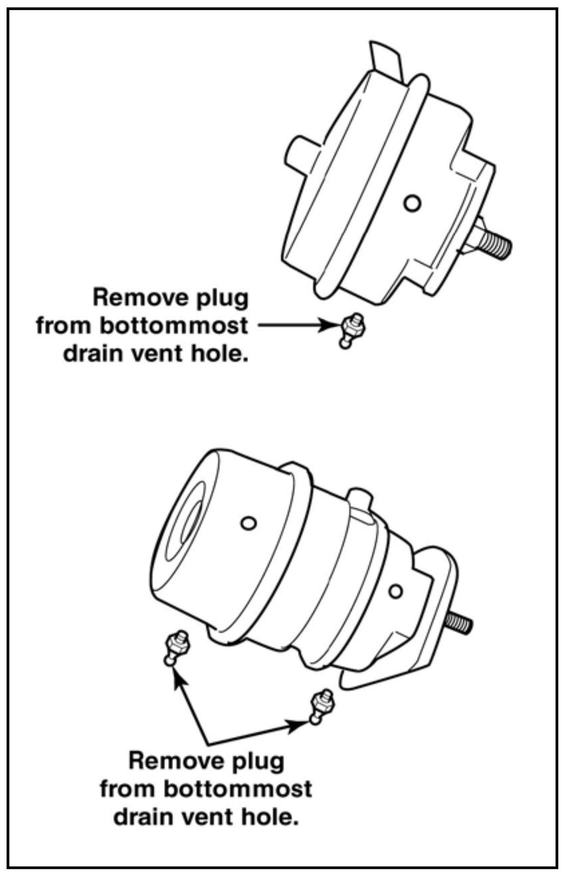


Figure 18

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**.)

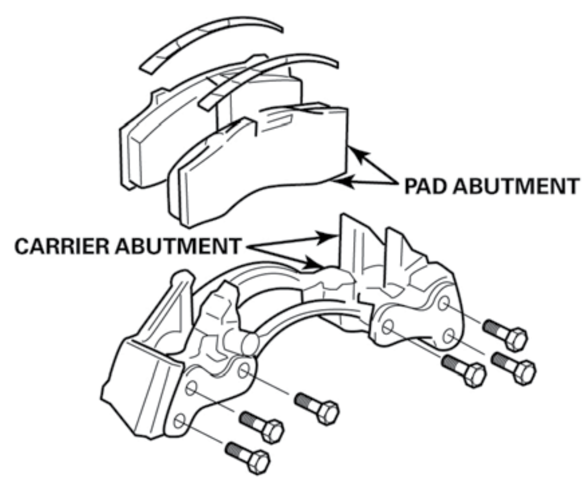
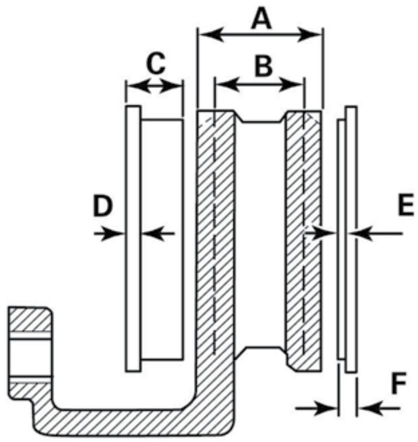


Figure 20

- 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.

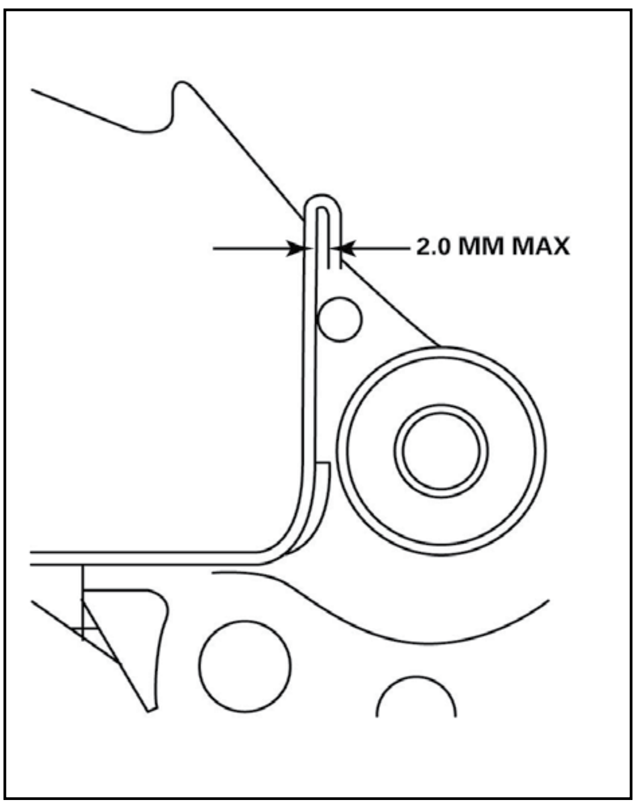


Figure 21

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

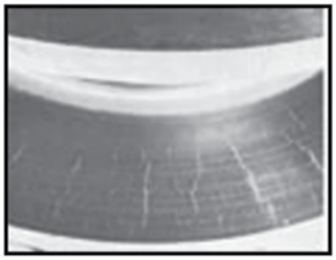
- Cracks—When the crack extends through a section of the rotor, replace the rotor.

  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.

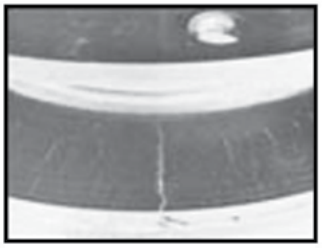
- Heat checks—Heat checks are short, thin, sometimes numerous, radial interruptions of the rotor braking surfaces. They are the result of disc brake operation. They are caused by the heating and cooling that occurs as the brakes are applied time after time. Heat checks will frequently wear away and reform. 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

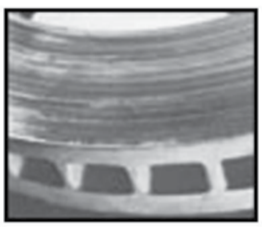
- The dimensions shown in **Figure 23** should help properly identify the correct replacement rotor for the brake used.



Example A1: Light Heat Checking

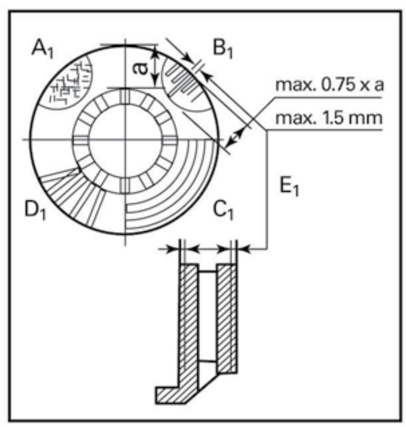


Example: B1/E1
Heavy Cracking greater than 75% of the Braking Surface Width



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%

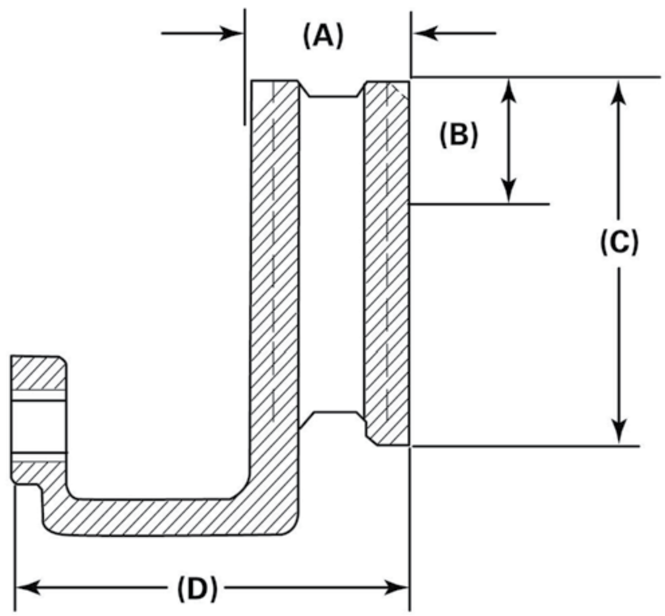
Figure 22

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.
- 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.

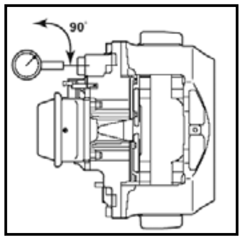


Figure 24

- 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**.)
- 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.

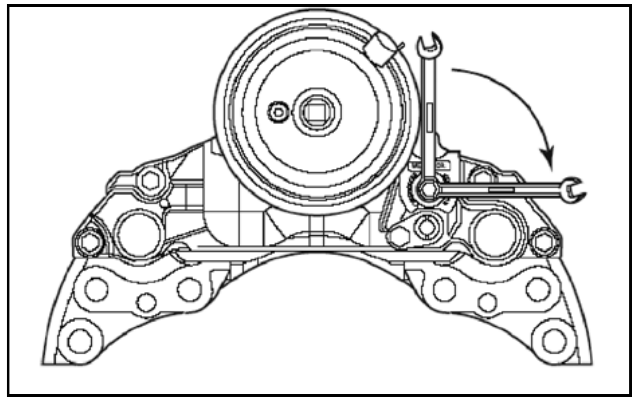


Figure 25

- 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.

