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Per the request of Paul Richards, enclosed please find our 5th Revised Air Brake Book. We saw your request for material in Brake Training, Fast Fax April 14.

Best Regards,
Holly Wange
Business Mgr.
CCJ

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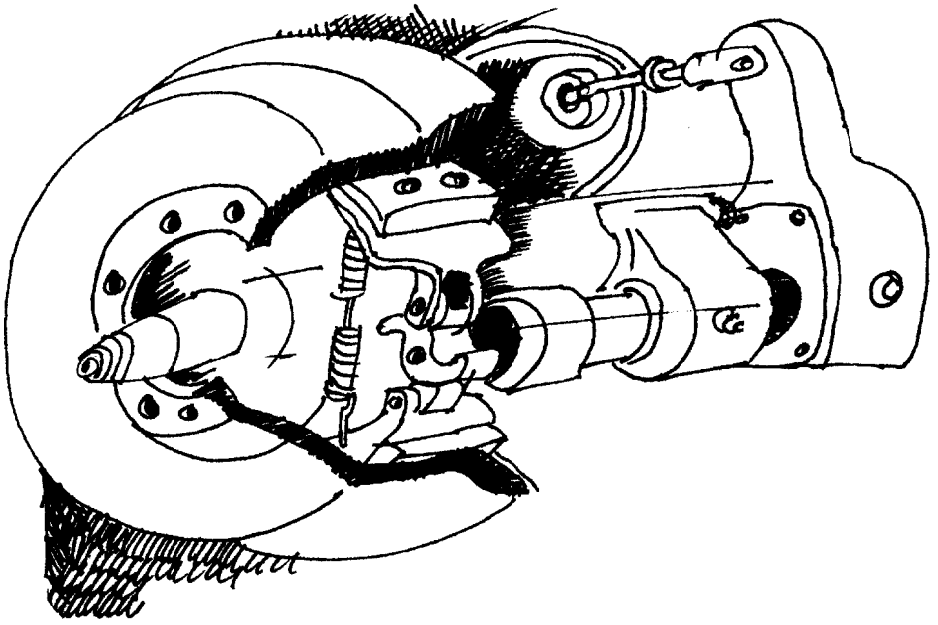
The Air Brake Book



5th Revised Edition

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Studies by NHTSA prove

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the only ABS

that has a cost-per-mile that's

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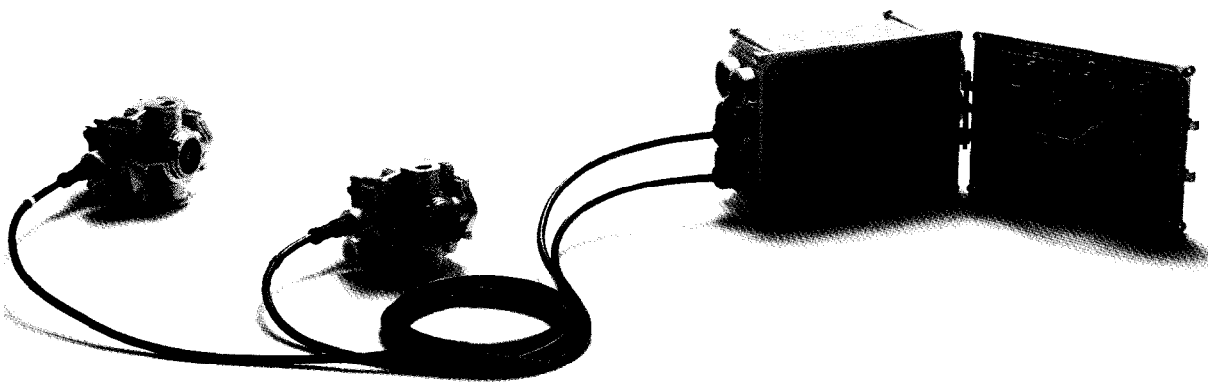

After two years and nine million miles of in-service NHTSA testing*, Midland's anti-lock braking system came in with a total cost of just 0.9 cents per mile. 54% lower than the next closest competitor.

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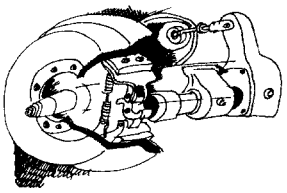

5th Revised Edition

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Introduction

It's a moving target.

Staying informed about the development of air brake system technology, the status of regulatory activity and evolving maintenance requirements is a moving information target.

When the first edition was published in 1988, The Air Brake Book immediately became the easy-to-read resource for up-to-date technical information on all end-user concerns about the design and use of heavy-duty air brake systems.

That premiere edition offered ten chapters. However, in the seven years hence, air brake product evolution and your subsequent information needs about air brake systems have erupted. This new 5th revised edition now contains 20 chapters filled with useful information and covers a broader range of topics.

Each story has been reviewed by its original author, CCJ editors all, and updated to reflect the current technical issues surrounding heavy duty air brake systems. Doing so helps ensure that we maintain the Air Brake Book's timeliness, topical integrity and usefulness to you.

This new edition reflects much that has been learned, or that has changed, since the 4th edition was produced. One story takes a hard look at the controversial trade offs presented by new long-stroke brake chambers. Field experience with the new generation of anti-lock brake systems has fueled the promise, but added a reality check, to the industry's ABS knowledge bank. And there is a new player in the slack adjuster market.

Air brake system vernacular evolves, too. We now must understand features with names like, "Service Brake Priority," and "Parking Brake Priority." So we have expanded the glossary of technical terms.

All of that and more is reflected in the comprehensive updates throughout this unique publication. The 5th edition is even easier to use and solidifies the book's identity as the educational-reference tool on heavy-duty air brakes for fleet maintenance managers and maintenance shop personnel.

I suppose that's why you'll find this book in thousands of maintenance shops all over North America and in many other countries as well. Almost anyplace you are likely to find American-style truck and bus equipment you also are likely to find The Air Brake Book.

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5th Revised Edition

The Air Brake Book

AIR BRAKE BASICS

A fundamental knowledge of brake system operation is the first step to understanding complex brake problems and making intelligent and cost-effective repair decisions.

By PAUL RICHARDS
Technical Editor

It's impossible to fix something without understanding how it's supposed to work. Brake system repair decisions can be difficult to make, and costly to execute, without a basic understanding of system components and their operation.

The following discussion details the operation of a typical S-cam air brake system on a single-axle tractor and trailer (see diagram, next page).

Systems vary somewhat, depending on the manufacturer and on optional equipment and configuration, but all can be thought of as comprising three sub-systems:

The supply system

The supply system, as the name implies, supplies pressurized air– the energy source for any air brake system.

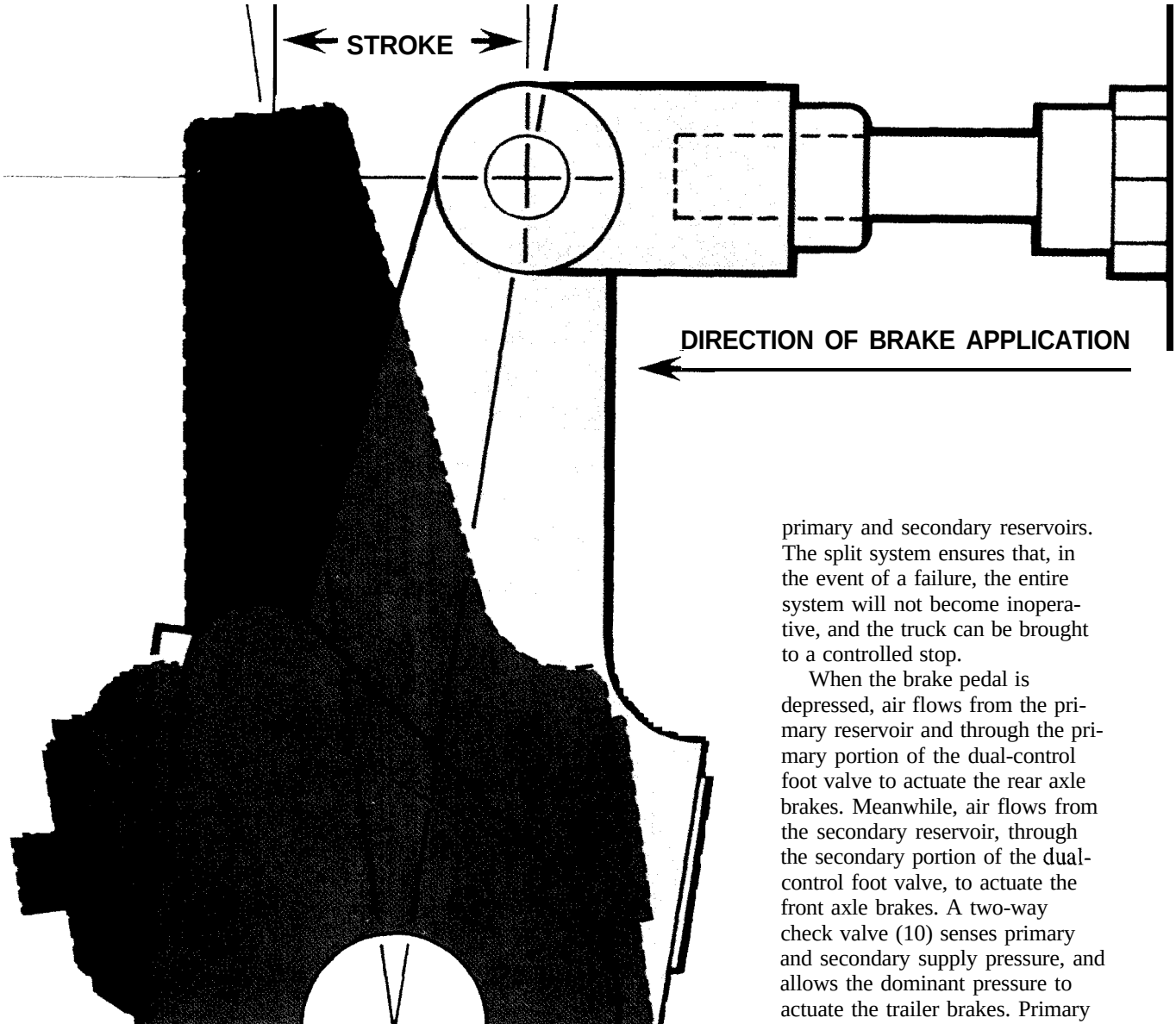
The key player in this sub-system (see the diagram on page 6) is an engine-driven air compressor (1). A governor (2), which may be integral with the compressor, controls the compressor's output by unloading or cycling it. Pressure is generally maintained at 100 to 120 psi, and is monitored by the driver by means of dash-mounted pressure gauges (3). A low-pressure switch (4) senses system pressure and sends an electrical signal to a dash light and/or buzzer to alert the driver when air pressure falls below 60 psi.

Air reservoirs, three per tractor and one or two per trailer, store the compressed air until it is needed to actuate the brakes (see *The fix is in*, in this manual).

Check valves (5) prevent pressurized air in the primary and secondary reservoirs from passing back through the compressor while it is not running.

A safety or "pop-off' valve (6) is usually installed in the reservoir closest to the compressor. In the event of system over-pressurization, the safety valve allows air to escape, preventing damage to air lines, reservoirs and other components.

The reservoir closest to the compressor is often referred to as a wet tank, since that is where atmospheric moisture-the number one enemy of air brake systems-condenses in the greatest quantities. Reservoirs are equipped with drain



valves (7) so water can periodically be eliminated. These can be manual or automatically operated. Alcohol is sometimes introduced into air systems operating in cold climates to prevent water from freezing and plugging air lines.

An aftercooler is an optional device that condenses and eliminates most of the water from an air system, but it is generally acknowledged that an air dryer (8) does a superior job in this capacity. An air dryer is a canister that usually contains a bed of desiccant material. As air passes through the material, moisture, as well as oil blow-by from the compressor, is captured by the material.

The control system

The control system consists of a series of pneumatic valves that direct air and control pressure to appropriate components. Although discussed here individually, different valves are often combined in a common housing.

The main valve is the dual-control foot valve (9), so called because it is actually two valves that operate simultaneously, in response to input from the driver's foot at the brake pedal.

Two valves are necessary because, after the wet tank output, the system splits into two separate brake circuits. Air downstream of the wet tank is divided between primary and secondary reservoirs. The split system ensures that, in the event of a failure, the entire system will not become inoperative, and the truck can be brought to a controlled stop.

When the brake pedal is depressed, air flows from the primary reservoir and through the primary portion of the dual-control foot valve to actuate the rear axle brakes. Meanwhile, 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 (10) senses primary and secondary supply pressure, and allows the dominant pressure to actuate the trailer brakes. Primary air can also be manually supplied to the trailer by means of a hand valve, (11) usually located on or near the steering column.

Two-way check valves are also used to allow dominant pressure to activate the stop light switch (12), and to release the parking brakes. Federal Motor Vehicle Safety Standard (FMVSS) 12 1 requires that the driver be able to release the parking brakes at least once from the cab, in the event of a failure in either circuit.

Relay valves (13) are used on trailers and on the rear axles of long-wheel-based tractors to minimize delays of brake application due to length of plumbing. These

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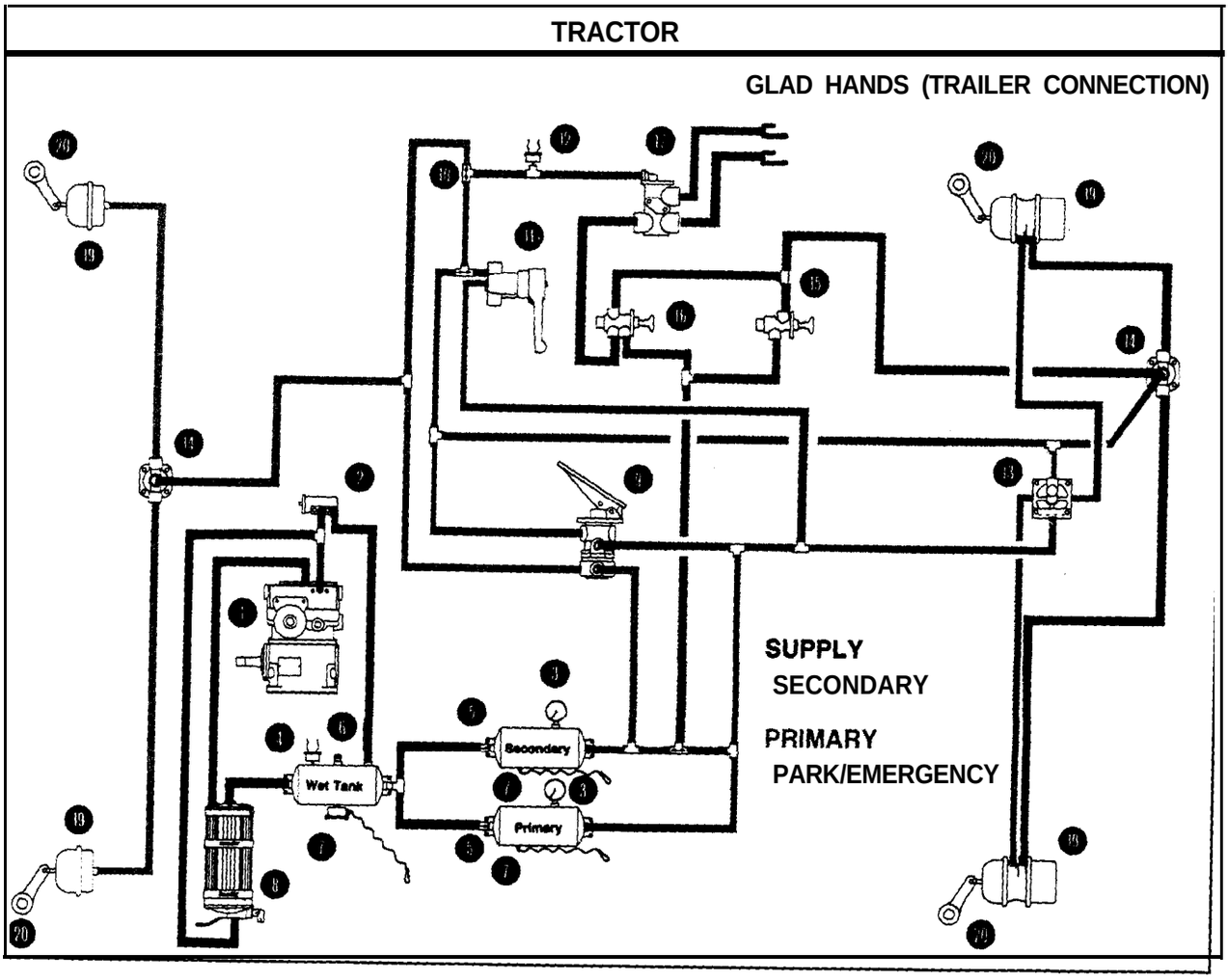


valves are directly supplied with unmodulated air pressure, and use air from the dual-control foot valve or manual trailer valve as a signal to quickly direct air to the brakes they serve.