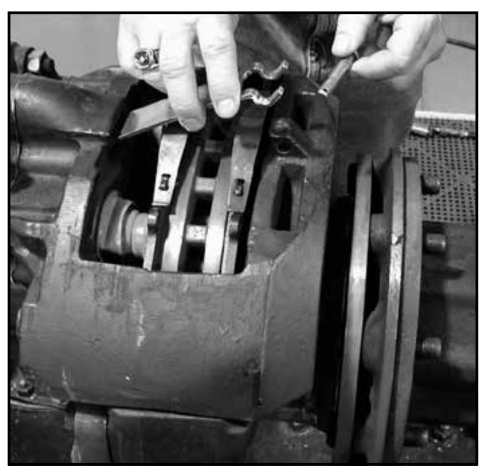


Figure 26

- 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.

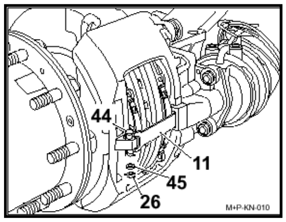


Figure 27

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.

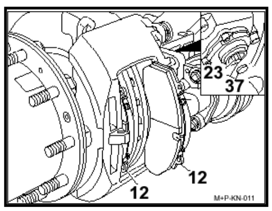


Figure 28

- If boots are damaged, they should be replaced.

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

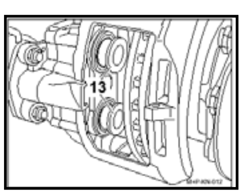


Figure 29

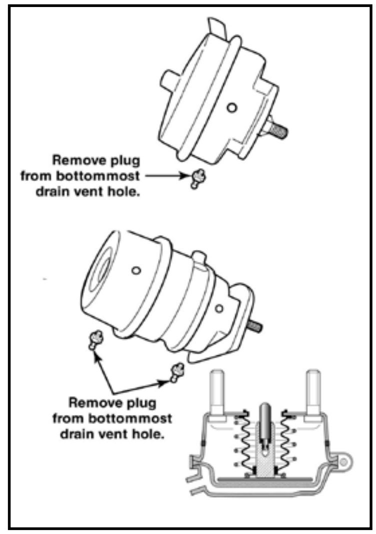


Figure 30

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.

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.

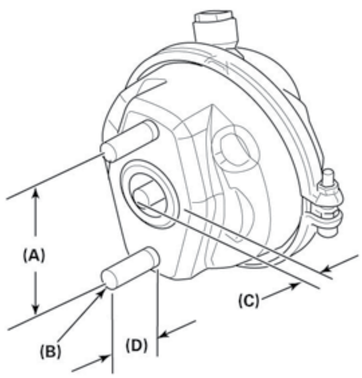
- Air disc brake chambers are different than drum brake chambers. Air disc brake chambers have an external seal and an internal boot to prevent contaminants from entering the caliper.

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		5/8"-11 UNC			
Bendix II		*M16x1.5*			
Haldex	*120.7+/–0.25* 4.75+/–0.009	*M16x1.5* 5/8"-11 UNC	*15+/–0.5* 0.59+/–0.019	*180-200* 135-150	*43* 1.69
Meritor		*M16x1.5*			
WABCO		*M16x1.5* 5/8"-11 UNC			

Figure 31

CHAPTER 4

DEFINING THE DRIVER'S ROLE IN BRAKE MAINTENANCE

By *CCJ* Staff

During the Commercial Vehicle Safety Alliance's three-day International Roadcheck last year, 6,710 commercial vehicles and 2,080 drivers we placed out of service for various violations and brake system violations (26.5%) were the leading cause.

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," said 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 equipment, floats and flatbeds may need more time."

Regardless of how long the inspection takes,

> **Experienced drivers become very aware of a vehicle's performance, and any change in stopping characteristics – including soft pedal, pulsation, pulling or excessive noise – are indications to have the vehicles brakes inspected by a qualified professional.**
>
> **Neil Ross**, Silverback HD Product Manager

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]," said 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," said Taki Darakos, vice president of vehicle maintenance & fleet services at PITT OHIO. "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 said. "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 said.

Transervice, where Darakos' served as Vice President of Maintenance before joining PITT OHIO, 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 said. "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 now standard with truck OEMs, but are still a premium investment over drums (generally well under $1,000). However, they offer reduced maintenance costs if they are maintained adequately.

"They're not indestructible," he said. "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."

As fleets transition from one friction type to another – namely from drum to disc – Silverback HD Product Manager Neil Ross said training technicians on the new equipment is paramount.

"Technicians should be performing wheel-off inspections every four months on a highway application and quarterly on a severe duty application," he said. "There are a host of online resources available from various manufacturers as well as quality aftermarket websites."

Post-trip inspections

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

"[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 said. "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 an officer 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 said. 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."

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

"Lighting is important," he said. "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

Having maintenance personnel regularly participate in driver safety meetings, detailing any truck spec changes and setting up equipment to guide drivers through pre- and post-trip inspections, can pay quick and large dividends.

"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 said. "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."

Darakos has before set a fault in the truck and walked 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 said.

Driver training is one of the biggest keys to dropping CSA violations, said Fallon, who advises fleets to get copies of CVSA's Out Of Service Criteria 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 said. "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 measuring 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 said.

Part of training, Darakos said, 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 said. "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 said 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 said. "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."

Frolick said the company's 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. Drivers also go through two mandatory safety meetings a year. A TransPro 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 said. "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."

When a driver performs poorly, fleets don't have an issue meting out punishment. But Frolick said 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 said.

Offering financial buy-in to the drivers saves far more than it costs in the long run, Frolick said. While inspection bonuses are independent of the company's safety awards, Frolick said 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 said 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 said 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."

Inside the 20% rule: Out of service brake adjustment, other violations – and how to prevent

By Todd Dills

Looking at the landscape for commercial truck inspections, Pennsylvania-based former local-department officer and long-certified DOT inspector Andy Blair sees plenty missed opportunities when it comes to troopers helping truckers with out of service violations. All too frequently, violations that put an owner-op or other driver out of service simply aren't explained at the point of inspection. Too many trucking companies large and small don't invest in the Commercial Vehicle Safety Alliance out-of-service criteria handbook, the only place you'll find those criteria in all their minutiae, according to Blair.

If 20% or more of a vehicle's brakes are out of adjustment by a quarter-inch or more, the vehicle is placed out out of service, and you can also get there with a series of "half brakes," where a brake is just 1/8-inch out of adjustment.

Kansas Highway Patrol trooper and Public Information Officer Nick Wright emphasized "the 20% rule is calculated on all brakes on the combination as it comes to us, meaning at the time of inspection," he said. On a typical five-axle tractor-trailer combination, "it takes two brakes – however you get there" – to put a combination out of service. "All vehicles that contribute to the 20% must be declared out of service."

Wright gave the example of a set of triples with "a lot of brakes and six different units" undergoing a Level 1 inspection:

In such a case here's what the inspector would be looking at:

- **Truck-tractor – 6 brakes**
- **Semi-trailer #1 – 2 brakes**
- **Dolly convertor #1 – 2 brakes**
- **Semi-trailer #2 – 2 brakes**
- **Dolly convertor #2 – 2 brakes**
- **Semi-trailer #3 – 2 brakes**
- **Total: 16 brakes.**

The 20% out of service criteria for adjustment alone would "kick in at four defective brakes," Wright said, whether "four full brakes, eight half brakes or two full and six half, etc."

Each unit that contributed to the 20%, meaning any unit with any single 20% brake defect, must be declared OOS, Wright said. "In this scenario, let's say we had one brake on the tractor in violation (full brake), and one on each trailer (full brake). That would put the truck and all three trailers OOS, but not the dolly convertors."

If you change the scenario and say all four are on the tractor, "then just the tractor is out of service," he added. "Ultimately, what I'm trying to point out is we calculate the 20% on the entire combination. We don't do 20% on each unit."

CHAPTER 5

STEP-BY-STEP AIR BRAKE INSPECTION

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 on jobsites 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 in which failure could be eminent.

Experts recommend you inspect the air brake system as an entire entity at one time, starting at the front and systematically working your way to the back of the vehicle. Since clean air – and a large supply of it – is the 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 the engine 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 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 with worn rings can introduce oil into the brake system and 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.