Relay valves come in a variety of "crack" pressures. Crack pressure is the air pressure value 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, and is determined, axle by axle, by how heavily loaded the axle served by a valve is, how big its brakes are, and how aggressive the linings are on those brakes.

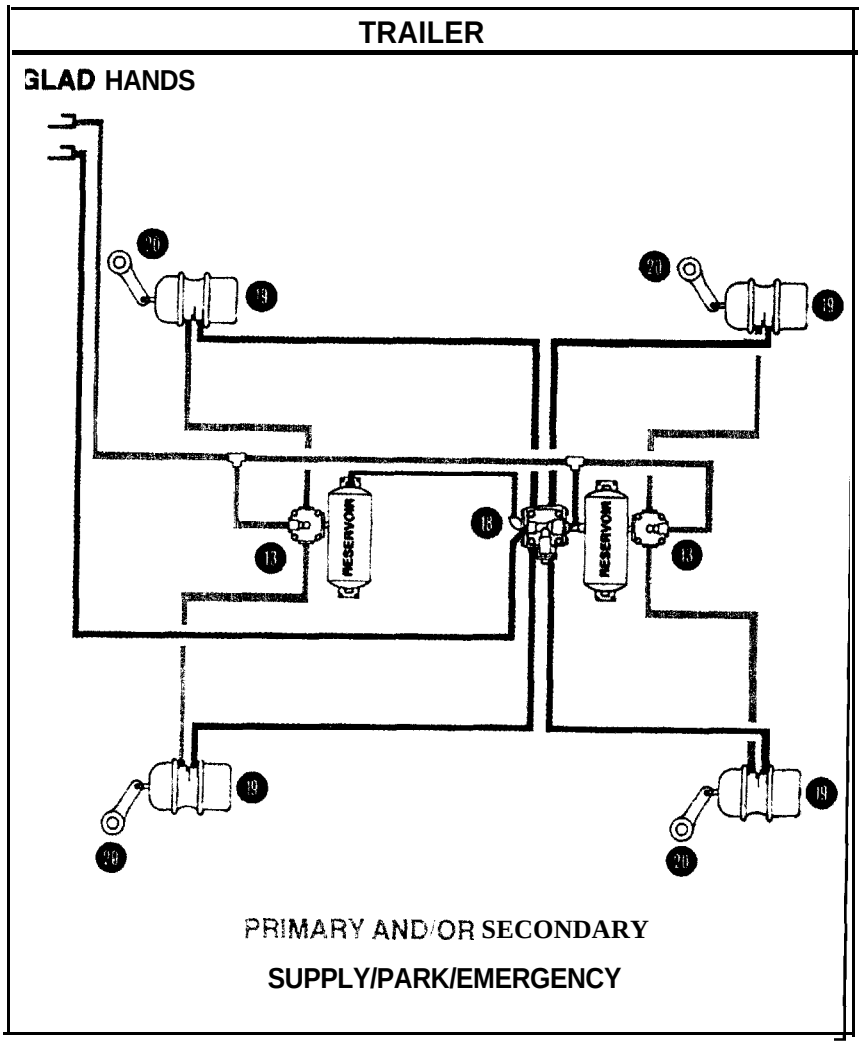
A valve that cracks at too low a pressure for a given axle can cause premature application, wheel lock-up and trailer pushing, if the affected axle is on the tractor. Too high a crack pressure can cause delayed application, insufficient braking and trailer pushing, if the affected axle is on the trailer.

After a stop, when the driver lifts his foot from the brake pedal, an optional quick release valve (14) allows brake actuation air to be quickly exhausted near the brakes it serves, rather than having to travel back through the supply line, thus speeding brake release time.

Minimum apply/release times, required by Federal Motor Vehicle Safety Standard (FMVSS) 121, are: .45 sec (apply) and .55 sec (release) for tractors and straight trucks; .6 sec (apply) and 1.2 sec (release) for non-pulling, single trailers.

Dash-mounted valves (15 and 16) control air pressure to the parking brakes. In most cases, these are spring brakes, so called because when no pressure is supplied, the brakes are applied by means of a spring. When air pressure is supplied, spring force is overcome and the brakes are released. More on that a little later.

A tractor protection valve (17)



senses pressure in one or both lines that carry air to the trailer. These lines are connected to the trailer by means of quick-connect air fittings called gladhands. When there is no pressure in the line(s)-due to trailer break-away or a gross air leak in the trailer circuit-the valve closes to maintain air pressure in the tractor circuit. In everyday use, the valve also works in conjunction with the dash-mounted trailer parking brake valve (16), to shut off air to the trailer circuit before disconnecting tractor from trailer.

The spring brake (or multi-function) valve (18) limits the air pressure used to keep the trailer parking brakes off and, by means of an integral check valve, isolates a failed reservoir, which would otherwise cause the parking brakes to be automatically applied.

Brake chamber type	9	12	16	20	24	30	36	50
Effective area of diaphragm (sq in.)	9	12	16	20	24	30	36	50
Pounds force developed with 60 psi	540	720	960	1200	1440	1800	2160	3000

Effect of brake chamber type (diaphragm area) on pushrod output force, with constant 60-psi application. *Photos and art courtesy of AlliedSignal and Midland-Grau.*

A ratio valve, also called a pressure-reducing valve, is used on many vehicles to limit air pressure to the front axle. The valve is available with several different "hold-off' pressures, which prevent the front brakes from operating until the driver has pushed the brake pedal down far enough to exceed that pressure.

Use of this valve has become somewhat controversial, in that many experts think front brakes ought to be just as aggressive as the rest of the brakes on a vehicle. Also, since ratio valves prevent the front brakes from operating during low-pressure stops-and the vast majority of stops are low-pressure-some warn that front brakes can be rendered inoperative by rust that builds up from disuse (see *Pros & Cons of Front Brake Limiting Valves,* in this manual).

The foundation brakes

Foundation brakes are where properly supplied and controlled air is used to stop a vehicle. When the brake pedal is depressed, air pressure is directed to brake chambers (19) at each wheel end. Brake chambers consist of a pressure housing, diaphragm and pushrod. As air pressure is exerted on the diaphragm, the pushrod on the other side of the diaphragm is extended.

The force the pushrod exerts is the product of the amount of air pressure applied in psi, and the area of the diaphragm in square inches. For example, 60 psi, applied to a chamber with a 16-sq-in. diaphragm would create a force at the pushrod of 960 lb. A 60-psi application to a chamber with a 30-sq-in. diaphragm would yield 1,800 lb of pushrod force. Improperly matched brake chambers, therefore, can cause severe brake balance problems.

The pushrod is connected to one end of a lever called a brake adjuster-often called a slack adjuster

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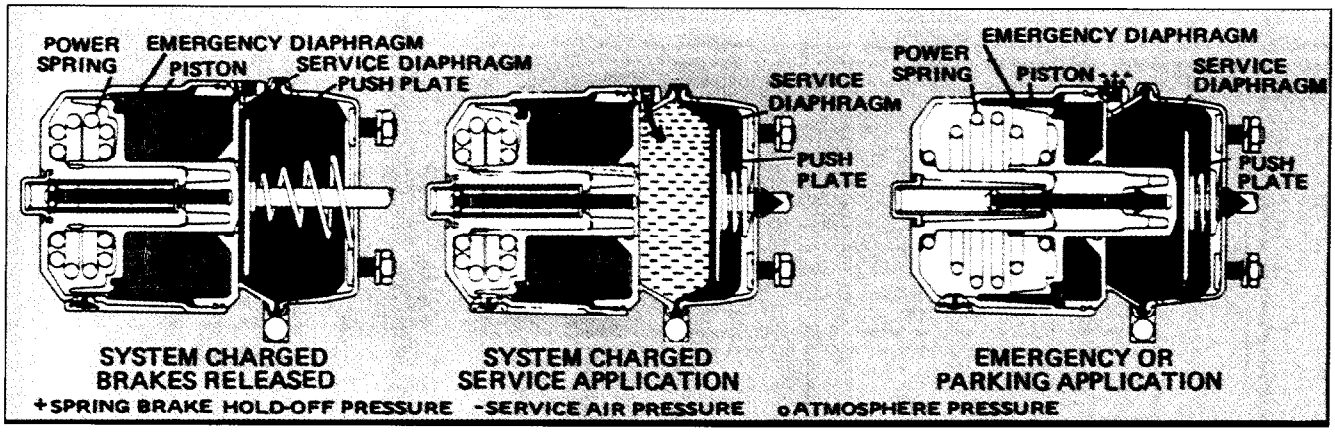
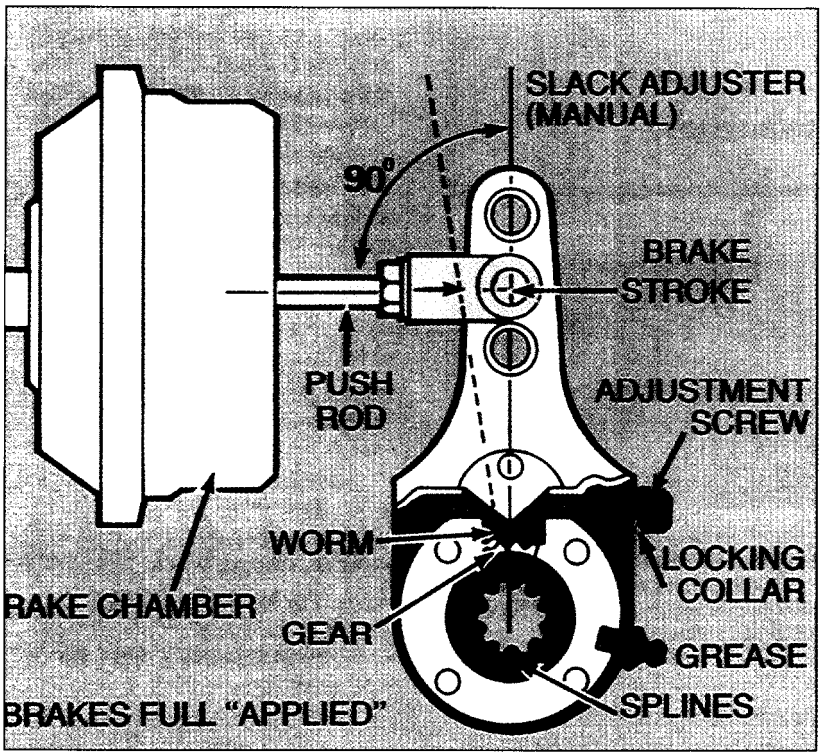


Piston-type spring brake (a second diaphragm is often used in place of piston). In normal "run" mode, system pressure overcomes spring pressure, and parking brake is held off. During normal service brake application, service air acts on diaphragm in right hand chamber, and is not affected by spring brake. In emergency or parking operation, air is exhausted from left hand chamber. Spring force moves pushrod to right, applying parking brake.

(20). The other end of the brake adjuster is connected to a shaft that runs perpendicular to the plane formed by the pushrod and slack adjuster. As the pushrod is extended, the shaft rotates.

The shaft, in turn, is connected to an S-shaped cam between the brake shoes. As the shaft rotates, so does the cam. The brake shoes are forced apart and against the brake drum, creating the friction needed to slow the vehicle. The amount of friction produced is determined, in part, by the size of the brakes, the coefficient of friction (aggressiveness) of the brake lining material, and mass and heat-rejection potential of the drum.



Action of chamber on brake adjuster. With chamber pushrod fully extended, properly-set adjuster forms 90° angle with pushrod.

Lining or brake block aggressiveness is indicated by means of edge coding on the material itself. Two problems with this identification method are: the coding is difficult, if not impossible, to read once the linings are well-worn; and, even if linings are replaced with material of the same rating, actual performance of the two materials can be quite different.

The slack adjuster is equipped with an adjusting mechanism to compensate for brake lining wear. If this were not so, the pushrod would be required to extend farther and farther as brake lining wear progressed. It wouldn't take long before the pushrod would not be able to extend far enough to apply the brakes. Some brake adjusters accomplish this adjustment automatically (see *Taking* Out *the Slack,* in this manual).

The brake adjuster has another function. It is essentially a lever, and a lever multiplies force in proportion to its length. A 4-in. long brake adjuster converts 1,000 lb of

force at the pushrod to 4,000 in.-lb torque at the camshaft.

The brake adjuster's length and the brake chamber's size are two variables commonly altered to meet braking requirements. The product of these two values is expressed as the "AL factor." This factor, when multiplied by 60 psi air pressure, is the industry standard for braking calculations.

For example, 60 psi, applied to a chamber with a 16-sq-in. diaphragm (the "A" part of the AL factor) would create a 960-lb pushrod force. Multiplied by a 4-in. brake adjuster (L), the actual torque on the brake camshaft would be 3,840 lb-in.

While it's good to understand the AL factor, the National Traffic Safety Board cautions against its use as a sole means of determining brake specifications, as it doesn't take into account component deflection and other variables.

In addition to applying the service brakes used in everyday driving, the brake chambers on the rear tractor axles and on the trailer axles apply the parking brakes. These brake chambers, (spring brakes), incorporate a second chamber, containing a second diaphragm and a powerful spring.

When the vehicle is in use, the dash-mounted parking brake valves are in the "run" (pushed-in) position. This supplies air pressure to the spring chamber, on the side of the diaphragm opposite the spring. Air pressure acting on the diaphragm compresses the spring, and the parking brakes are held off. This does not affect the operation of the service brakes.

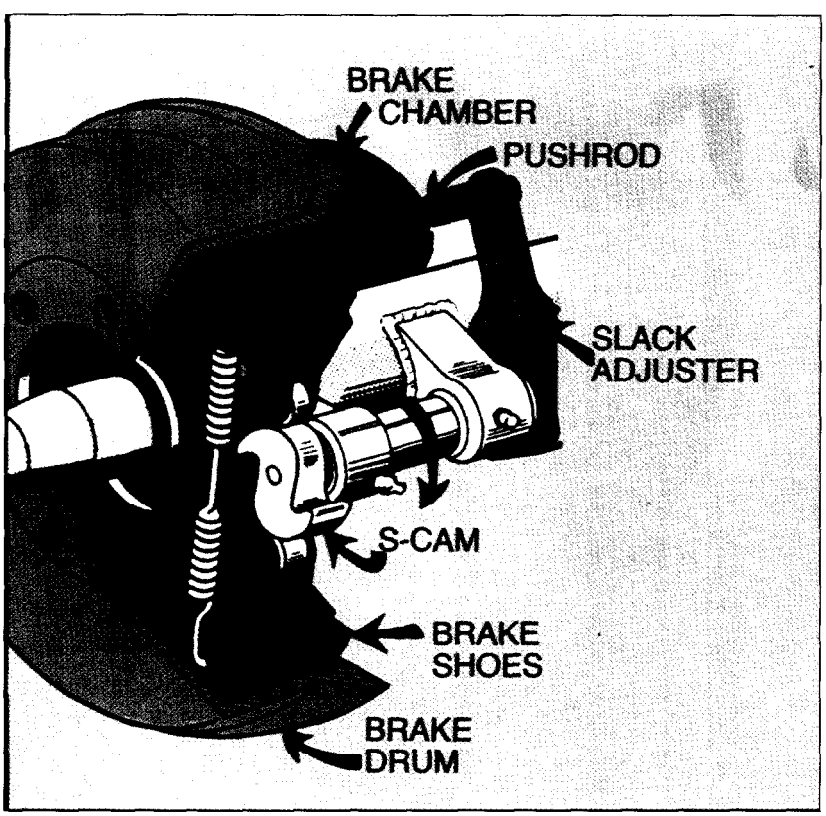
When the vehicle is parked, the dash valves are pulled out. This exhausts spring brake hold-off air, allowing the spring to apply the parking brakes. In the event of a loss of system pressure, hold-off air pressure is, in most cases, overcome by the parking brake spring, and the brakes are automatically applied to provide emergency stopping. (See *The fix is in,* in this manual.)

An alternative to spring brakes that is becoming increasingly popular is the International Transquip system. It uses air pressure to apply the parking brake, and a piston-and-rack to mechanically hold the brake in the parked position. The advantage of this system is that it allows a driver to modulate emergency brakes by using the service-brake (foot) valve, even if a parking-chamber hose is severed.

Per FMVSS 121, the parking brakes must be able to hold a vehicle, loaded to its gross weight rating, stationary on a smooth, dry, concrete roadway, facing uphill or downhill on a 20% grade. In the emergency mode, the parking brakes must be able to exert a retarding force equal to 28% of the gross axle rating.

A common option, called anti-compounding, prevents additional pressure (from an inadvertent application of the service brakes) from being added to the pressure already being exerted by a parked spring brake.

With this option, when the parking brakes are on and a service brake application is made, a double check valve sends air pressure to the hold-off side of the spring brake chamber, cancelling the redundant, potentially harmful, force of service-application air pressure.



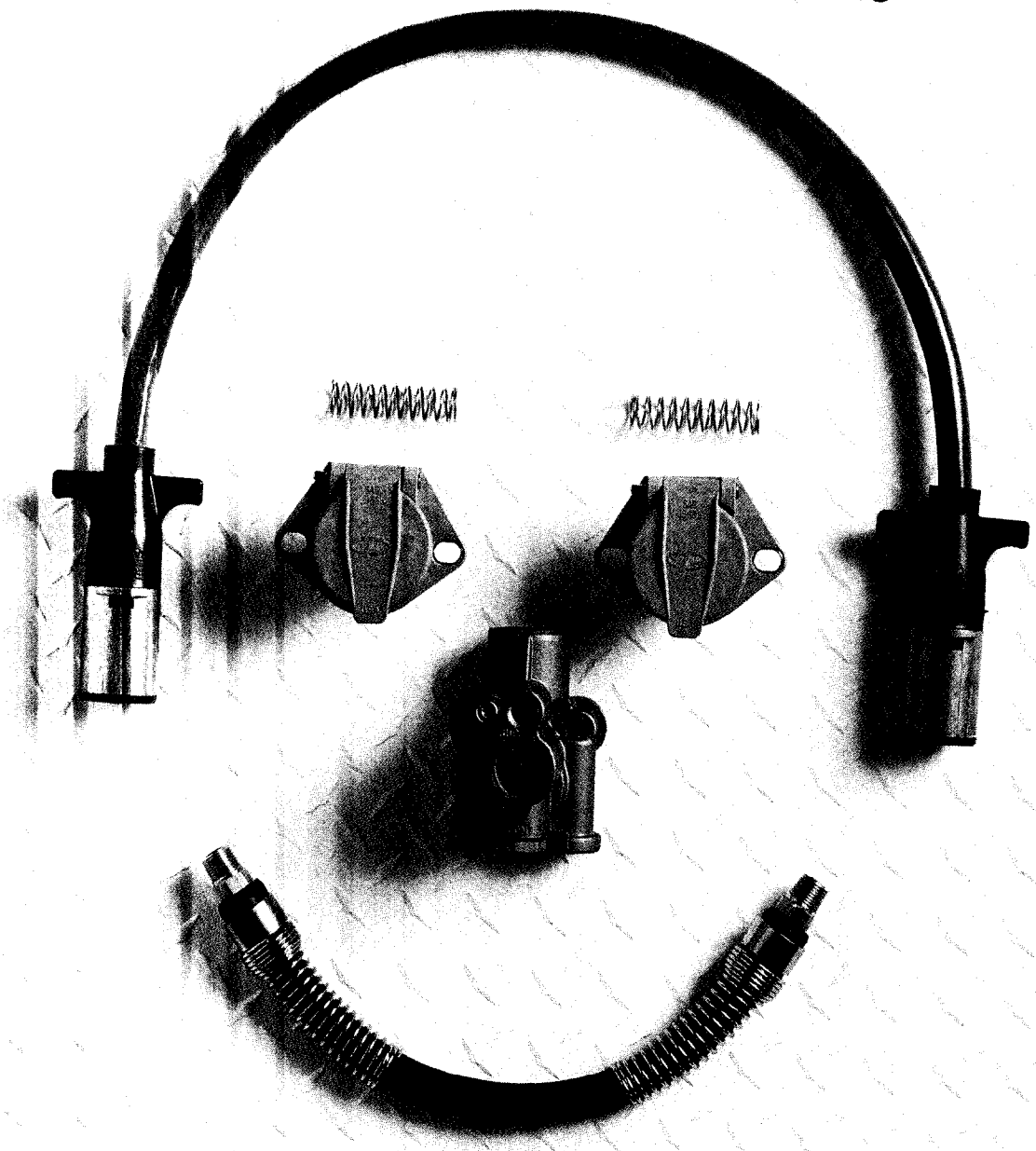
Foundation brake operation. When pushrod is extended, brake adjuster, camshaft, S-cam rotate. S-cam spreads brake shoes apart and against brake drum.

More to come

If you're getting the idea that air brakes are complicated, you're in good company.

Hopefully, we've provided some understanding, or helped clarify fundamentals that will be a basis for dealing with more complex braking topics to be discussed later in this manual. Cl

REMEMBER WHEN A FACE, A NAME, AND A PRODUCT WERE AS ONE.



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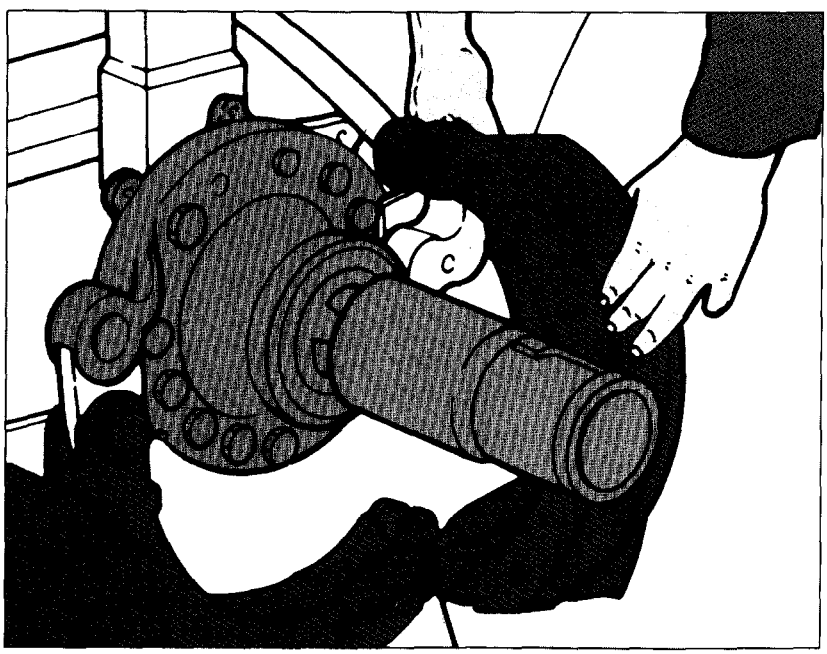
AIR BRAKE PM

Today's air brake systems are so rugged, preventive maintenance often winds up on the bottom rung of the priority ladder. But the value of brake PM shouldn't be forgotten-it's easy, and it pays big dividends.

By PAUL RICHARDS
Technical Editor



Most brake experts agree that even the most complicated balance, timing and compatibility problems can be minimized by a good PM program. We're talking about steps taken to keep brakes performing as they did when they were new, to prevent problems from occurring, and to detect small problems before they become big ones. It's some of the easiest work your shop can perform, and it has the potential to save your operation from expensive inspection violations, accidents and litigation.

Routine **checks: what & when**

Since every operation is a little different, maintenance intervals will vary. Except for reservoir draining, which should be done daily unless the system includes an air dryer, and manual brake (or slack) adjustment, which should be checked at least weekly, only experience will produce a reliable timetable for preventive brake maintenance.

Most brake manufacturers recommend that a visual inspection for wear, broken parts, chafed or badly routed air lines and other obvious damage be made whenever any brake service is required. Generally speaking, such a check should be made at least every three months.

Whatever interval you choose, it's a good idea to accompany the inspection with a thorough operational check. "When it comes to brake PM, most people just think of foundation brakes," says Dick Durack, senior technical communications representative, AlliedSignal Truck Brake Systems, Elyria,

Continued

Don't forget to change air dryer desiccant per manufacturer's recommendations. Access is generally easy. For example, Bendix AD-IP cartridge is replaced by removing single bolt from bottom of dryer. **Photos and art courtesy of AlliedSignal and Rockwell.**

Oh. "But you've got to look at the whole system. The best way to do that is to go from the front bumper to the taillights, making sure everything is doing what it's supposed to."

Since air is the lifeblood of a brake system, there's got to be enough of it. And it's got to be clean. So the compressor's as good a place as any to start your PM inspection. With the engine running at full, governed rpm, air pressure should build from 85 psi to 100 psi in 25 seconds or less, with normal-size reservoirs. If it doesn't build up in time, and the system isn't leaking, there's a good chance the compressor intake is being restricted by a dirty air filter. While that's not a catastrophe in itself, it can quickly lead to complications.

When a compressor tries to draw air through a plugged filter, a vacuum is created during the intake stroke. That vacuum is partially relieved by oil sucked past the compressor's piston rings.

During the compression stroke, the oil is pumped into the discharge line and gums-up components downstream-especially relay valves. Periodic checking and replacement of air filters is an easy way to ward off expensive headaches.

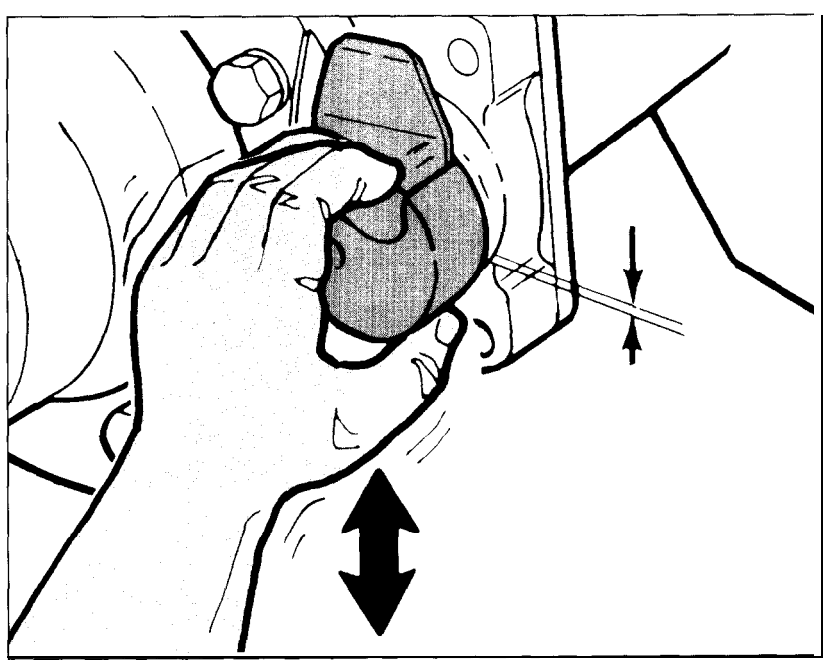
Even with a clean air filter, a compressor can pass oil if its oil control rings are excessively worn. Failure to change compressor oil—or engine oil, if the compressor shares oil with the engine-is the most common cause of premature ring damage. Another cause is a damaged or ill-fitting air filter that allows abrasive contaminants to enter the compressor.

"Periodically disconnect the discharge line from the compressor," advises Chuck Wittenberg, task team manager, Midland-Grau Heavy Duty Systems, Kansas City, MO. "If it's sludged-up to the point where the inner diameter is substantially reduced, that's a sign that the compressor is passing excess oil."

Anything leaking? It's easy to find out without getting your hands dirty-use the test outlined in the Commercial Driver's License preparation manual. Run the engine until the system is fully pressurized, and shut off the engine. Release the service brakes and time the air pressure drop. The loss rate should be less than 2 psi/min for straight trucks and less than 3 psi/min for combination vehicles.

Next, apply the service brakes to at least 90 psi and time the pressure drop (don't count the initial drop when you hit the pedal). The loss rate should be less than 3 psi/min for straight trucks and less than 4 psi/min for combination vehicles.

If leakage is suspected, paint air



Wiggle S-cam up and down to check for radial play. Also, move in and out to check for end play. Most manufacturers recommend no more than a few hundredths of an inch. More can cause uneven application and brake chatter. If excessive play is not obvious, use a dial indicator to be sure.

lines and components with soapy water and watch for bubbles. Or use an ultrasonic leak detector.

Once satisfied that a system is holding its air, make sure all chambers and spring brakes are applying and releasing on cue, and that pushrod travel is within limits, even where automatic brake adjusters are used.

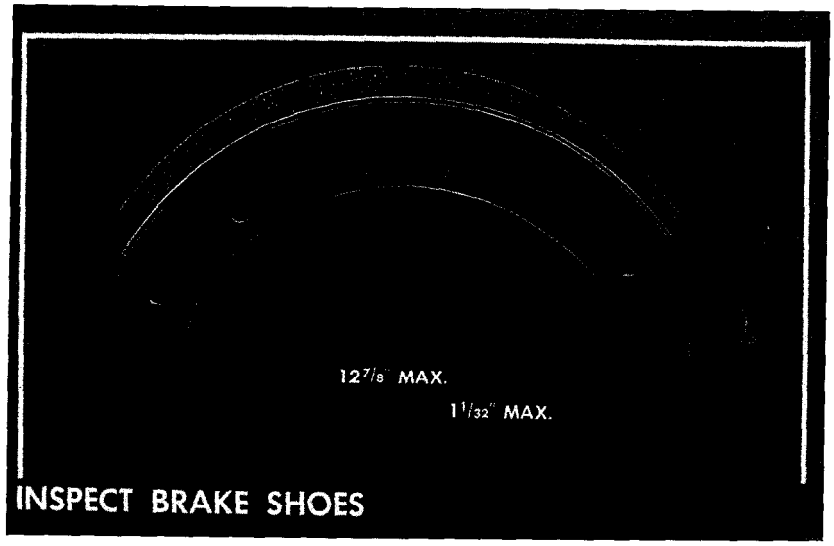
Remember that automatic brake adjusters aren't a set-it-and-forget-it item. They need to be selected, installed and maintained in strict accordance with the manufacturer's instructions.

The maximum allowable pushrod travel is 1 3/4 in. for type-l 6, 20 and 24 chambers, and 2 in. for type-30 chambers. Also remember that, when properly adjusted, the adjuster and pushrod should form about a 90" angle, with the brakes fully applied.

Improperly adjusted brakes often are responsible for a host of more complex problems, especially when all the brakes on a vehicle are not adjusted to the same degree. When one or more brakes are out of adjustment, they're not doing their share of the braking. This results in brake imbalance and increased stopping distance.

Moreover, any properly adjusted brakes on the vehicle are forced to do extra work, resulting in excessive heat and wear. While a heat-damaged drum and prematurely worn lining at one or more wheel end(s) could indicate a dragging brake, the astute fleetman will be quick to suspect an out-of-adjustment condition elsewhere on the vehicle.

Lubrication is an oft-forgotten PM measure. Whenever a vehicle is brought in for chassis lubrication, brake adjusters, air chamber brackets, anchor pins and cam rollers should be lubed, too. This helps automatic brake adjusters stay that way, keeps manual adjusters easily adjustable, allows camshafts to rotate freely and



When installing relined shoes, be sure dimensions are within manufacturers specs-in this case 12 7/8 in. Check for excessive lining-to-shoe clearance, and for elongated slots and holes.

staves off costly wear. Follow manufacturers' lubricant recommendations for individual parts, and avoid getting grease or oil on brake linings.

When it's time to reline

While no one can tell you how long a set of linings will last in your operation, lining thickness should be measured whenever the vehicle is serviced, or at least every three months. It is generally agreed that linings should be replaced when the thinnest point gets down to about 1/4 in. thickness.