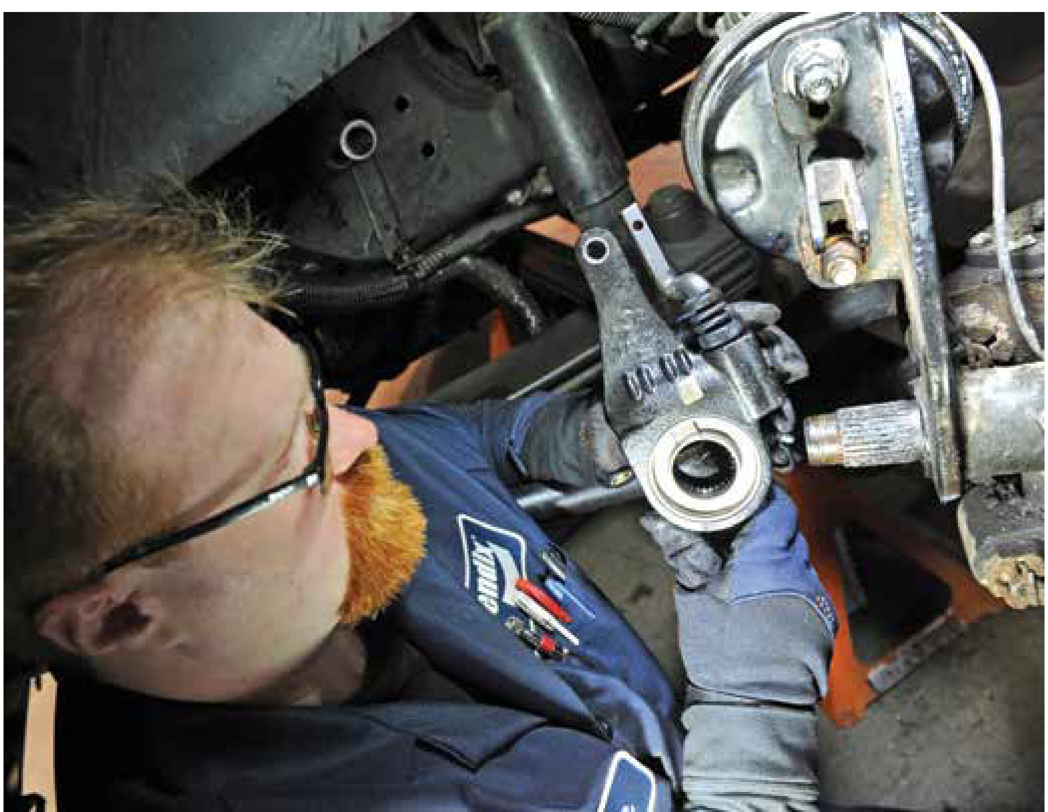
Leaks and adjustment

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 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 properly applying and releasing. 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 end 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 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 cause damage to components. To determine power stroke, start the engine, build reservoir pressure to between 90 and 100 psi and 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 take 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 permissible to adjust manual slack adjusters to obtain the proper free and power strokes, adjusting auto-

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 its unavoidable, 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 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.

matic slack adjusters is not allowed. 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 proper stroke, 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, 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.

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. You should never allow a vehicle to leave your shop with a 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 and cause damage to other vehicle components and/or result 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 its strength and capacity. 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. 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 during 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 component damage.

Don't skip the hoses and tubing

Brake hoses and tubing are critically important to the performance of the entire braking system, so it's important that these components be in good shape and free of kinks, said Brian Screeton, Bendix supervisor – technical service training.

"Visual inspections should also include regular checks of tubing and hose condition, positioning, and connections, both during pre-trip walkarounds and in the shop," he said. "Additionally, we recommend that before drivers get on the road, they routinely perform 90- to 100-psi brake applications – with the wheels chocked and the parking brakes released – listening for leaks that might be attributed to hoses and/or tubing."

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 bleed-offs, 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

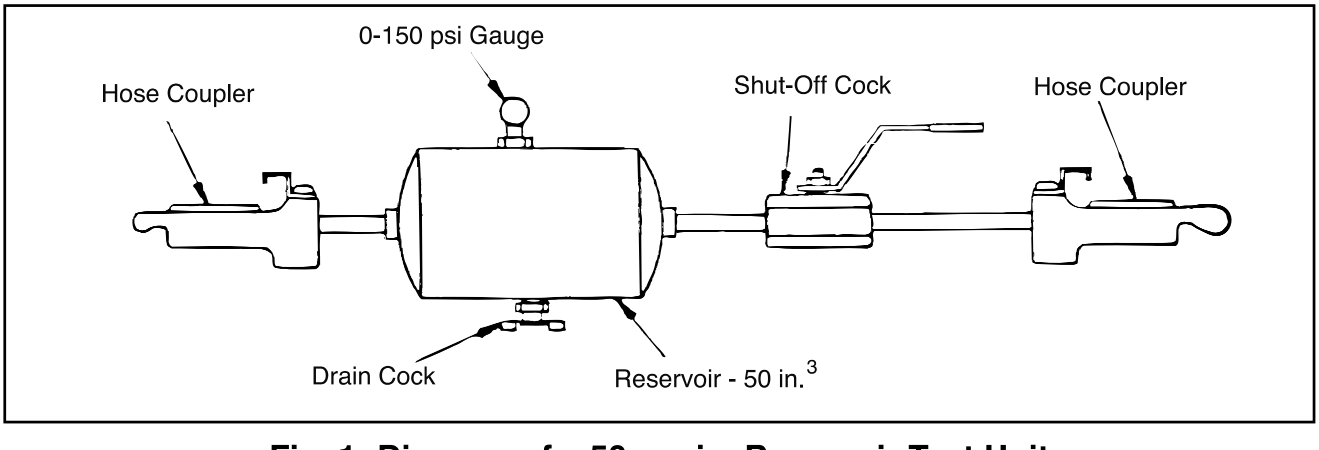


Fig. 1: Diagram of a 50-cu. in. Reservoir Test Unit

gladhands; open shut-off valves on test units, 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, fiber, 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.

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**

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

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

2022 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% 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

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.
- Clamp-type chamber adjustment limit:

– Type 20 (6 25/32-inch O.D.) J2899 Marking D = 1 3/4-inch stroke
– Type 24 (7 7/32-inch O.D.) J2899 Marking D = 1 3/4-inch stroke
– Type 30 (8 3/32-inch O.D.) J2899 Marking E = 2-inch stroke

Long-stroke, clamp-type chamber adjustment limit:

– Type 20 (6 25/32-inch O.D.) J2899 Marking E with 2.5-inch rated stroke = 2-inch stroke
– Type 20 (6 25/32-inch O.D.) J2899 Marking F with 3-inch rated stroke = 2 1/2-inch stroke
– Type 24 (7 7/32-inch O.D.) J2899 Marking E with 2.5-inch rated stroke = 2-inch stroke
– Type 24 (7 7/32-inch O.D.) J2899 Marking F with 3-inch rated stroke = 2 1/2-inch stroke
– Type 30 (8 3/32-inch O.D.) J2899 Marking F = 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% 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% 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 or a permanently and securely mounted item on the towing vehicle (e.g., bolted on hitching system).
- On any trailer equipped with spring brakes, more than 25% 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% of the friction surface and passes through the rotor or has cracks in the vents.
- A rotor surface is worn to or through center vents.
- Portion of drum/rotor missing or in danger of falling off.

Hose/tubing

- Damage extending into the reinforcement ply. Rubber impregnated fabric cover is not reinforcement ply. NOTE: A reinforcement ply is a braid or a spiral layer of fabric or steel.
- 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 pressure gauge

- Inoperative or defective primary or secondary air pressure gauge.

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

- Both 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 assembly has loose or missing mounting bolts or is not secured causing it to shift out of position.
- 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.

Air Brake Pushrod Stroke

Consider Keeping a Chamber Stroke Measurement Record

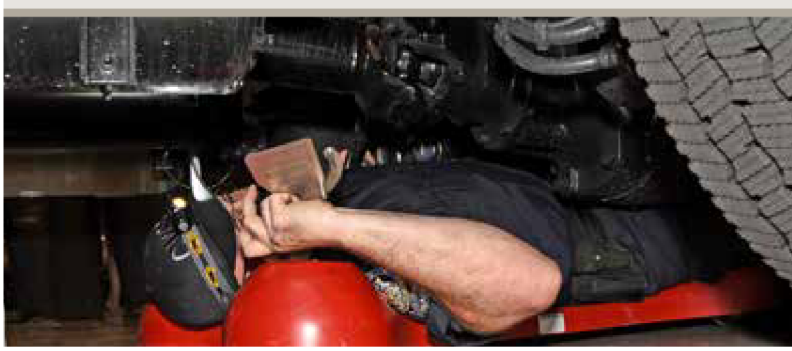
Many fleets and owner-operators have found success in preventing violations by tracking brake chamber stroke measurements at each wheel-end as part of their periodic maintenance programs. This involves recording pushrod stroke each time it is measured. *See Table 2.*

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.

Commercial Vehicle Safety Alliance

Air Brake Pushrod Stroke

Why is it so important?

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	F	9" (228 mm)	3" (76 mm)	2 1/2" (64 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.

Air Brake Pu

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:

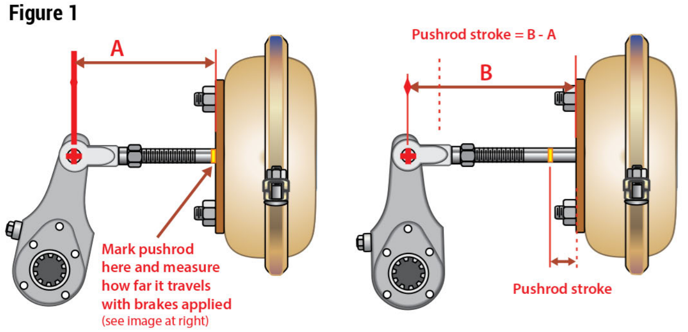
Step One – Ensure the vehicle is in a safe location and make sure the wheels are properly chocked to prevent rolling. Release the spring brakes. Confirm your dash gauge indicates 90 to 100 psi (620 to 690 kPa) supply pressure in the air brake system reservoirs. Then, shut off the engine. ***Note:***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

shrod Stroke

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 previoulsy 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).

CHAPTER 6

BRAKE ADJUSTMENT A TOP 5 TRUCK OUT OF SERVICE VIOLATION THANKS TO MISDIAGNOSIS AND IMPROPER SHOP PRACTICES

By Jason Cannon and Tom Quimby

They're called automatic slack adjusters for a reason, and the manufacturers that make them want to keep it that way.

Yet despite years of warnings, automatic slack adjusters (ASA) continue to be manually adjusted by technicians who may not know any better, or who may be eager to get a truck out of the shop and back out on the road.

"If a fleet is manually adjusting a slack adjuster regularly it can harm the longevity of the unit," warned Chris Christiansen, warranty/technical services coordinator, Accuride Corporation.