When choosing a replacement lining, fleetmen are advised to adhere to manufacturers' recommendations. Simply matching the edge codings by no means ensures that original frictional and wear characteristics will be duplicated. And buying lining on price alone is an invitation to incompatibility. "We spend a lot of money evaluating linings," says Tom McNorton, national technical manager for Rockwell International, Troy, Mich. "We look at everything, so we know what works."

Before installation, check that relined shoes haven't "grown" beyond manufacturer specifications. Check for elongated slots and holes, and look for loose rivets and excessive shoe-to-lining clearances. (Also, *see Restoring S-Cum Performance*, in this manual.)

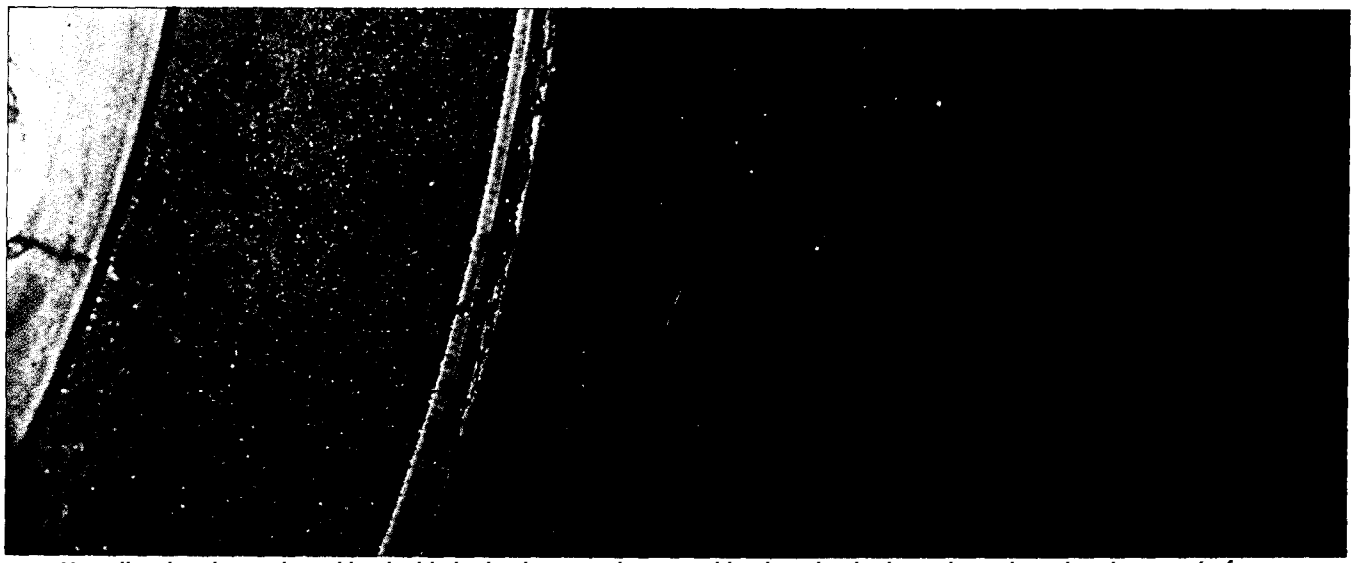
Reline time is the time to perform a thorough inspection of axle ends. Check spiders for hairline cracks. Drums should be checked for scoring, cracking, excessive inner diameter and/or runout. Look carefully at cams and camshafts; cam faces should be free of ridges, cracks and flat spots. Camshaft bearing journals should be smooth. Check for cracked or deformed splines.

Wiggle the S-cam up and down to check for radial play, and in and out to check for end play. Generally, only a few hundredths of an inch in either direction is permitted. Excessive play can cause uneven application and brake chatter.

If it's a close call, use a dial indicator to be sure.

Check chamber brackets for

Continued



Heat discoloration and cracking inside brake drum can be caused by dragging brake at that axle end, or by an out-of-adjustment condition elsewhere on vehicle.

cracks, bends, looseness, and worn or damaged bushings (or bearings, if so equipped) and seals. The chambers themselves should be examined for cracks, clogged vent holes, bent pushrods, and for loose mountings, air fittings and clamp rings. Likewise, brake adjusters should be checked for cracks, damaged splines, worn clevis pin bushings and sticky adjustment nuts.

Examine return springs carefully. Better yet, don't re-use them. "Return springs are highly stressed," warns Rockwell's McNorton. "If they are even slightly corroded, there's a good chance they'll fail."

All of the above checks can be performed fairly quickly, but they require some attention to detail and a little judgment, which suggests that brake mechanics ought to be a pretty well-trained bunch. In reality, though, that's often not the case. "It amazes me," McNorton says. "In Europe, a brake mechanic is highly regarded. Here, it seems that the first job a guy gets after floor-sweeping duty is brake work." In an effort to reverse that trend, many brake system and component manufacturers offer seminars and clinics for brake mechanics. Taking advantage of these may be one of the smartest ways to spend brake maintenance dollars. A list of air brake training opportunities is provided near the end of this manual.

Miscellaneous tips

The following additional recommendations are offered by AlliedSignal's Durack, Midland's Wittenberg and Rockwell's McNorton:

- 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 purge an air system, so what goes in stays in. Accumulated foreign matter will eventually interfere with proper system operation. Also, air lines should be suspended well above deck plates to prevent hose chafing.
- Wherever possible, specify that brakes be mounted so that, as they are applied, S-cams rotate in the same direction as the wheels they serve. When S-cams apply opposite the direction of wheel rotation, hardware and linings wear out more quickly, and brakes are noisier.
- Don't let the compressor unloader be the forgotten component. Once a year, remove and lubricate it, and replace all rubber parts.
- Don't mix manual and automatic brake adjusters on a vehicle. That's asking for an adjustment imbalance.

If you must do it, never mix them on the same axle.

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

Maintaining brake systems before trouble occurs will prevent lots of problems and minimize ones that crop up.

"You could take the approach, 'Fix it when it breaks," summarizes AlliedSignal's Durack. "But in the long run, it's going to cost you." ❑

Rockwell Stopping System™ Expertise

You never know what's coming...what's hiding around the next bend in the road. A sheet of ice. A stalled vehicle. A washed-out bridge. All you know is that you'd better be ready to hit the brakes at a moment's notice in order to stop your rig safe and sound.

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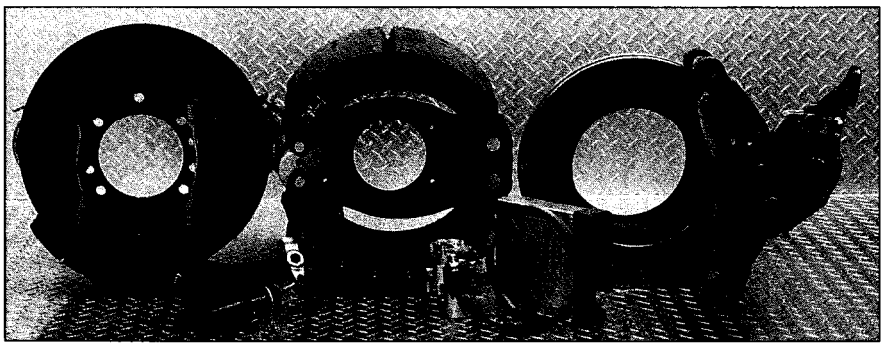
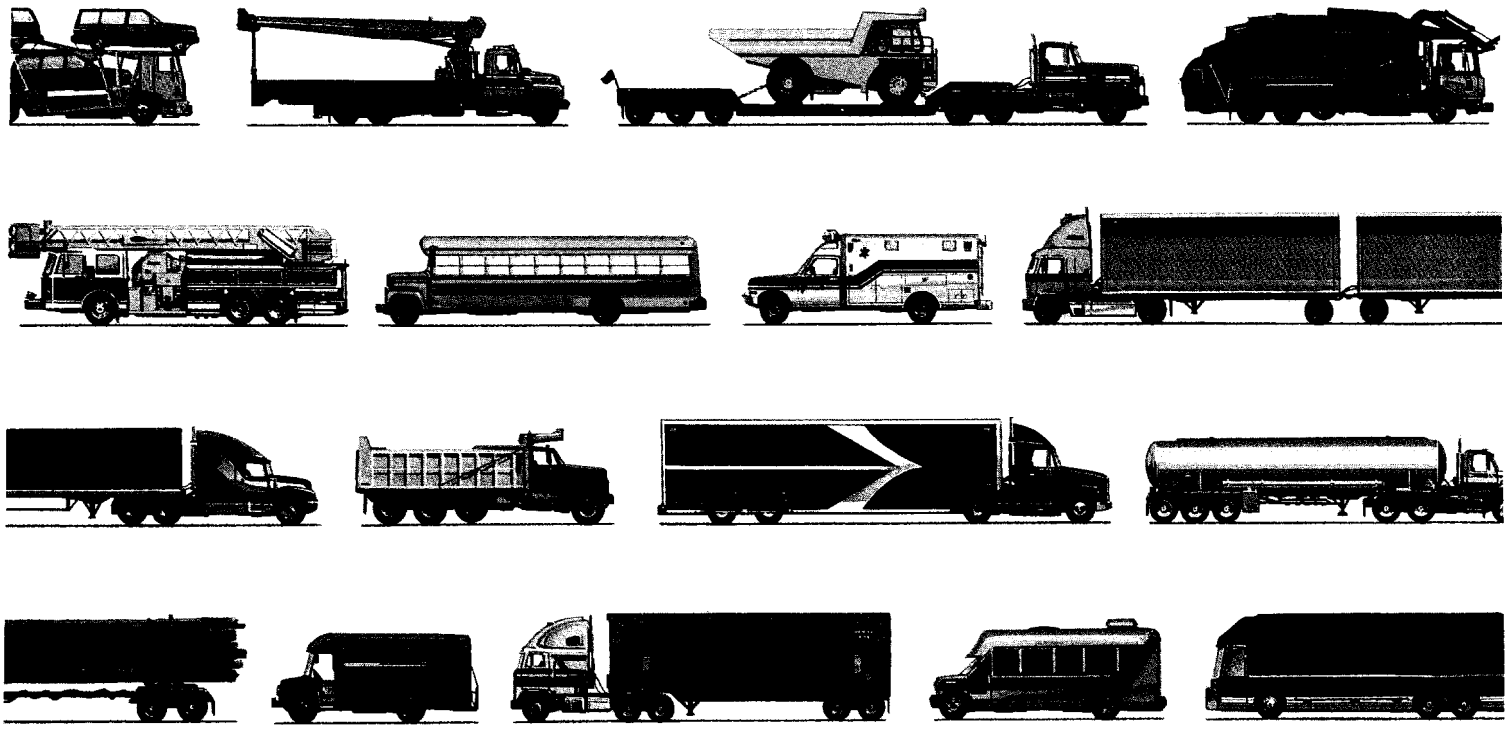


Rockwell

Q. How do you stop millions of rigs every day?

A. Very carefully.



Restoring S-CAM Performance

There's more to a brake job than swapping shoes. Restoring the system to original condition will yield safer stops and longer intervals between relines.

By PAUL RICHARDS, Technical Editor

When rebuilding an engine, no conscientious mechanic would toss in a new set of rings and neglect to look at the condition of liners, pistons, valves, heads, and other vital parts.

Why? Because the engine is a **system** of components working together. Individual components depend on each other to perform properly.

The same is true of the foundation brakes. Observing the condition of all brake components when performing a brake reline will explain premature lining wear or brake performance problems, and head off future troubles.

Most experts agree that minimum acceptable lining thickness is 1/4 in., which should be slightly above the rivet heads. There is a possibility of drum scoring or camshaft turnover when the lining is less than minimum thickness. Regard reline time as an opportunity to restore total system performance.

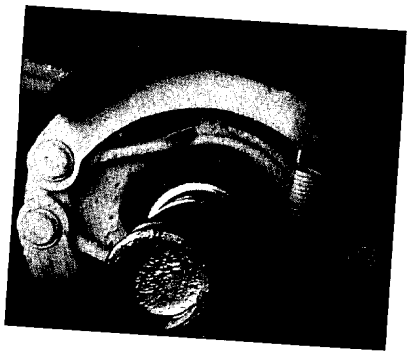
Start with slack adjusters

A good place to begin is by inspecting the slack (brake) adjusters. Manual and automatic slack operation should be checked by adjusting the brake to force the lining against the drum. As contact is made, you should feel resistance through your wrench. No or little resistance as you tighten up means the slack's adjustment mechanism is broken, and the slack adjuster should be replaced. With an automatic slack adjuster, follow the manufacturer's directions for adjusting. It may be necessary to remove the self-adjusting pawl before the slack can be manually adjusted.

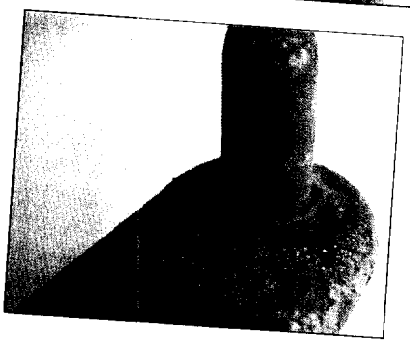
Check cam splines for wear. Excessive wear allows lost motion between the slack adjuster and camshaft. Replace the camshaft and/or slack if there is more than .020 in. free movement between slack and camshaft.

While you're at it, check the clearance between the slack clevis pin and its bushing. Clearance should not exceed .020 in. Continued

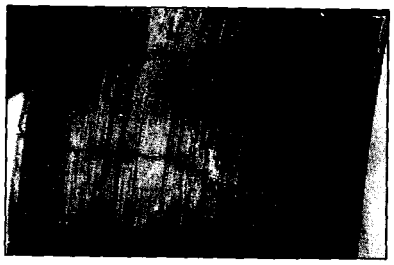
Tapered wear results from worn anchor pins, holes or brushings, or worn outer S-cam bushings These allow applied force to push shoes to one side. This condition often is accompanied by outer edge abrasion on brake shoes, caused by the shoes tracking out of alignment.



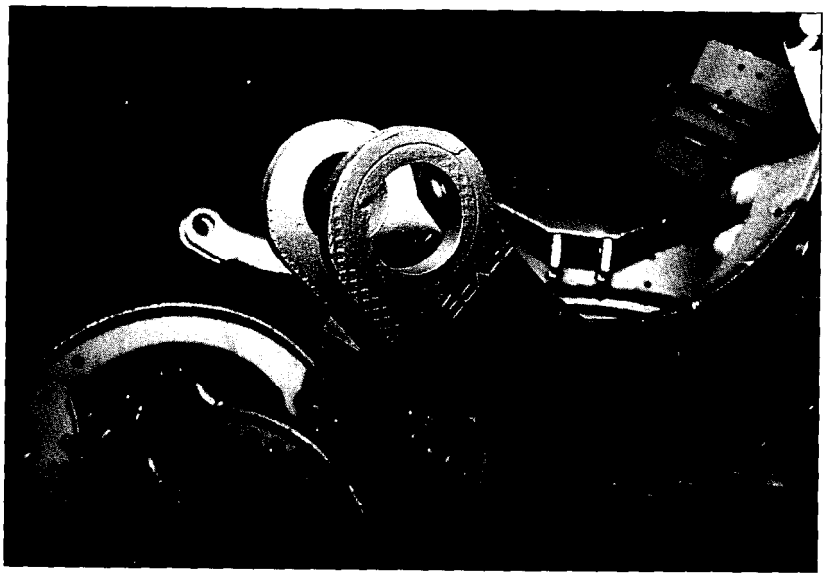
Unequal lining wear between leading and trailing ends of shoe may mean weak return spring, worn outer S-cam bushing, or out-of-arc shoe.



Check clearance between slack clevis pin and its bushing. Replace bushing and/or pin if clearance exceeds .020 in.



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



Look for distorted anchor pin holes. If elongated, proper adjustment is impossible, and tapered wear is likely.

If slacks are to be removed, do yourself (or the next guy) a favor. When reinstalling a slack, use an anti-seize compound on the camshaft splines to make it easier to remove next time.

Interpret shoe wear

Don't just throw old shoes in the core bin. Look at 'em. Lining wear should be even around the circumference of the brake assembly, and from inboard to outboard. More wear on the bottom, top or one side could indicate that peripheral brake hardware is worn. When that's the case, brakes can't be properly adjusted.

For example, look for tapered wear, a condition where the shoes show more wear at the inboard or outboard side, rather than wear that's uniform. Worn anchor pins, holes and bushings, or outer S-cam bushings can allow applied force to push the shoes to one side, resulting in tapered lining wear.

This condition often is accompanied by outer edge abrasion on the brake shoes. This is caused by the shoes tracking out of alignment due to worn parts. Reusing shoe rollers and anchor pins, therefore, is not recommended.

Note: 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 anchor pins are stubborn, douse them with a light, penetrating oil, let the oil work in, and tap them out as gently as possible. Or use a puller designed for that purpose.

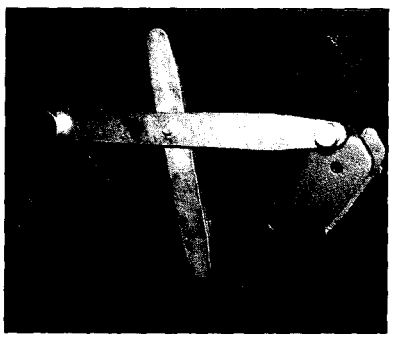
Clean the spider with a solvent and/or wire brush, and inspect for broken welds or cracks in the camshaft and anchor pin areas. Check tightness of the spider securing bolts, and be sure the spider is not bent-the anchor pin holes must be parallel to the centerline of the axle. Otherwise, the shoes won't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

Don't confuse tapered lining wear with a high ridge on the inside edge of the linings. This is actually beneficial, as it prevents a lip being etched into the drum, and makes drum removal easier. It also helps keep water and contaminants out of the brake assembly.

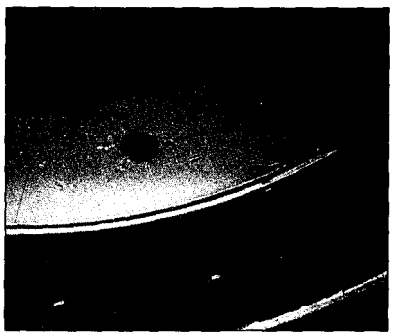
Unequal lining wear between the leading and trailing ends of a shoe may be the result of a weak return spring, a worn outer S-cam bushing, or an out-of-arc shoe.

Attempting to adjust a brake with any of these conditions will result in dragging and high contact pressure at one spot of the lining. This will lead to rapid lining wear and heat damage to the drum.

Are any linings cracked? If so,

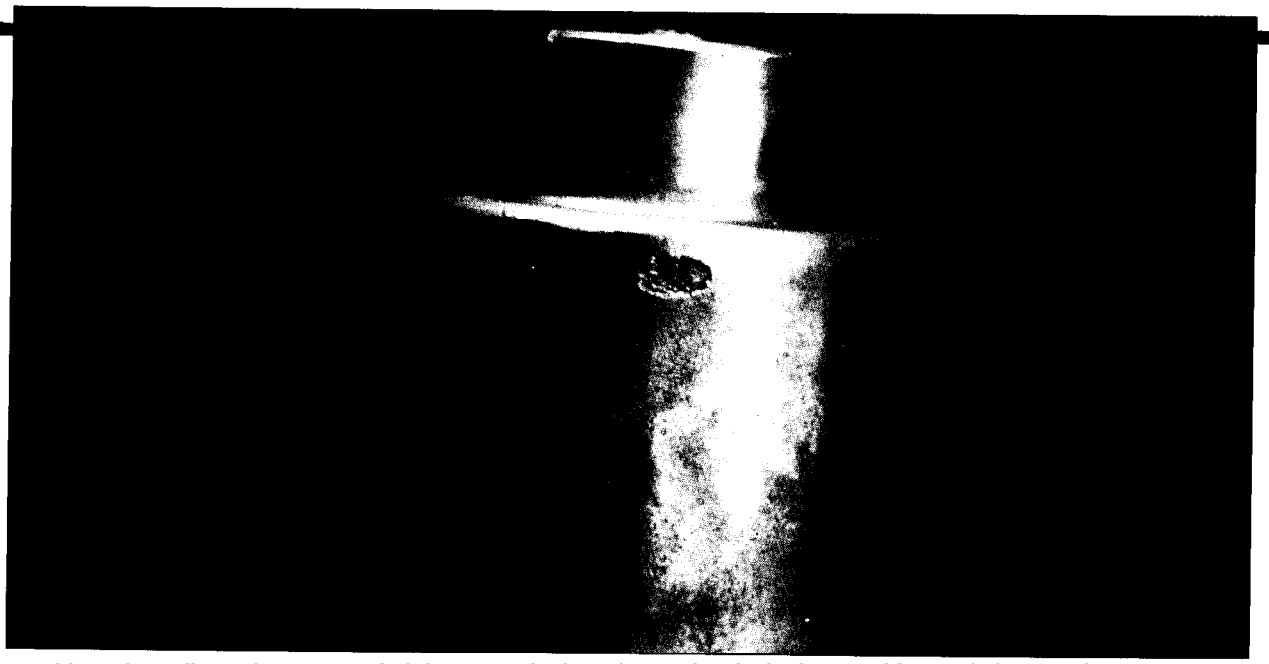


Always check replacement shoe's dimensions-don't assume arc is correct.

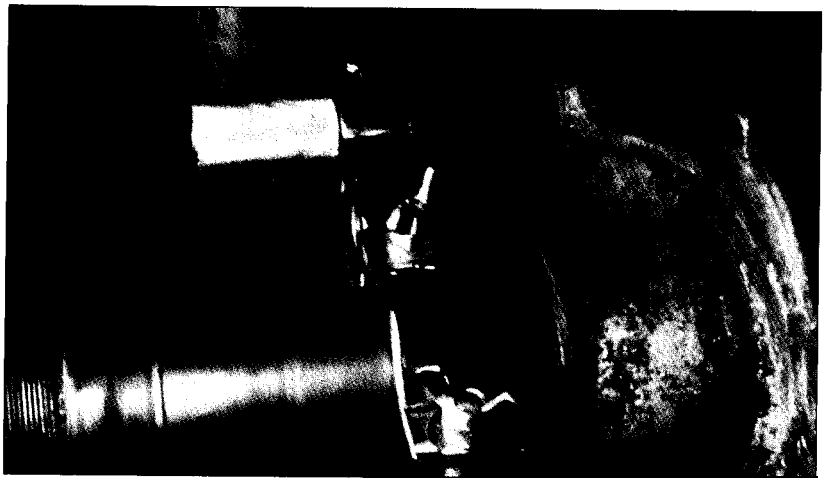


Tiny marks around spring retainer hole (center of photo) are from removing retainer for reline. Three marks likely mean three relines– cause to suspect dimensions and hole sizes.

it's a good bet that they were loose on the shoe. This can be caused by a shoe that's out of arc, rust buildup on the shoe surface, or improper riveting. When replacing the shoes,



Avoid reusing rollers. Flat spots and pitting cause brake noise, and make brakes "grabby" and slow to release.



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

make sure the lining is tight and follows the contour of the shoe. Always check a replacement shoe's dimensions-don't assume it's okay just because it's got new lining.

When choosing new or rebuilt shoes or new friction material, stay with name brands. "Bargain" products are likely to give you more trouble than you bargained for.

If linings are contaminated with oil or grease, correct the cause before relining. 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 the lining is otherwise okay, but an area no larger than 10% of the total lining area is contaminated by grease or oil, 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.

Don't overlook hardware, drums

Check cam bearing surfaces for wear. Replace cam if wear exceeds .010 in. A cam that's within tolerance, but has deep grooves caused by the seals can be reused. But it will admit abrasive contaminants and accelerate bearing and cam wear. The cam bearing should be replaced at each reline.

Carefully look at the S-cam and rollers for flat spots and irregularities. An irregular surface on these parts will cause brake noise and make brakes "grabby" and slow to release. If in doubt, throw it out.

Return springs are inexpensive, and there's almost no excuse for reusing them...but, if you must, be sure they're not stretched, broken or corroded.

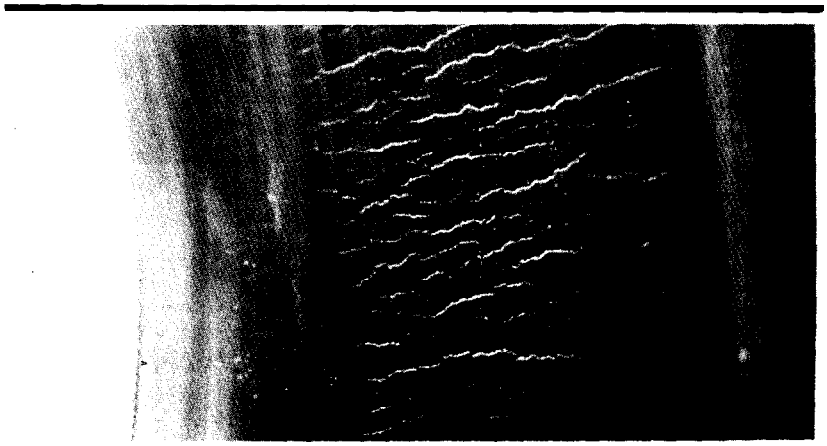
When reassembling, don't forget to lube the cam bearing and seals, and anchor pin bores and bushings.

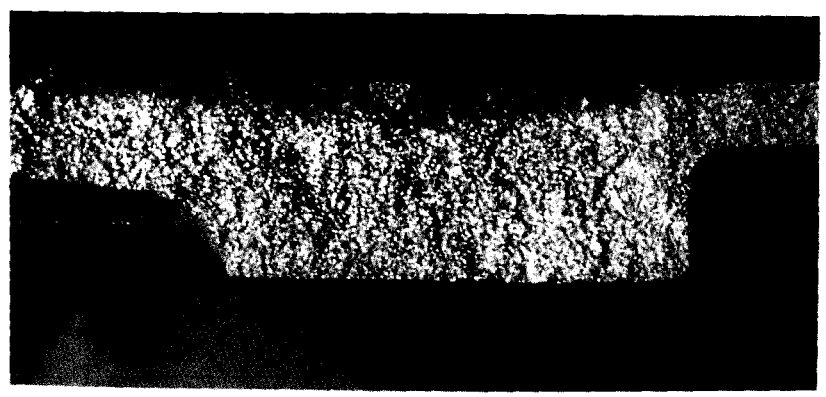
No matter how good a reline you've done, the linings must have a smooth, round drum to rub against. Light scoring and abrasion are okay, as long as they're no deeper than .010 in. A drum with surface heat checks should be periodically inspected. The checks may wear away. But if it's obvious that they are getting worse, discard the drum. Needless to say, any crack through the drum's thickness means the drum should be scrapped.

To check for roundness, 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 in. of each other, the drum can be cut or rotated one bolt hole and rechecked. If severely out of round, the drum should be discarded.

Whether a drum should be cut (turned) is a matter of debate.

Continued





Left: Replace cam if bearing surface wear exceeds .010 in. Deep seal grooves admit abrasive contaminants and accelerate bearing and cam wear. Below left: Mild scoring (less than .010 in.) and tight heat checking inside drum are acceptable..

Legally, it's permissible to cut a heavy-duty drum to .080 in. oversize, but bear in mind that the radius of the new lining won't match that of the drum. Reduced braking performance and lining damage will result.

Also remember that one of a drum's jobs is to absorb heat, and the heavier the drum, the more heat it can absorb. Turning a drum removes valuable metal and reduces the drum's effectiveness.

If you want top performance, replace drums as wear approaches .080 in.

The key to a good reline is to remember that brakes are a ***system*** of components working together to get the job done. If part of the system isn't right, the system isn't right.

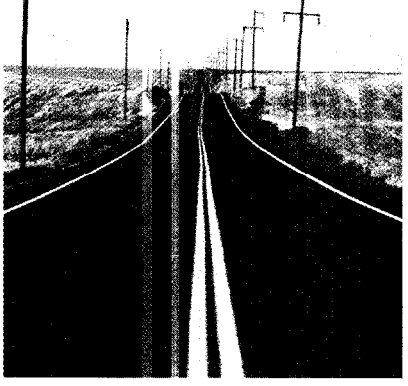
If you extend that line of thinking, the same is true of the entire vehicle. Wheel seals, bearings, axles-anything you touch during a brake job should be treated with the same respect given the brake components. Bring everything as close as possible to original condition, and you won't be sorry.

It costs more up front, but a thorough job will pay for itself in long life and trouble-free operation. ❑

Editor's note: Special thanks to NAPA Rayloc, Atlanta, Ga., and, especially, to Lanny Edwards, NAPA heavy-duty specialist, for their help in preparing this article. Photos courtesy of NAPA Rayloc.

Above left: *Deep* heat *cracks* lead *to drum failure.* Left: Cross-section of failed drum shows crack progression.

They may tell you this is the only way to go-



But, what about where you need to go?

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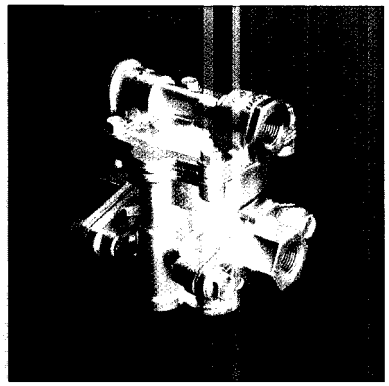
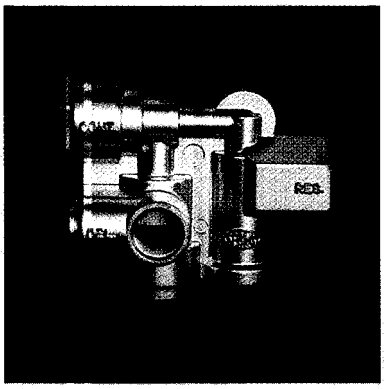
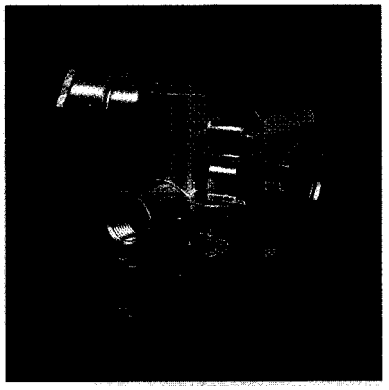