"The reasons behind adjusting an ASA outside of a brake reline should be investigated such as alignments, bushing wear, wheel conditions, etc.," Christiansen said.

Any drum or disc brakes that require manual adjustment at a time other than installation are not functioning properly and need to be serviced by a trained mechanic, noted Silverback HD Vice President of Operations Keith Roth. "Regular inspection to ensure that brakes are staying adjusted without human intervention is essential to any fleet maintenance PM," he added.

During last year's Brake Safety Week, 13.5% of the 28,694 commercial motor vehicles inspected were placed out of service for brake-related violations. With out of service brake violations continuing to top the annual CVSA International Roadcheck, manually adjusting an automatic slack adjuster can not only lead to more brake problems down the road, it can also lead to accidents.

Following their mandated use on tractor-trailers in 1994 and trailers in 1995, the NTSB issued a scathing report in early 2006 condemning the practice of regularly adjusting ASAs. NTSB ruled an ASA adjustment had led to a runaway truck accident in Pennsylvania in 2003 that claimed the life of the driver and an 11-year-old child riding in a car that the dump truck had struck during its descent on a steep downgrade.

That report, in part, reads: "The drivers and mechanics who manually adjusted the automatic slack adjusters on the trucks involved in the Glen Rock and El Cerrito accidents did not look for underlying problems with the adjusters or related foundation brake components; consequently, they misdiagnosed the brake problems, probably because they were not properly educated on the function and care of automatic slack adjusters and how they relate to foundation brake systems."

The NTSB went on to write that "warnings in existing materials available to owners, drivers, mechanics and inspectors of air-braked vehicles equipped with automatic slack adjusters have not been successful in communicating the inherent dangers of manually adjusting automatic slack adjusters to correct out-of-adjustment brakes."

That ruling eventually led to a mandate that led to a change to service literature on the topic of ASA adjustment.

"Automatic slack adjusters are just that – automatic," Roth said. "Having a functional slack adjuster that automatically adjusts free play clearance is not just about compliance, but rather it's about having a loaded vehicle stop safely."

Kraus noted ASAs should not be manually adjusted to correct excess brake stroke, as doing so is a dangerous practice when a brake is only out of adjustment or over stroke limitations," he said. "Excess stroke is an indication of component malfunction that manual adjustment cannot fix. Manual adjust-

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.

ment or de-adjustment shortens ASA life, except Meritor Stroke Sensing ASA due to its unique pull pawl design. A manual adjustment gives drivers false sense that everything is working correctly."

That sense false sense that everything is working correctly, Roth said, "is playing a dangerous game with safety."

Road and traffic conditions can easily cause excessive brake stroke in a short period of time depending upon travel circumstances, Roth added. "A brake that has excessive stroke can reduce a vehicle's stopping power to half or less of designed efficiency, causing extreme danger," he said.

Keith McComsey, Bendix Spicer Foundation brake director of marketing and customer solutions, said if a technician feels the need to adjust an automatic slack adjuster, it is because there is some other issue within the drum brake system that should be investigated.

"Automatic slack adjusters should not be manually adjusted in an effort to correct excessive pushrod stroke," he adds, "because this condition indicates that a problem exists with the automatic adjuster, with the installation of the adjuster, or with related foundation brake components, which manual adjustment will not fix."

There may be times, however, when manual adjustment is required — like during ASA installation and when brake repairs and overhauls, such as relines, are performed.

"Haldex does not recommend or approve manual adjusting of the automatic brake adjuster except for emergency purposes when the wheel-end brakes cannot be released by air pressure, and when routine brake/wheel-end maintenance is performed like a brake reline," said Randy Petresh, vice president of technical services, Haldex Brake Products. "In addition, manual adjustment will mislead diagnosis of wheel-end brake issues during troubleshooting investigations."

When manual adjustments are necessary, "never use an air impact wrench to adjust an automatic slack adjuster as this can damage the internal mechanism/adjuster," McComsey said. "Use of wrenches and sockets or ratchets is recommended."

Lubrication and greasing

Lubrication is a key maintenance component, and

McComsey noted there are two reasons to grease a slack adjustor.

"First, it protects the adjuster's internal gear sets, clutches, and other components from premature wear," he said. "Second, the action of forcing new lubricant into the ASA purges the old grease, along with any contaminants or water that have found their way in. Both support vehicle safety by maintaining the correct brake stroke and providing optimal stopping performance."

Cleaning the purge slot on the boot, and adding grease until the old grease is fully purged and you see new grease exiting the purge hole, McComsey said "is a requirement," but referred to "manufacturer's recommendations for lubrication of the adjuster, noting the suggested mileage, frequency and lubricant grade."

Roth added camshaft and bushings should also be greased.

A grade 2 lubricant endorsed by the National Lubricating Grease Institute is recommended for preventive maintenance inspections on Bendix ASAs approximately every three months or 30,000 miles.

Tom Gauerke, national fleet account manager for Chevron Lubricants, noted that it's important to use a non-Moly grease on slack adjustors as the Moly can cause stickiness within the moving parts and the brakes to malfunction.

Techs should be careful not to over-grease, which Patrick Kealy, ZF North America OEM trailer business leader, CVCS division, warns can compromise seals and allow contaminants to enter ASAs and increase wear.

"Any time you've got a vehicle in the shop, it's also worth greasing the S-cam brake tubes and automatic slack adjusters," said Mark Holley, Bendix director of marketing and customer solutions – Wheel-End. "This quick process helps prevent rust and corrosion and helps keep the slack functioning properly."

Keeping brakes in check

During CVSA's three-day International Roadcheck last year, 26.5% of all vehicle out of service orders were the result of brake system violations. Brake adjustment (12.4%), was No. 4.

"The most common failure of an automatic slack adjuster is when a mechanic or a driver continues to adjust them," said Kealy. "They are automatic and therefore typically only need to be adjusted when they are installed for the first time or every time a brake job is performed."

However, ASAs may be targeted for OOS violations when other brake hardware is actually at fault.

"ASAs often get blamed during CVSA inspections for OOS conditions, but many times the other foundation components are worn down causing overstroke conditions." Jon Erickson, ASA product engineer, Gunite

"ASAs often get blamed during CVSA inspections for OOS conditions, but many times the other foundation components are worn down causing overstroke conditions," said Jon Erickson, ASA product engineer, Gunite. "Changing the ASA in this instance may allow the system to reset enough to be compliant. Replacing an ASA due to an OOS may get your vehicle back on the road but the other foundation components should be studied at the earliest possible convenience to verify the braking system is in acceptable condition."

ASAs have been in the market long before they were first mandated in 1994. For instance, Haldex rolled out its first U.S. version in 1980.

"The basic design has been very stable ever since that time except for continuous improvement initiated minor changes in material and processing like seal improvement," Petresh said. "The only significant change occurred about 10 years ago with the design, development and production of a new model, the self-setting automatic brake adjuster."

Like many other components that hit the market, ASAs were designed to improve safety and lower maintenance requirements for fleets.

"A truck owner had to make daily inspections or adjustments to the brakes before the automatic slack adjuster was implemented on trucks," said Eric Iott, product specialist, Meritor. "The inspection expense was large and the potential for error in the adjustment was much greater with manual adjustment slacks."

Regular maintenance and accurate troubleshooting remains key to a long, safe service-life devoid of OOS infractions.

Troubleshooting ASAs starts with a stroke test per "the CVSA to verify your brakes are out of adjustment," Kealy said. "After confirming other components in the foundation brake are working correctly (such as brake shoes, drums, S-Cam, S-Cam bushing, etc.), look at the ASA.

"Back off the brakes to check operation of the ASA," he adds. "Place a wrench on the adjustment screw and apply the service brakes. You should see the wrench rotate in a clockwise motion which indicates the ASA is taking up the clearance between the drum and shoe. Greasing the S-Cam spline and clevis pin should also be included as part of this maintenance and will help with ASA removal the next time."

Any time the clearance is excessive, or potentially too tight, is an indication the brake requires maintenance.

"One type of maintenance that is often overlooked by fleet maintenance programs is camshaft to bushing free play," Roth said. "Worn cam bushings with excessive wear and play often result in out of adjustment brakes. In addition, excessive cam bushing wear can often cause the lower brake shoe to drag on the drum, causing excessive wear, extreme wheel end heat and longer stopping distances. Often the ABA can be misdiagnosed as the problem when, in fact, the automatic adjuster may be fine. The camshaft and bushings requiring replacement can be the culprit."

And technicians should always follow manufacturer service requirements and instructions. If the ASA is diagnosed as faulty, replace it with a new one.

"It is not recommended to 'fix' an automatic slack adjuster," McComsey said. "If it is not adjusting properly, or has other damage to it, it should be replaced."

Don't smack the spider

Heat and a hammer have long been the recipe for removing an anchor pin but doing so may warp the spider. Heat removes the metal's temper, and hammering a hot spider will cause permanent distortion, reduced brake performance and abnormal wear. Bent spiders degrade lining-to-drum contact.

When removing anchor pins, don't heat the spider and try to hammer them out.

If you don't have a puller specifically designed to remove the pins, try dousing them with a light penetrating oil and give it time to work in before tapping them out as gently as possible.

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.

WHICH SHOES ACTUALLY COST LESS?

SilverbackHD new lined shoes with ceramic friction run cooler, last longer and deliver quiet, safe stops. Buying a relined shoe may save a few dollars upfront, but if your brakes do not last as long, you just wasted your money.

Outsmart your competition and buy the shoes that Outperform and Outlast!

WIN THE CHAMPIONSHIP, NOT JUST THE GAME!

SILVERBACK HD

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, ask 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 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. 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 pre-delivery 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.
- 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.

Recommended Practice

RP 609D **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. Self-adjusting brake adjusters are required on any vehicle manufactured on or after October 20, 1994 per Federal Motor Carrier Safety Administration regulation FMCSA 393.53. The National Transportation Safety Board (NTSB) warns that self-adjusting brake adjusters should not be manually adjusted in an effort to correct excessive pushrod stroke.

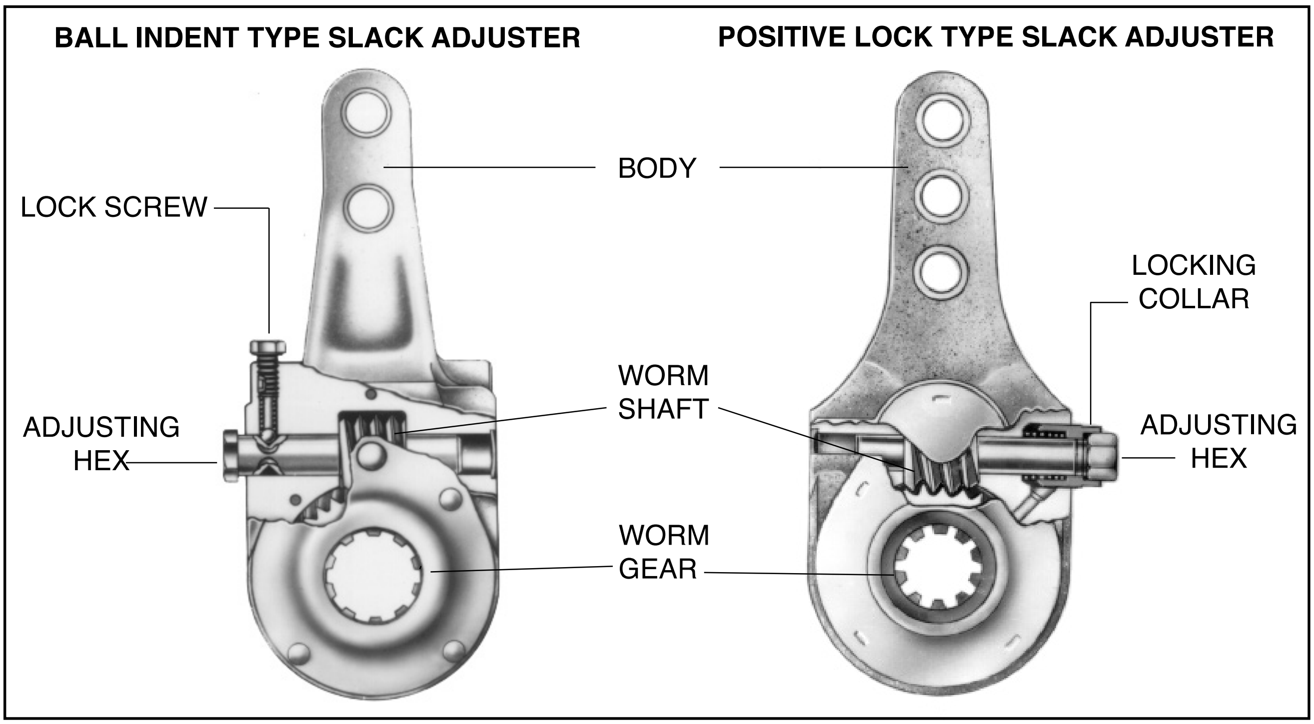


Fig. 1: Manual Brake Adjusters

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.

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. Manually adjusting self-adjusting brake adjusters at increased frequency beyond a brake change may prematurely reduce the life of adjusters.

BRAKE ADJUSTER REPLACEMENT

When replacing a brake adjuster, it is recommended that the replacement be of the same size as the original equipment. The changing chamber size or slack arm length should not be changed without properly consulting the OEM. All self-adjusting brake adjusters on a vehicle should be made by the same manufacturer. Mixing slack adjuster brands on an axle or across a vehicle is not recommended as it can cause alteration to braking performance and wear. 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).
- Threaded or welded clevis.
- Adjuster arm to link pin hole distance.
- 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

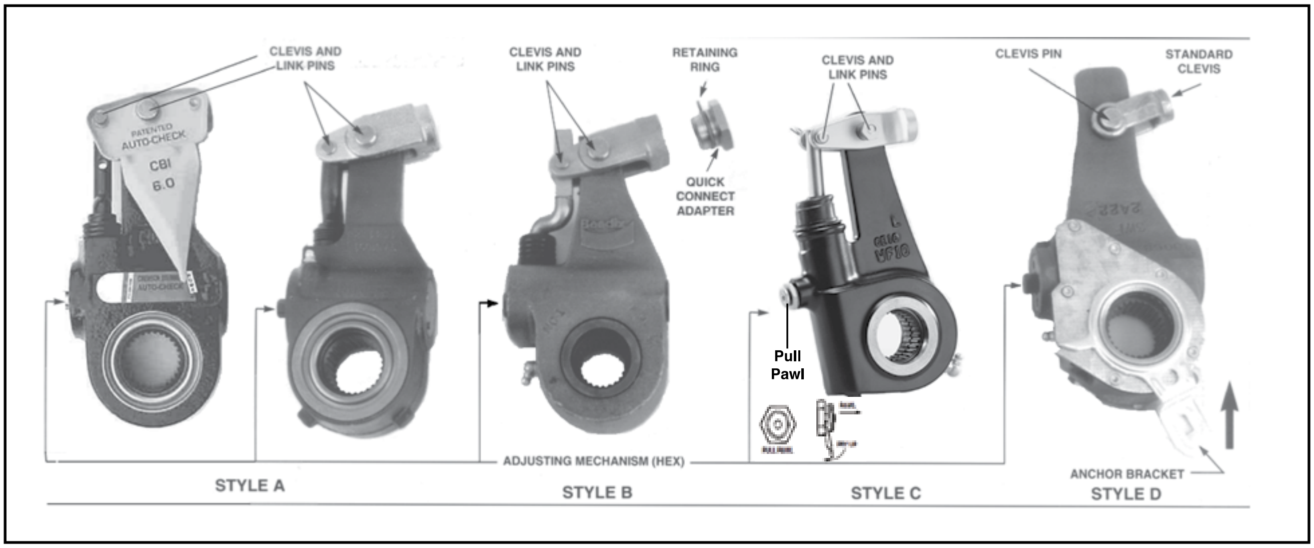


Fig. 2: Self-Adjusting Brake Adjuster Types

to shim it to between 0.005 inch (0.127mm) and than 0.060 inch (1.524mm) of end play.

5. Tighten the jam nut on the push-rod-to-clevis attachment (1/2 - 20 300-400 in. lbs. [33.9-45.2 N-m] to 5/8 - 18 400 in. lbs. [45.2 N-m]).
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**.

C. Self-Adjusting Brake Adjuster Removal—

1. Remove the clevis and link pins and the anchor bracket nut or pawl, if necessary (see **Figure 2**).
   a. Style A—Remove the clevis and link pins.
   b. Style B—Remove the clevis and link pins. Merely removing retaining ring quick connect yoke will not allow proper inspection of the clevis pins or housing bushing.
   c. Style C—Disengage 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.

   NOTE: For Style C, the ratchet pawl must be disengaged while backing the adjuster out of the clevis.

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. If a new clevis or style of clevis is required, 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.

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

b. Welded clevis usage to align with proper setup.

c. Clevis pin distances are 1.02", 1.3" and 1.38" and cannot be mixed.

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 0.005" (.127mm) and 0.060" (1.524mm) inch of end play.
7. Using the correct gauge or template, (see Fig. 2, Styles A, B, and C) check for the proper mounting angle.
   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.
8. Move the anchor bracket until the pointer is aligned with cut-out in the body of the slack, then secure all anchor bracket hardware.

   NOTE: Some adjusters in style D (see **Fig.2)** are self-setting and are not provided with a pointer or alignment cut-out. Follow the manufacturer's instructions for proper installation.

9. Tighten the jam nut. 1/2"-20 to 25-40ft-lb (33.9-54.2 N-m), 5/8"-18 to 35-50ft-lb (47.5-67.8 N-m).
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. Position a wrench or socket over the adjusting mechanism.

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

12. 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.
13. Reverse the rotation, backing the brake adjuster off one-half (1/2) turn.
14. Apply the brakes at 90-100psi for ~25 applications and measure the chamber power stroke at 90-100 psi brake application pressure as described in the previous section.

    NOTE: It may take an automatic adjuster up to 50 brake applications to find its final adjustment point at which point it should be measured. Taking the measurement directly after the 1/2 turn back-off will invariably return measurements that are out of spec.