Protected Reservoir System



Spring Brake Priority System



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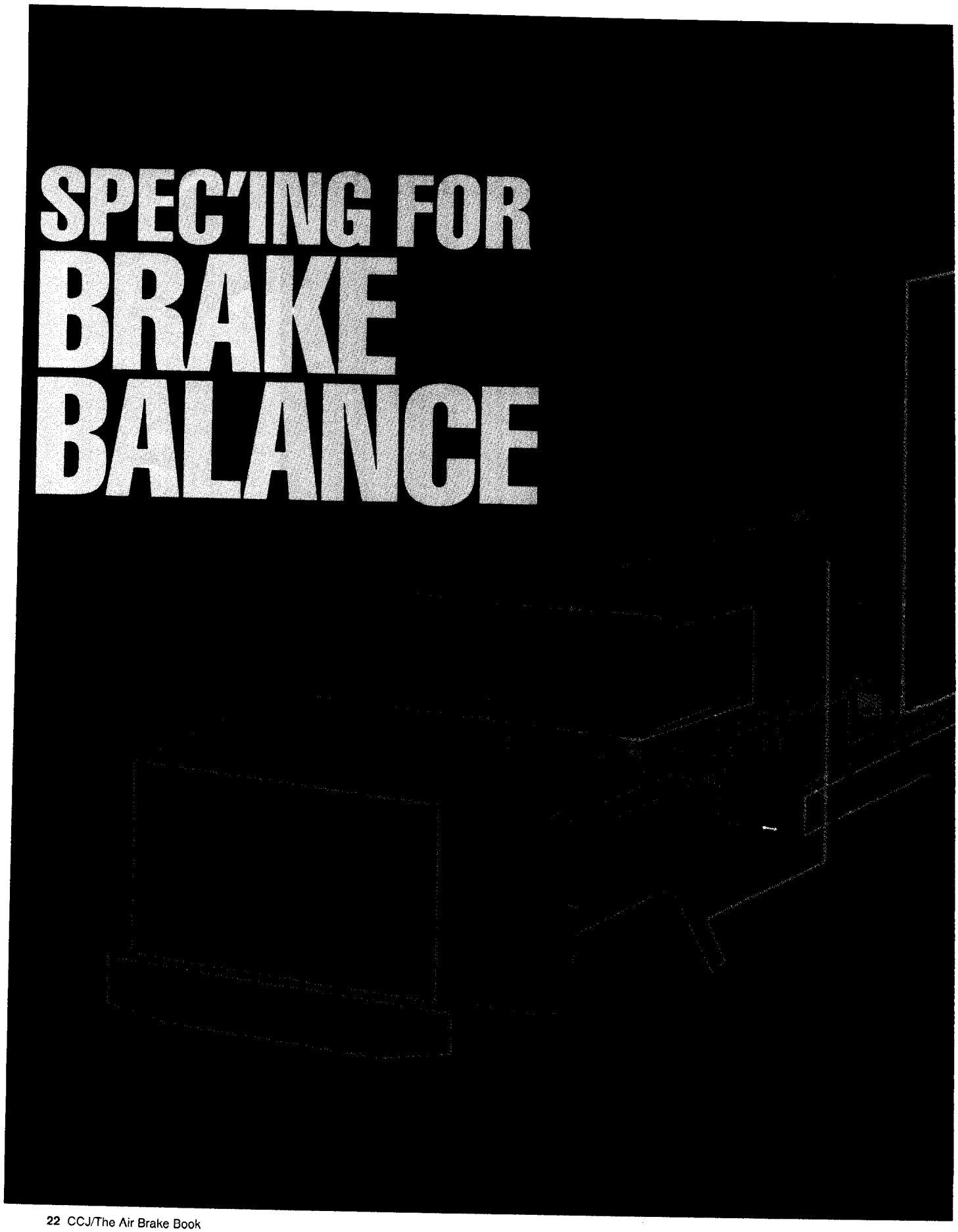
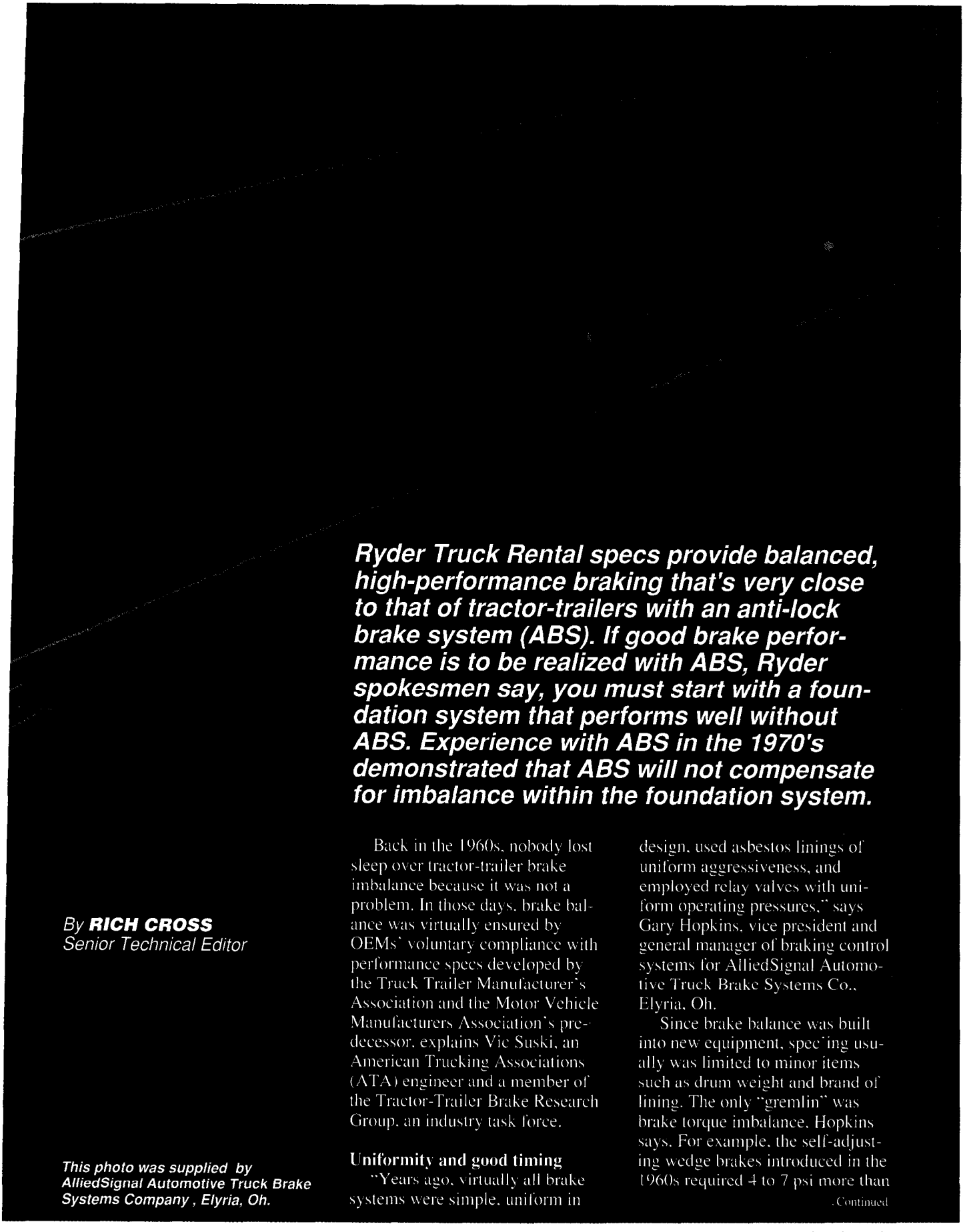
SPEC'ING FOR BRAKE BALANCE





Ryder Truck Rental specs provide balanced, high-performance braking that's very close to that of tractor-trailers with an anti-lock brake system (ABS). If good brake performance is to be realized with ABS, Ryder spokesmen say, you must start with a foundation system that performs well without ABS. Experience with ABS in the 1970's demonstrated that ABS will not compensate for imbalance within the foundation system.

By ***RICH CROSS***
Senior Technical Editor

This photo was supplied by AlliedSignal Automotive Truck Brake Systems Company , Elyria, Oh.

Back in the 1960s, nobody lost sleep over tractor-trailer brake imbalance because it was not a problem. In those days, brake balance was virtually ensured by OEMs' voluntary compliance with performance specs developed by the Truck Trailer Manufacturer's Association and the Motor Vehicle Manufacturers Association's predecessor, explains Vic Suski, an American Trucking Associations (ATA) engineer and a member of the Tractor-Trailer Brake Research Group, an industry task force.

Uniformity and good timing

"Years ago, virtually all brake systems were simple, uniform in design, used asbestos linings of uniform aggressiveness, and employed relay valves with uniform operating pressures," says Gary Hopkins, vice president and general manager of braking control systems for AlliedSignal Automotive Truck Brake Systems Co., Elyria, Oh.

Since brake balance was built into new equipment, spec'ing usually was limited to minor items such as drum weight and brand of lining. The only "gremlin" was brake torque imbalance, Hopkins says. For example, the self-adjusting wedge brakes introduced in the 1960s required 4 to 7 psi more than

Continued

S-cam brakes to make shoes contact the drum, resulting in a 50% torque variation at actuation pressures below 15 psi.

In general, balanced braking was simple to achieve until the decade of the 1970s, says Larry Strawhorn, ATA's vice president of engineering.

No uniformity and bad timing

The approach of the 1970s heralded an era when news media began focusing on "Killer Trucks" unable to stop in time to avoid a collision.

Fleetmen attributed "truck-involved" (not necessarily truck-caused) accidents to everything from sloppy brake maintenance to rampant tailgating, claiming the current brake designs were more than adequate.

But Uncle Sam disagreed. He reached into his hat for a magical panacea and came up with the infamous Federal Motor Vehicle Safety Standard 121. FMVSS-121 mandated stopping distances that only could be met with anti-lock (i.e. anti-skid) brake systems.

Proposed in 1970 by the National Highway Traffic Safety Administration, FMVSS 12 1 didn't become effective until 1975. Despite the delay, final regulation proceeded so quickly that anti-lock systems had to be designed hastily, without adequate field-testing or fine-tuning.

Because every vehicle maker choose a different route to compliance, FMVSS 121 introduced a Pandora's box of brake system variables, including:

- a hodgepodge of relay valves smaller than previous models that varied substantially in crack pressures, release pressures and flow characteristics;
- asbestos linings that varied substantially in aggressiveness and rate of wear;
- very fast, aggressive brakes, with mandatory front brakes;
- a built-in timing imbalance, thanks to a tractor-simulator with excessively large air reservoirs. To be compatible. trailers needed large, control air lines...1/2-in. OD (3/8-in. ID) instead of the 3/8-in. OD (1/4-in. ID) lines previously used. Typically, a real-world tractor would "lose its breath" trying to fill the culvert-size lines on a 121-trailer. So trailer braking often was delayed, Suski says.

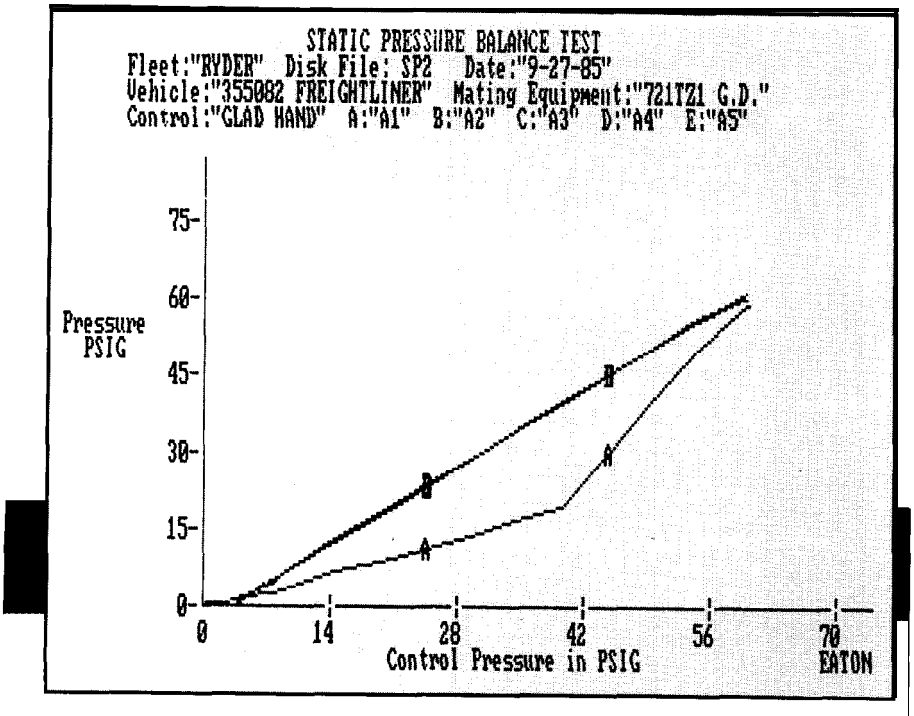
First-generation anti-lock sensors and black boxes connected to OEM-supplied wiring harnesses were poor at best. Further, anti-skid components "were not rugged enough to survive the low level and lack of sophistication of truck maintenance procedures," according to an analysis of FMVSS-121 published by The Insurance Institute for Highway Safety (IIHS) , Arlington, Va.

Within 18 months of FMVSS-121's effective date, only 20% of anti-lock-equipped fleets had acquired suitable diagnostic equipment, and only 15% had trained their mechanics about the intricacies of anti-lock, IIHS says.

FMVSS-121 generated a vast increase in the number of maladjusted brakes, IIHS claims, because aggressive brakes caused

60-mph Stopping Distance Test of Ryder Unit at 80,490 lb GCW

Tractor:	Freightliner FLD 12064ST tandem-axle conventional
Front Axle	12,000-lb-rated, loaded to 11,790 lb for test Rockwell 15 X 4 in. brakes Rockwell automatic slack adjusters Type 20 brake chambers Abex 3030-197 non-asbestos linings Bendix LQ5 proportioning valve Bridgestone R-299 295/75R22.5 low-profile tires
Drive Axles:	17,000/34,000-lb-rated, loaded to 34,220 lb for test Rockwell 16 1/2 X 7 in. brakes Rockwell automatic slack adjusters MGM Type 30 spring brake chambers Abex 3030-197 non-asbestos linings Bridgestone M-71 1295/75R22.5 low-profile tires
Trailer:	Fruehauf tandem-axle 48-ft dry freight van
Trailer Axles:	20,000/40,000-lb-rated, loaded to 34,480 lb for test Rockwell 16 1/2 X 7 in. brakes Rockwell automatic slack adjusters MGM Type 30 spring brake chambers Abex 3030-197 non-asbestos linings Bridgestone R-194 295/75R22.5 low-profile tires
First Stop:	254 ft (full-pedal application) with no axle lockup
Second Stop:	254 ft (full-pedal application) with no axle lockup
Third Stop:	258 ft (full-pedal application) with no axle lockup
Fourth Stop:	255 ft (full-pedal application) with no axle lockup



Bottom line (A) shows how LQ5 proportioning valve reduces Ryder's front-axle braking by 50% during applications to 40 psi. braking at 40 to 60 psi is reduced by less than 50%, and full braking is provided at anything above 60 psi.
Top line (B) depicts perfect pressure balance between tractor tandem and trailer tandem. During panic stops, the brakes on all five axles are balanced.

Tractor-Trailer Torque Balance Ratio:

$$\frac{\text{Tractor Weight}}{\text{Trailer Weight}} \times \frac{\text{Trailer Deceleraton}}{\text{Tractor Deceleration}} = 1.00 \text{ (Perfect)}$$

Torque Balance at 20 mph, 20 psi:

$$\frac{44{,}770 \text{ lb}}{35{,}280 \text{ lb}} \times \frac{2.09 \text{ ft/sec/sec}}{2.60 \text{ ft/sec/sec}} = 1.02$$

Torque Balance at 60 mph, 40 psi:

$$\frac{44{,}770 \text{ lb}}{35{,}280 \text{ lb}} \times \frac{2.89 \text{ ft/sec/sec}}{3.06 \text{ ft/sec/sec}} = 1.19$$

linings (especially those on tractors) to wear quickly. In witness of that fact, Ryder Truck Rental's director of maintenance, Blaine Johnson, attributes a 70% to 80% reduction in lining and drum life to the influence of FMVSS- 12 1.

But most fleetmen were forced to leave their brake spec'ing solely to the OEMs because of the need to certify vehicle compliance with FMVSS- 12 1.

Much to NHTSA's dismay, it became evident that FMVSS- 12 1 created more problems than it solved. Fleetmen began telling horror stories about potentially-dangerous incompatibility of pre- 12 1 and post- 12 l equipment. And odd brake failures, such as faulty wheel sensors causing brakes to be released instead of applied, gave anti-lock a bad reputation.

In 1978, a storm of protest rained on NHTSA's parade with a vengeance. And a lawsuit by PACCAR finally resulted in FMVSS- 12 1 stopping-distance provisions (and anti-lock) being dropped.

Mild brakes return, but...

"The demise of FMVSS- 12 1 generated a mad scramble on the part of vehicle makers to reduce the complexity and the number of brake controls and to de-power their systems," Johnson says. "The results were disturbing because every OEM went about de-powering in a different way. Some opted for less-aggressive linings and/or front-axle limiting valves, while others used smaller chambers, different slack adjuster lengths, valves with hold-off springs and different crack pressures, or a combination of ingredients."

The enduring legacy of FMVSS- 12 l, Johnson says, is a mind-boggling lack of uniformity among brake system components.