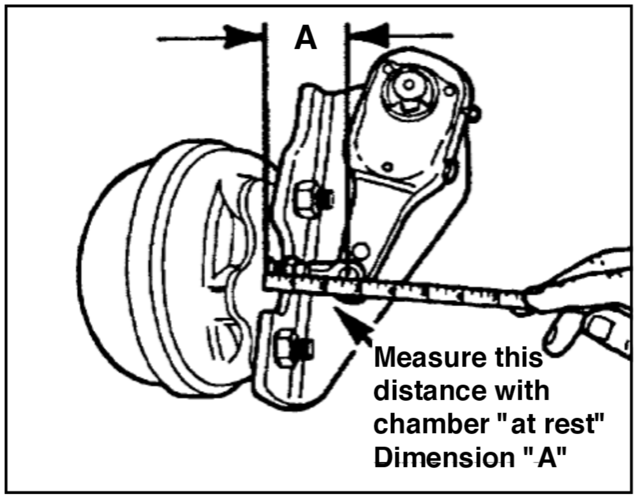


Fig. 3

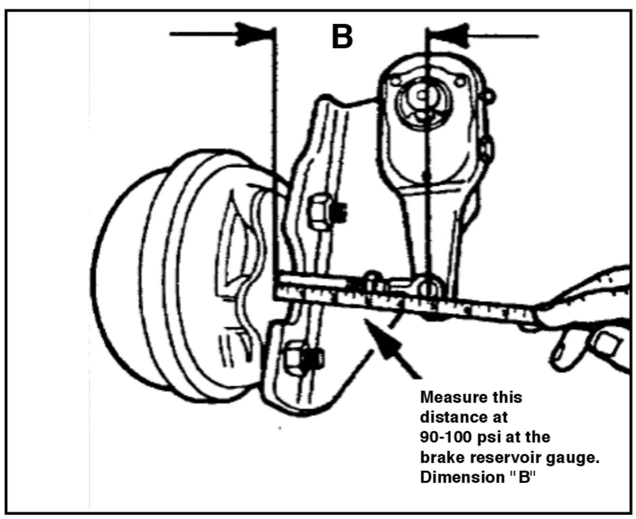


Fig. 4

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

15. 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

BRAKE ADJUSTMENT PROCEDURE

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

⚠CAUTION :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 until .015" feeler gauge can be inserted between the brake pad and drum over the entire brake pad surface; this is typically ~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 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.

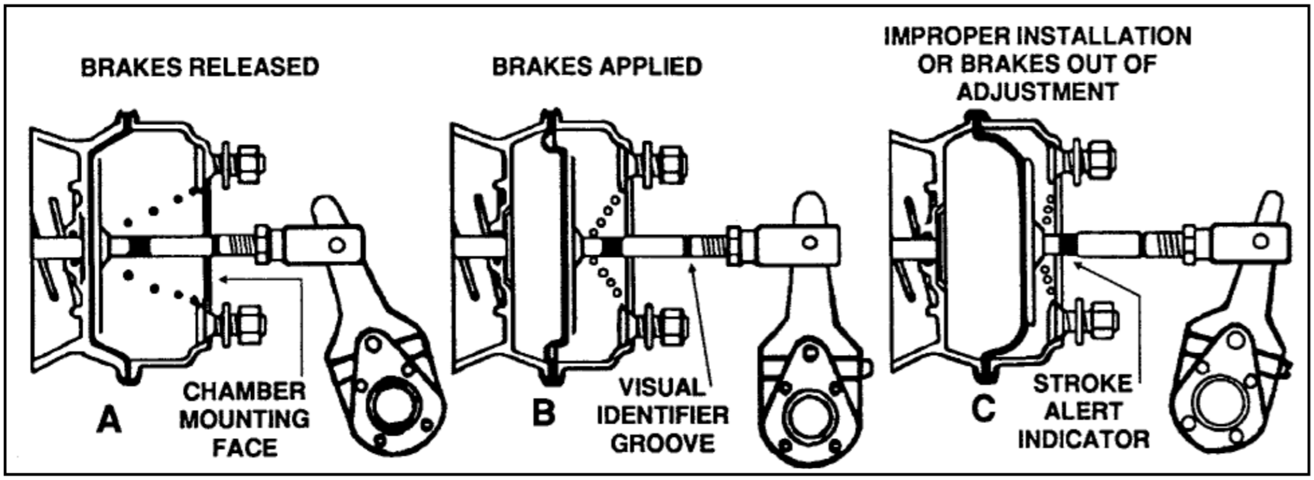


Figure 5

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**.

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

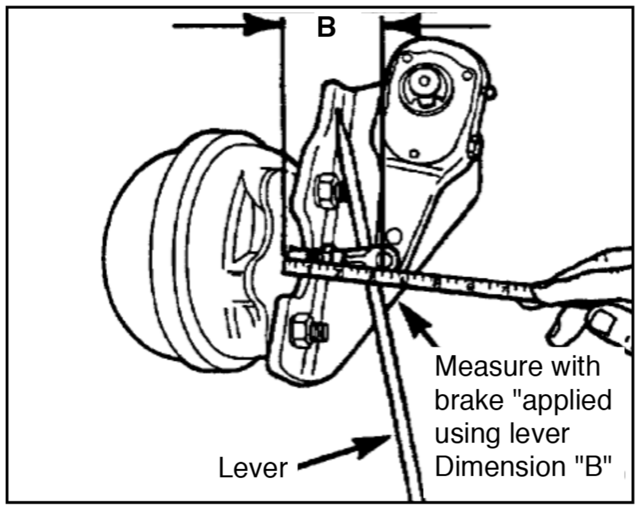


Figure 6

self-adjusting brake adjuster is equipped with a pawl, disengage the pawl with a pawl tool or flathead by prying up the cap for the brake adjustment and then properly reengage the pawl once adjustment is complete. 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. Reverse the rotation and back the adjuster off a small amount at a time and use a sheet of paper as a clearance check. After each back off, check to see if the paper can be inserted between the brake pad and drum. Stop backing off once the paper can be inserted across the entirety of both brake pad faces. Remove the paper after checking is complete.
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.

   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. Disengage 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). By prying up the cap with a pawl tool or flathead.
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 mechanism as follows (see **Fig. 2**):
   - Style A: Minimum 15 ft-lbs (20.3 N-m) counter clockwise (CCW)
   - Style B: Minimum 15 ft-lbs (20.3 N-m) CCW
   - Style C: Maximum 45 in-lbs (5.0 N-m) (CCW (pawl disengaged)
   - Style D: Minimum 13 ft-lbs (17.6 N-m) 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 and can lead to dragging brakes. Lubrication and inspection may be necessary at earlier, intervals due to different operating conditions.

CHAPTER 7

SELECTING THE RIGHT BRAKE LINING

By *CCJ* Staff

Photo courtesy of Silverback

In trucking applications, friction is the force that slows the vehicle. The brake system is the means by which that force is applied, but the brake lining is actually the component that bears the brunt of all the heat, weight, energy and force created during braking.

Brake manufacturers conduct 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," said 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 said, tests are conducted on peripheral characteristics such as lining squeal and vibration. In all, he noted, 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," said John Hawker, a retired consulting engineer that previously worked with Bendix and Dana. "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," explained 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 compound 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 noted. "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.

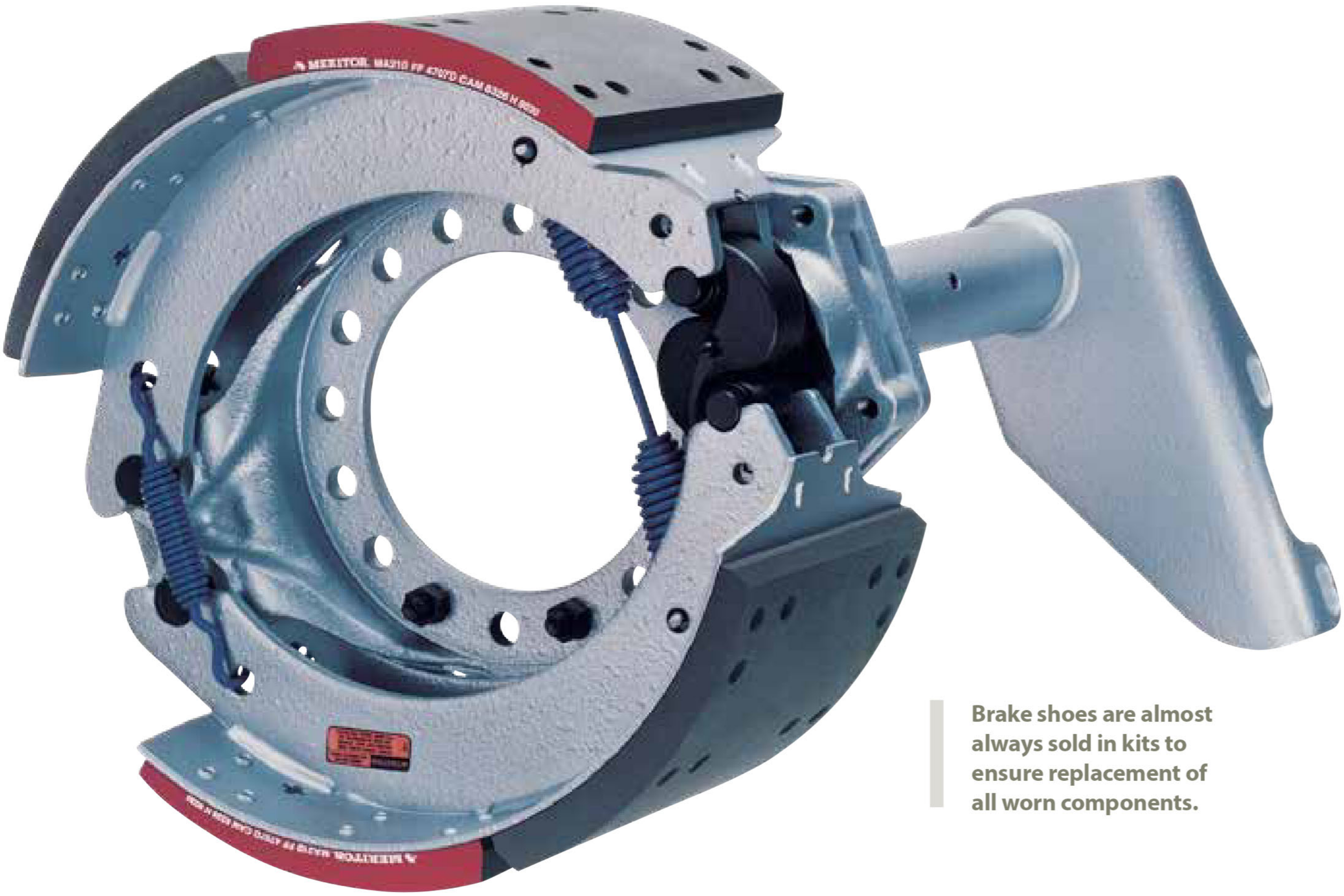
Each manufacturer blends these compounds in various amounts under computer control. The mix is pressure-cured in long slabs, then baked, cut and shaped. Rivet holes are drilled, and the lining is affixed to a shoe or pad. Samples are pulled and checked to ensure quality and durability, including analysis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