Uniformity sought, again

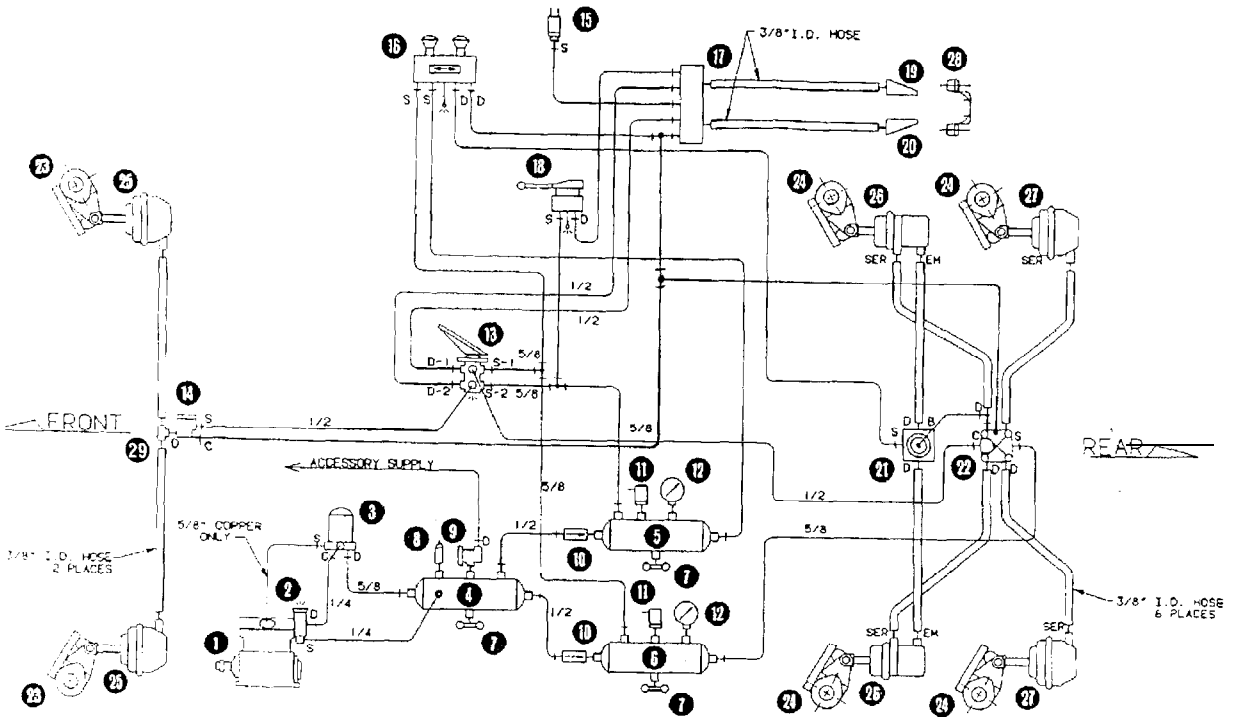
Industry groups are pursuing the development of performance standards, akin to those of the '60s, for brake valves and linings. Continued

AIR BRAKE SYSTEM FOR

PORT LEGEND	
B	Balance
C	Control
D	Delivery
EM	Emergency
|/	Exhaust
SER	Service
S	Supply

LIST OF MATERIAL

Item No.	Quantity	Model	Description
1	1	TF-550	Air compressor
2	1	D-2	Governor
3	1	AD-9	Air Dryer
4	1		Reservoir-supply
5	1		Reservoir-service-front
6	1		Reservoir-service-rear
7	3		Drain cock
8	1	ST-3	Safety valve
9	1	PR-4	Pressure protection valve
10	2	SC-1	Single check valve
11	2	LP-3	Low pressure indicator
12	2		Air pressure gage
13	1	E-6/7	Dual brake valve
14	1	LQ-5	Bobtail ratio valve
15	1	SL-5	Stop light switch
16	1	MV-3	Modular dash control valve
17	1	TP-5	Tractor protection valve
18	1	TC-2/TC-7	Trailer control valve (optional)
19	1		Trailer hose assembly-control
20	1		Trailer hose assembly-supply
21	1	QR-1 C	Quick release with double check valve
22	1	B P - R 1	Relay valve (4psi nom crack press)
23	2	ASA-5	Slack adj.-front-automatic
24	4	ASA-5	Slack adj.-rear-automatic
25	2		Brake chamber-front
26	2		Spring brake actuator-mid
27	1		Brake chamber-rear
28	1		Dual dummy coupling
29	1	QR-1	Quick release valve



A TANDEM AXLE TRACTOR

RYDER BRAKE EQUIPMENT SPECIFICATION

Control Valves	– Bendix PP-1, PP-7 & PP–8/PP-1 push control valves and a DC-4 double check may be used in place of the MV-3 illustrated. Refer to Bendix drawing SA-8165-76 for "Tractor Park" and SA-8165-37 for "Trailer Charge" three button installations.
	Bendix TP-3 tractor protection valve, quick release valve and two double check valves may be used in place of the TP-5 illustrated.
Foundation Brakes	– Steer axle -15 in. x 4 in. Rockwell "Q"
	Drive/rear axles -16.5 in. x 7 in. Rockwell "Q"
	Drums – Cast iron, balanced, outboard mounted, 108 lb
	Linings – Abex non-asbestos 3030-l 97
Chambers	– Steer axle – Type 20 brake chambers
	Drive/rear axles – Type 30 MGM spring brakes
Slack Adjusters	– Steer axle – 5.5 in. automatic
	Drive/rear axles – 5.5 in. automatic with tire radius of 19.9 in. or larger 5.0 in. automatic with tire radius of 19.8 in. or smaller

In 1994, for example, the Society of Automotive Engineers (SAE), Warrendale, Pa., and ATA's The Maintenance Council (TMC) , Alexandria, Va., agreed upon laboratory test procedures that makers of brake lining may use to certify their products as compliant with meaningful friction ratings.

By 1995, SAE is scheduled to develop a list of qualifications for brake-lining test labs (including those operated by lining makers). Subsequently, plans call for an SAE review board to examine test data and either "pass" or "fail" a lining on that basis. A list of linings approved by the review board would then be published, and distributed publically.

Now, let's return to a review of brake regulation. Modification of the tractor simulator plagued by excessively large air reservoirs became mandatory on May 3, 199 1. Also mandatory on that date for new vehicles were revised maximum application and release times, plus new requirements for gladhand timing.

Between June 2, 1989, and May 3, 1991, each trailer manufacturer had three options: meet existing requirements, using the unmodified tractor simulator; meet revised requirements, using a modified tractor simulator; meet requirements which are approximately equivalent to existing requirements, using a modified tractor simulator.

Asked whose specs appear to work especially well, Suski praises Ryder Truck Rental's brake system which provides "outstanding stopping distances and controllability."

Spec everything, Ryder says

The key to brake balance is spec'ing each and every piece of hardware on a tractor, trailer and converter dolly, Johnson says. The point is, leaving component selection to the whim of vehicle makers can still lead to imbalance requiring corrective tinkering.

Ryder's equipment performance approximates FMVSS- 12 1 's original stopping distance requirement -245 ft-when braking at 60 mph.

To demonstrate this fact, Ryder spec'ed a tandem-axle Freightliner conventional and 48-ft tandem-axle trailer and sent the combination to Bendix's test track.

With an 80,000-lb GCW, the tractor-trailer's best stop was 254 ft from 60 mph, with no lockup at any axle.

Its worst performance was a 258-ft stop from 60 mph, with no lockup.

Ryder's brake specs for tandem-axle tractors and tandem-axle trailers appear on the diagrams in this article.

By specifying every valve, you can dictate nominal crack pressure (the inlet pressure required to open the valve) and pressure differential (the difference between inlet and outlet pressures), Johnson says.

Ideally, you don't want control

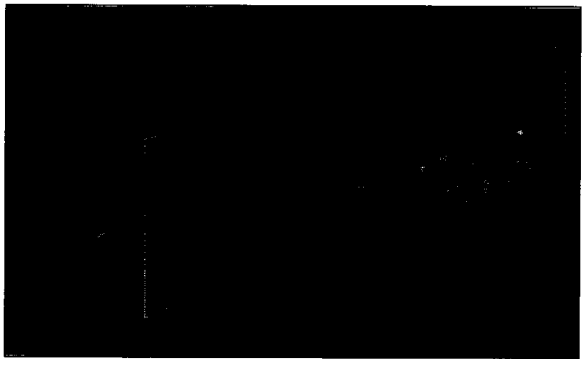
Continued

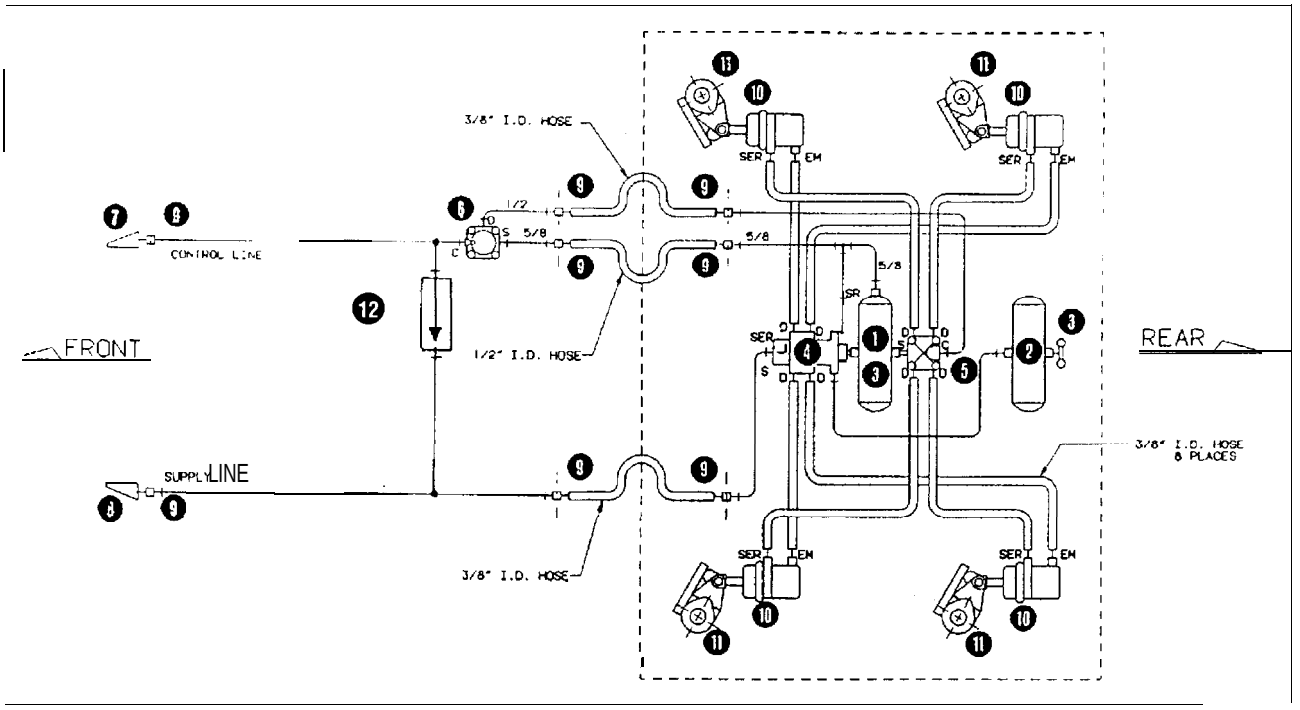
AIR BRAKE SYSTEM FOR A

PORT LEGEND	
C	Control
D	Delivery
EM	Emergency
\ I /	Exhaust
SER	Service
S	Supply
SR	Ser Reservoir

LIST OF MATERIAL

Item No.	Qty.	Model	O.E.M. Piece No.	Description
1	1		101127	Reservoir-service
2	1		101128	Reservoir-service
3	2			Drain valve
4	1	SR-5	102831	Trailer valve assembly
5	1	R-12/14		Relay valve (4 psi nom crack press)
6	1	R-8P	287114	Pilot relay valve
7	1	HC-2		Coupling-control
8	1	HC-2		Coupling-supply
9	8			Anchor fitting
10	4			Spring brake acturator
11	4	ASA-5		Slack adjuster-automatic
12	1	SC-1	226691	Single checkvalve





TANDEM "SLIDING AXLE" TRAILER

RYDER BRAKE EQUIPMENT SPECIFICATION

Foundation Brakes	– 16.5 in. x 7 in. Rockwell "Q" Drums – cast iron, balanced, outboard mounted Linings – Abex non-asbestos 3030-l 97
Chambers	– Type 30 MGM spring brakes
Slack Adjusters	– 6.0 in. automatic with tire radius of 19.9 in. or larger 5.5 in. automatic with tire radius of 19.8 in. or smaller

line pressures to vary by more than 2 psi from one end of a combination to the other. That will eliminate most air distribution imbalance.

To keep relay valves from gumming up and slowing down, Ryder specs a Bendix AD-9 air dryer.

Thanks to dry air, the fleet has had no problems with sticking valves during its vehicle retention period of five years or 500,000 miles.

Tires dictate slack length

To avoid torque imbalance, Ryder specs linings, chambers, and varies slack length for drive and trailer axles on the basis of tire radius, Johnson says.

Axles having low-profile tires lock at relatively low application pressures.

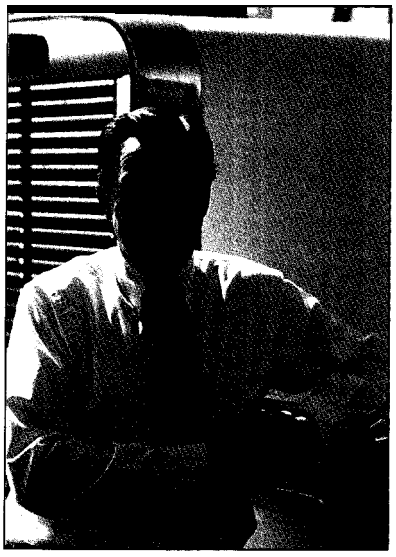
Therefore, axles with relatively small tires should be fitted with shorter slacks than axles with bigger rubber, according to Johnson. See diagrams for details.

"Before we spec'ed slacks on the basis of tire size, lightly-laden trailers would cause low-profile tires to lock and smoke at the approach to every toll booth. After tire size became a factor in our specs, we haven't had the problem," he says.

Ryder now specs Rockwell automatic slacks for most tractors, trailers and dollies.

If Rockwell units interfere with suspension parts, however, Ryder's spec reverts to Haldex or Bendix automatic slacks.

To ensure that slack adjusters are properly positioned on new equipment axles, Ryder maintenance personnel conduct spot checks, using plastic "installation templates" made by Rockwell. There are separate templates for tractors and trailers.



Blaine Johnson claims the enduring legacy of FMVSS-121 is a mind-boggling lack of uniformity among brake system components.

Big front brakes, but limited

Johnson is a strong promoter of aggressive front brakes and limiting valves because they:

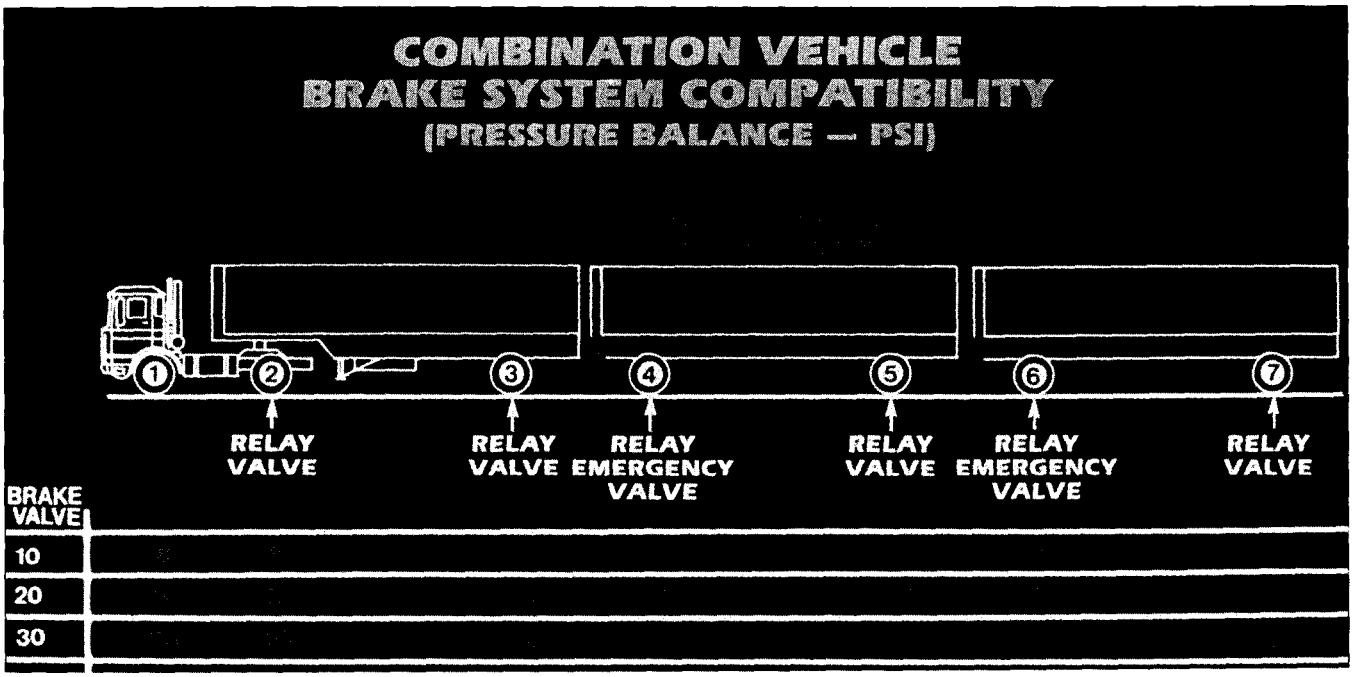
- reduce stopping distance better than weaker front brakes;
- reduce the risk of locking the drive axle(s) and causing a jackknife, especially when a trailer is empty or lightly loaded.