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 is left in the component. Many brake wear gauges have a minimum thickness check, but also have a 50% 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

Photo courtesy of Silverback



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

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 kits, 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 with 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 offers 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 that tells you if the shoe requires single or dual anchor pins. It also will have a coefficient of friction generated by the material – an alphabetical sequence designating the coefficient of friction for the lining material. Coefficient of friction can be identified as EE, FF or GG, for example. The higher the alphabet scale, the more aggressive the material.

A final piece of data on the edge code tells the batch – or specific manufacturing data – pertinent to the 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, and 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. "You need to know who manufactured that part so you know it's being backed by somebody," he stressed. "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."

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, said 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 noted. "But don't just depend on edge codes alone."

All manufacturers provide weight charts that detail how a particular lining corresponds to the weight a vehicle hauls. It's an easy way to make sure that you've done your homework and you've chosen the appropriate lining on for the job.

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 stressed. "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, a different working environment or driving condition may necessitate changes to a vehicle's 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 noted, 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 said.

Heat is another critical factor. "Drum-type brakes are effective up to a certain temperature, and then they start to fade away," said 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."

OEM or aftermarket?

OEM quality or equivalent parts are recommended to ensure that fleets install the same (or better) high-quality components that were designed for the vehicle, but Silverback HD Vice President of Operations Keith Roth said OEMs can be in a tough spot in that most components are designed to meet certain minimum performance characteristics specified by the engineering department of a component and vehicle manufacturer.

"These specifications are often a balance between meeting certain government required regulations,

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

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

along with considerations for price and life cycle," he said. "In the aftermarket, you have the OEM original component as the benchmark, with various performance and cost alternatives competing with this benchmark."

On one side are the lower cost options. Relined shoes, for example, will perform ok but not as well as the as new steel shoes with the same friction, because relined shoes usually have some roughness to the table due to previous corrosion. That, in turn, provides uneven reduced heat dissipation versus a new shoe that will provide a longer life span, according to Roth.

On the other hand, a better performing product is often available in the aftermarket versus the original OEM product – for example, an advanced friction formula that may provide longer life versus the original OEM design, but the OEM chose not to use it because of an increased cost in the production of the vehicle.

"An example of this would be the piston-style spring brake that was subject to high corrosion rates on the exposed paction, which all North American truck OEMs used for vehicle production up until the mid-1970s when fleets demanded that truck OEMs start using the superior double diaphragm design (3030) sold only by the aftermarket," Roth said. "That is now still the standard today."

Roth said the golden rule of truck parts is "that you get what you pay for, so be careful who you choose as a partner parts supplier. In everything there is cheap garbage, there is middle of the road reliable and there is high-performance," he added. "Fleets need to make sure they are buying replacement components from reliable part supplier partners that are committed to lowering their cost per mile."

> **… the golden rule of truck parts is that you get what you pay for … In everything there is cheap garbage, there is middle of the road reliable and there is high performance.**
>
> **Keith Roth**, Silverback HD Vice President of Operations


A rocket launch sees temperatures as high as 5800°F.
So, ROCKET SCIENCE utilizes CERAMIC to build rockets and launch pads, due to its incredible heat resistance.
SilverbackHD does the same.
TRUST THE SCIENCE
Utilize SilverbackHD new lined ceramic brakes to run cooler, stop faster and last longer.
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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 fleet 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

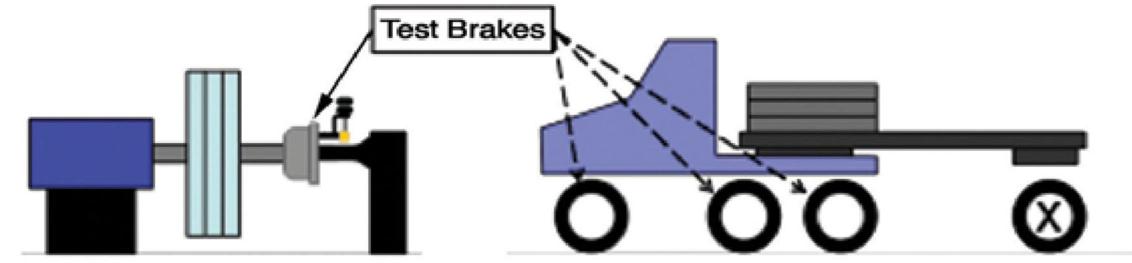


Figure 1

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 below, 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 confirmed 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 influenced 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			
Configuration	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 specifications 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 specifications 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
	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
6x4 Tractor Built Before 8/1/2011 (Pre-RSD) & Tandem Trailer	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 confirmation 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 significantly 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 Classification*.

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 number. 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 only.

(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					
	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					
					Additional brake sizes, linings, axle ratings, etc. can be supplied as special configurations for any wheel size.				
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 number. 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 classification 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

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, which causes 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 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.

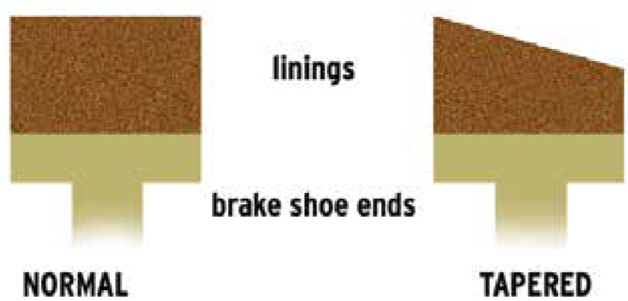
For those reasons, reusing shoe rollers and anchor pins is not recommended.

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 from being etched

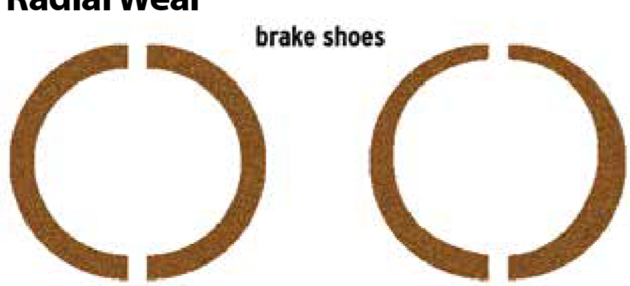
Axial tapered wear results from worn anchor pins, holes or bushings, or worn outer S-cam bushings. These allow force to push shoes to one side.

Axial Wear



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.

Radial Wear

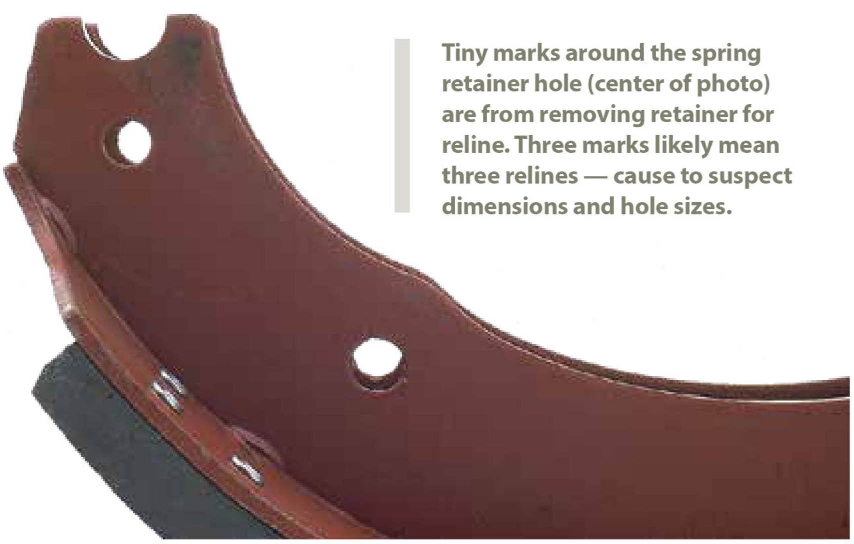


Cracked linings likely were loose on the shoe. This is caused by a shoe that's out of arc, rust buildup on the shoe surface or improper riveting.

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.



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.

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 don't 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 specifically designed puller.

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, which will cause tapered wear.

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 other 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, however it's generally recommended that 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 and will cause 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

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.

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

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 okay just because it has new lining.

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.

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 fine as long as they haven't cut any deeper than .010 inch into the drum.

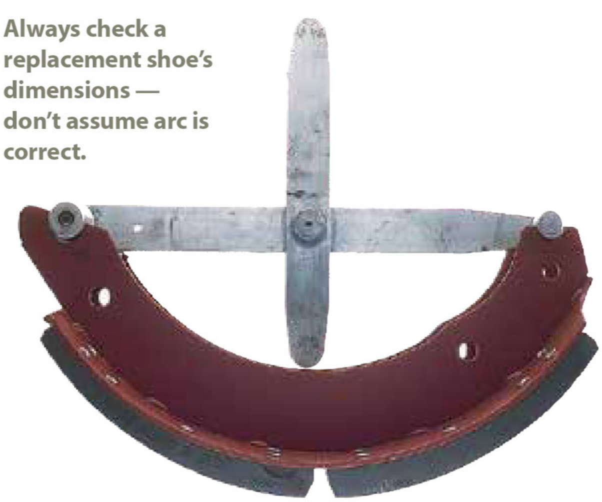
A drum with surface heat checks should be inspected periodically, as the checks may wear away over time. If it's obvious that they are getting worse, discard the drum. Needless to say, any crack through the drum's thickness means the drum should be scrapped.

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 tolerance.

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

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

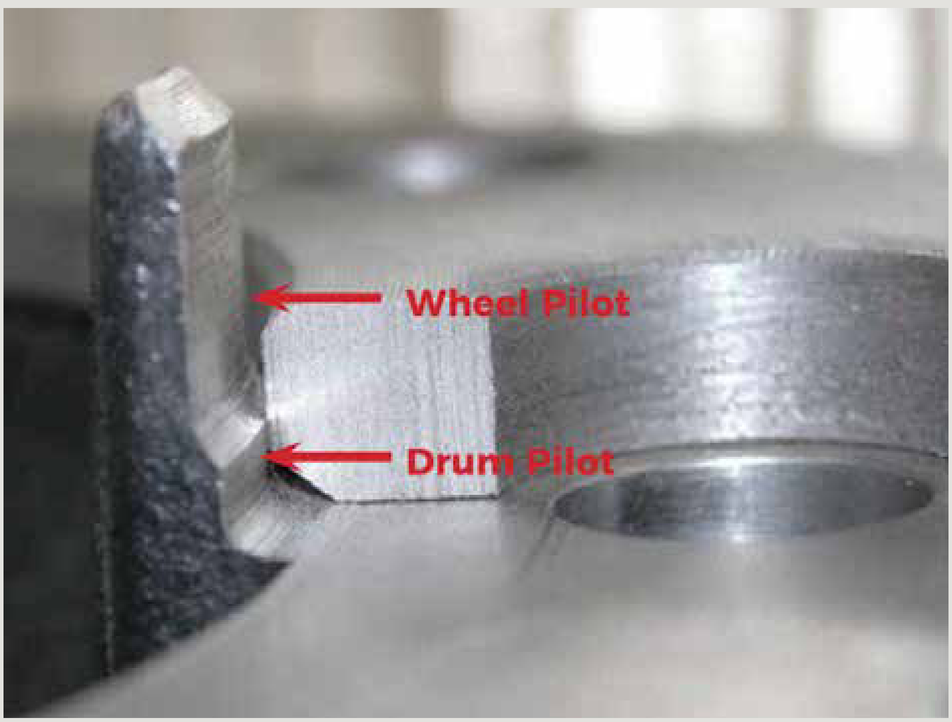


can be cut or rotated one bolt hole and rechecked. If severely out of round, the drum should be discarded.

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.

Out of round/Out of balance



In the field "Out of Round" is generally a result of brake drum imbalance – or it not being balanced within accepted North American standards.

A mis-piloted drum will be mounted on the wheel pilot instead of the drum pilot. The approximate difference in size between the wheel pilot and the drum pilot is 0.078.)

SilverbackHD recommends when installing a drum that technicians inspect the hub for damage of foreign material build up; inspect for corrosion in the mounting areas; remove any corrosion or build up and replace hub if damaged; and, when the drum is mounted on the drum pilot, to check if it is flush to the flange face of the hub.

Courtesy Silverback HD

CHAPTER 9
CALIPER STUCK?

By *CCJ* Staff

Caliper pistons that are not returning properly, or appear to be seized in the bore, can be caused by residual hydraulic pressure keeping the piston applied.

The troublesome units should be inspected for twisted or restricted brake hoses; cracked or otherwise damaged steel brake lines; improper adjustment of the master cylinder push rod; improper adjustment of the power brake booster pedal rod; and defects in the master cylinder or proportioning valve.

Silverback HD recommends installing and bleeding the replacement caliper. If the piston does not return properly or is seized, open the bleeder valve and recheck. The caliper is working correctly if the piston releases.

Uneven or accelerated pad wear can be caused by a defective caliper, although defective mounting hardware or incorrect installation may be the actual problem.

If the caliper slides, or mounting pins are not functioning properly, it will cause outboard pad wear. If the caliper bushings are worn or the mounting hardware is defective, it will cause horizontal or vertical tapered wear. If the mounting hardware, brake hoses or brake pedal are faulty, or there is booster misadjustment, excessive heat will build up from constant friction. This causes cracked lining, chipped edges or short life.

Rotors should be replaced or turned if there are grooves in the friction surface.

If pads are improperly installed it will cause a step in the lining, so Silverback HD recommends checking installation and looking for defective mounting hardware, replacing if necessary.

CHAPTER 10

TROUBLESHOOTING BRAKE IMBALANCE

By *CCJ* Staff

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

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 to guarantee safe, efficient stopping. If just 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 extreme temperatures under which foundation brakes operate. 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 get hot, their drums naturally expand, causing linings to fade and brake-chamber stroke to increase. In these instances, it can take the vehicle up to 75% more 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.

"Even shoe or pad wear means balanced brakes," said Keith Roth, vice president of operations for Silverback HD. "Uneven wear means unbalanced brakes."

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, too.

Differences between linings are most likely to sneak up as 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 non-asbestos 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. Edge codes, for example, which offer easy identification of a lining's aggressiveness.

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%.

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," 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.

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 and cause them to slow down or fail. 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. 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.

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% smaller than original-equipment tires can cause a vehicle to be over-braked. In fact, an 18% reduction in rolling radius can result in an 18% 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%. And changing to a less aggressive lining – or, with engineering approval, placing some sort of pressure modifier in the system – will help resolve an over-braking 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 search 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. When checking a drum for excessive wear, 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 to 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% of braking involves application pressures for linehaul applications below 20 psi, and approximately 84% 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, leading to 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 over-braked 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 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 down the rig, 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 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 over-brake if axle loading is substantially less than its rated capacity. The same rule applies to trailers with over-spec'd axles. This can lead to compatibility, wear and maintenance issues.

One option to resolve an over-spec'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. 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.

What causes brake imbalance and how can I prevent it?

A balanced brake system is when the entire brake system, from front to back, (including the tractor and trailer) react at the correct time to produce equal timing and brake pressure.

According to Silverback HD, brake imbalance can be caused by many factors:

- Disc and drum brakes perform differently, so matching like brake designs will provide more consistent performance.
- Various brands of friction and material types within those brands have different performance characteristics.
- Each friction formula has different stopping power vs other friction formulas
- If different friction formulas are used on different axles (or sides of a vehicle), the brake with the higher coefficient of friction will do more work; the lower friction may gradually glaze over due to lack of work, and the results are unstable braking (or worse); the higher friction wheels will deliver faster wear rates and more stopping power; the lower friction wheels won't do their share of the work and instability results; and certain brakes, when overworked, can also potentially fade and cause instability under load.

To ensure you have proper brake balance, Silverback HD suggests the following:

- Challenge your parts supplier to assist you in selecting the right friction for your application.
- Utilize one brand and formula of friction on all axles and wheels on a given tractor trailer combination whenever possible. For instance, a fleet hauling potato chips on the Plains will need a much lighter friction than a refuse or cement hauler running with heavy loads in hilly country or stop and go city. Fleets should understand what friction brand and formula helps them accomplish their maintenance goals and stick with it. New steel shoes will provide the longest life cycle possible for the chosen friction.
- Always perform complete vehicle brake jobs, never one axle or one wheel at a time.
- Resist the temptation to fix symptoms. Look for causes of rapid wear and/or very low wear as compared to other wheels. Dig deep to fix the cause as opposed to just what's on the surface.

With the exception of a steer axle, all wheels should wear out at the same rate. If that's not the case, you have a maintenance problem that needs to be found.

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

Silverback HD
www.silverbackhd.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

Silverback HD
www.silverbackhd.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

Silverback HD
www.silverbackhd.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

Silverback HD
www.silverbackhd.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

Silverback HD
www.silverbackhd.com

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

Marathon Brake Systems
www.marathonbrake.com

Meritor Inc.
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NeoBrake Systems Inc.
www.neobrake.com

Raybestos
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Roadranger Parts Marketing
www.roadranger.com

Silverback HD
www.silverbackhd.com

Southwest Trailers & Equipment
www.swtrailer.com

Stemco Duroline
www.stemco.com

TMD Friction Inc.
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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

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www.braketechtools.com

Central Tools Inc.
www.centraltools.com

Equipment Supply Co.
www.esco.net

Hennessy Industries Inc.
www.ammcoats.com

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Di-Pro Inc.
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FleetPride Inc.
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PDC Power Products
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Automann Inc.
www.automann.com

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www.bendix.com

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www.brakesystemsinc.com

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Coronet Parts Mfg. Co. Inc.
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Napa Truck Parts
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www.RyderFleetProducts.com

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www.webbwheel.com

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www.wabco-na.com

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.

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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 lock-up 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).

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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.

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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 21⁄2 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.

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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 immedi-

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ately 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.