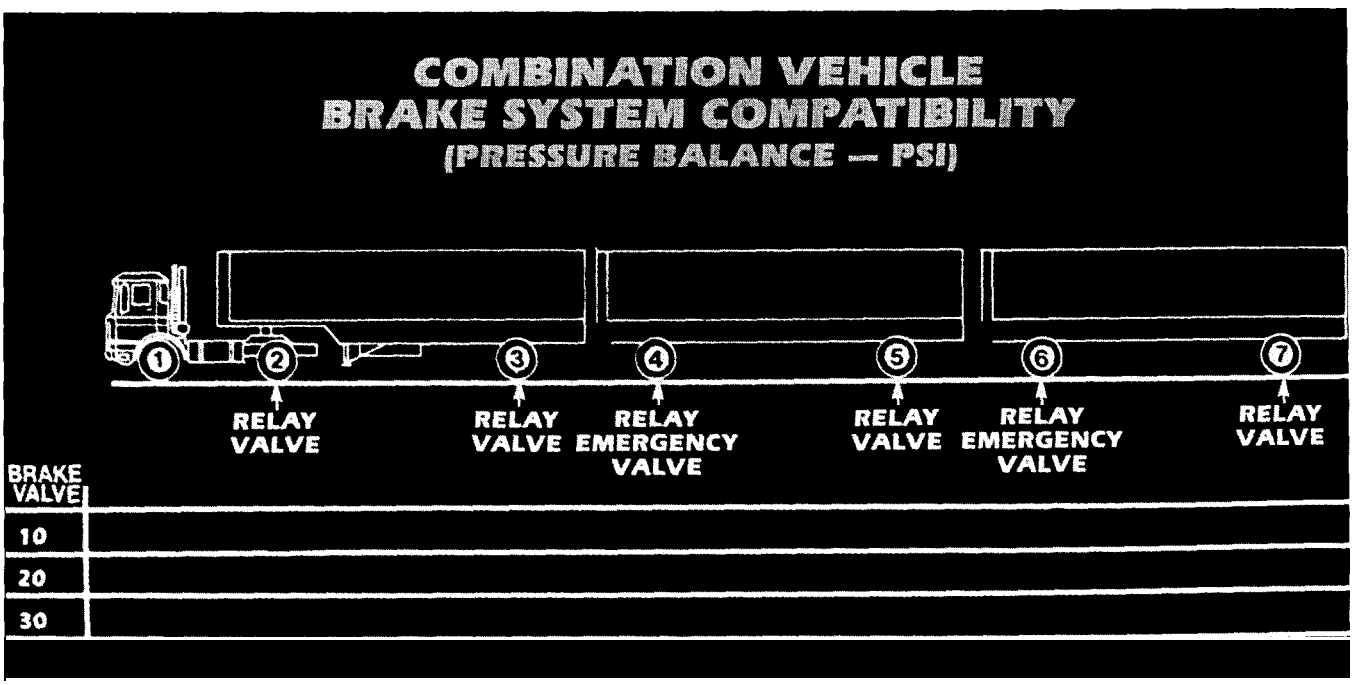
On the other hand, Johnson believes aggressive front brakes on a tractor can be dangerous without a limiting valve such as the Bendix LQ-5. An LQ-5 provides full brake torque during a panic stop, while eliminating the risk that mild braking on a slippery downgrade may lock the front axle and prevent steering around a curve, he says.

Specifically, an LQ-5 reduces front-axle braking by 50% during service applications up to 40 psi. Braking at 40 to 60 psi is reduced by less than 50%, and full braking is provided at anything above a 60-psi application (see graph).

As a result, drivers aren't paranoid about premature lockup, are less likely to back-off or plug front brakes, and have stronger-than-average front brakes at their disposal to reduce stopping distance in an emergency.

Ryder's straight trucks have essentially the same brake specs as tractors, except that a front axle limiting valve is deleted. Continued





Using Bendix dolly relay booster valves, initial 10 psi application degrades to 1 psi by the time it reaches rearmost axle. In contrast, Bendix R-8P pressure equalizing valve eliminates any pressure drop, ensuring pneumatic brake balance.

Keep specs flexible

At one time, Ryder's management thought about moving up to 16- x 5-in. front brakes.

Today, however, the fleet is satisfied with the performance of 15- x 4-in. S-cam front brakes with Type 20 chambers, according to Johnson.

Ryder's brake specs remain flexible, allowing for changes that immediately take advantage of new products.

Looking ahead, Johnson says he's keeping an open mind about the return of mandatory anti-lock brake systems.

He hopes that today's versions will be fail safe, reliable, easy to troubleshoot and simple to maintain. ❑

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Steve Howse
Technical Service Manager
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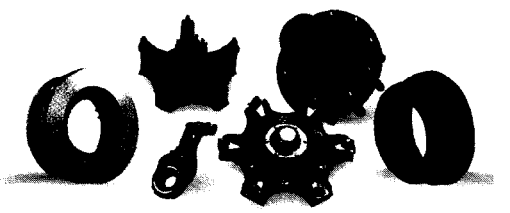

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TROUBLESHOOTING BRAKE BALANCE

Tractors that brake faster and more aggressively than trailers can cause rapid lining wear, loss of brake adjustment on tractors, bumping of tractors by trailers, jackknifing and panic stops with more panic than stop. Here is a look at causes and troubleshooting of brake system imbalance.

By RICH CROSS
Senior Technical Editor

Note: *This article is based upon technical literature provided by a wide variety of industry sources. Special thanks to brake consultant Richard Radlinski of Radlinski & Associates, East Liberty, Oh. and Sid Williams of the American Trucking Associations' engineering department, Alexandria, Va., for their assistance.*

A "Killer Truck," as defined by the news media, is a tractor-trailer unable to stop in time to avoid a fatal collision. Excessive stopping distances typically result from maladjusted brakes which exceed the readjustment limits specified by the Commercial Vehicle Safety Alliance in their out-of-service criteria.

Stopping distance is likely to increase 25% to 35% when all brakes on a heavily-laden combination vehicle are cool but maladjusted. When these maladjusted brakes become hot, causing drums to expand and brake-chamber stroke to increase, stopping distance easily can increase by 75% or more.

There's also a tendency for tractors to brake faster than pre-1991 trailers. Those trailers also tend to drag their brakes because they're slow to release.

Because overworked and dragging brakes can wear out linings in a jiffy, they often are not adjusted frequently enough to maintain good performance.

Automatic slack adjusters don't necessarily solve the problem because lack of maintenance and worn parts may cause them to fail or stop working properly.

To further muddy the water, a mix of automatic and manual slacks can unbalance the braking performance of a tractor-trailer that originally had no problem with over-braking or uneven lining wear. Brakes with properly-functioning automatic slacks always are on the job, promoting faster lining wear than manual slacks which are only adjusted periodically and provide reduced braking efficiency.

A tractor-trailer is said to be unbalanced if all brakes do not apply and release at the same time and/or fail to develop equivalent braking force.

Brake force imbalance can result from torque imbalance, pressure imbalance and/or different tire sizes.

Torque imbalance results from some brakes having more or less muscle than others due to: oil-soaked linings; mirror-polished drums and glazed linings; higher-friction linings; lack of uniform

drum-to-lining contact; drums beyond tolerance; tighter **adjustment**; bigger chambers; longer or improperly-installed slacks; overspec'ing of axle GVWR by a fleet.

Pneumatic or air pressure imbalance occurs when the tractor-trailer's system delivers different air pressures to brake chambers on the combination.

The most common causes are: the use of relay valves on the tractor and trailer which, by design, provide a different amount of pressure drop across the valves; improperly functioning relay valves. Quick-release valves also can have characteristics which upset pressure balance.

In turn, timing imbalance occurs when some brakes receive air faster than others. Common causes include: Federally-mandated use of oversized control lines on pre- 199 1 trailers, which slows brake application; poor plumbing design; failure to use booster valves, where appropriate.

Other **causes** of imbalance include: air leaks; a front-axle limiting valve; excessive use of the trolley valve.

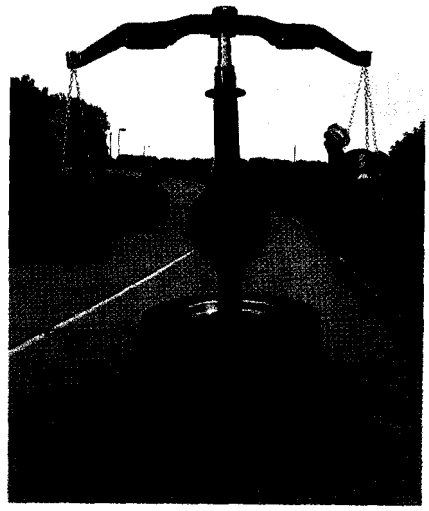
Low-pressure imbalance

If pre- 199 1 equipment causes driver complaints about trailers bumping tractors at low application pressures, Uncle Sam deserves some of the blame.

When Federal Motor Vehicle Safety Standard 12 l took effect in 1975, it required trailers to be compatible with a tractor simulator delivering a gale-force slug of air. To achieve compatibility, trailers needed l/2 -in. OD control lines (3/8-in. ID) lines instead of the 3/8-in. OD (1/4-in. ID) lines previously used.

During normal braking, a real-world tractor doesn't blow hard enough to fill the trailer's oversized control line quickly. Consequently, trailer braking is delayed, especially with multiple-trailer combinations. In some cases, the delay treats drivers to a disconcerting bump as the trailer smacks into the power unit. If push comes to shove when braking through a slippery curve, for **example**, a jackknife is possible.

Seeking to eliminate the delay, the National Highway Traffic Safety Administration (NHTSA) has: modified the tractor simulator; changed maximum application and release times for trailers; specified air-delivery times for control-line gladhands at the rear of tractors, towing trailers and dollies. Detailed in the *Federal Register* of May 3, 1989, the changes became mandatory on May 3, 199 l.



"Retrofit of remanufactured or aftermarket air valves can destroy pneumatic balance."

Trailer bumping can be eliminated by retrofitting a smaller control (service) line to the trailer and/or by making changes to the tractor that would speed gladhand timing. This would cause trailer brakes to apply faster during normal brake applications. And there shouldn't be any degradation of stopping distance during a panic stop.

Alternatively, tractor brake application can be slowed by a plumbing change. But slowing tractor brakes has the potential to adversely affect stopping distance, NHTSA warns.

Since a fleet **may have** twice as many trailers as tractors, making a change in the power unit's brake system tends to be more attractive.

For example, trailer brake release time can be cut in half by: adding a quick-release valve at the tractor protection valve; retrofitting a tractor with a combination quick-release valve and gladhand assembly.

One source of a combination valve is Phillips Industries of Montebello, Calif., whose "Quick Dumping Gladhand Service" device only takes a few minutes to install.

It must be strongly emphasized, however, that any brake modification ideally should have engineering approval by the vehicle OEM. An ill-advised deviation from OEM plumbing may **cause** more serious problems than it cures.

While American Trucking Association's Engineering Department is not aware of any carrier being hauled into court for brake system modifications that degrade performance, the possibility exists. And it could be an issue in any litigation resulting from an accident.

The driver's role

Drivers often compound a tractor's or trailer's tendency to overbrake by lightly dragging brakes on long downgrades.

Brakes often are dragged at application pressures below 10 psi. At that pressure, either the tractor or trailer brakes may not receive enough air to contribute their fair share to the braking effort.

If only half of a combination vehicle is forced to do most of the braking, its linings become progressively hotter. A temperature of 600°F damages linings, dramati-

Continued

cally increases their wear rate, and expands drums, causing brake chamber strokes to extend into a less-effective range.

At the same time, light braking prevents full and uniform contact between the linings and the drum. So localized hot spots form on the drum's friction surface. In some cases, hot spots may reach 1450°F.

Sudden cooling of the drum after brake release may cause dark, hard bumps to form on its friction surface. These bumps, which multiply like rabbits, subsequently cause uneven lining-to-drum contact at all application pressures. And that's not all.

Bumps also may cause fatigue cracking, leading to drum failure, because they expand/contract at a different rate than the rest of the drum's friction surface.

If bumps are detected before cracks form, a grinder can remove them and the drum can be resurfaced. If dark spots can't be removed completely, however, the drum should be scrapped before dangerous cracks develop and the drum fractures.

Disregard claims that light and steady downhill braking is best. NHTSA tests conclusively prove that intermittent and moderate brake applications or snubbing (as opposed to rapid, light fanning which quickly depletes reserve air) is the best way to prevent brakes from overheating on downgrades when a brake system is not balanced. Each brake application should slow the vehicle by about 5 mph.

Also keep in mind that reasonably heavy drums provide a better heat sink than light drums and reduce brake lining temperatures...which, in turn, reduces lining wear. Most steering axle drums weigh about 6.5 lb while drive/trailer drums average 100 lb.

High-pressure imbalance

If a tractor's brakes do most of the work, a combination vehicle can't slow down very quickly without the driver pushing harder on the brake treadle.

Should the tractor continue to brake more aggressively than the trailer, the risk of locking the drive axle and jackknifing is substantial, especially on a slippery road with an empty or lightly-laden trailer in tow. Or, if trailer brakes do most of the work, increasing the brake pressure may cause trailer swing.

While anti-lock braking systems (ABS) prevent over-braked wheels from locking, ABS is not a substitute for balanced braking.

For example, sustained high-pressure braking of an ABS-equipped tractor is not recommended. That's because a trailer which lacks ABS (or functional ABS) may receive enough air to lock its brakes, perhaps causing the trailer to swing rapidly into an opposing traffic lane. Further, a tractor with non-functional ABS would be inclined to jackknife as a consequence of full and sustained braking.

Some tractors are over-braked because tractor axles have been over-spec'ed for the loads typically carried, and brakes are sized according to gross axle weight rating.

Benefits of greater-than-needed weight capacity include higher resale valve, plus the fact that axle durability is enhanced by large gear sets and bearings. But the tractor always will over-brake if axle loading is far less than rated capacity. This caveat also applies to trailers with over-spec'ed axles.

The solution to over-spec'ed brakes may be to switch to less-aggressive linings and/or (if possible) attach chamber push rods to a different slack adjuster hole to reduce braking force. Keep in mind that spacing between slack adjuster holes varies by make.

Ideally, ask your vehicle OEM and/or brake component supplier for technical advice before making changes. An on-site brake torque balance test also is advised before fleet-wide modifications are made.

A tractor also can over-brake because its trailer lacks a quick-release valve, or a relay valve with a quick-release feature. Lacking such a valve, trailer brakes may be slow to release. Resultant drag causes trailer linings to wear rapidly, resulting in loss of brake adjustment.

Compounding the problem of keeping trailer brakes adjusted is the frequency with which many units "float" within a multi-terminal system, sometimes resulting in sporadic maintenance.

Another cause of accelerated trailer lining wear is the propensity of some drivers--motivated by a desire to minimize wear on tractor brakes, or fear of jackknifing, or front axle lockup leading to loss of steering control--to "throw out the anchor" by relying solely on the trolley valve when decelerating on a slick highway or downgrade.

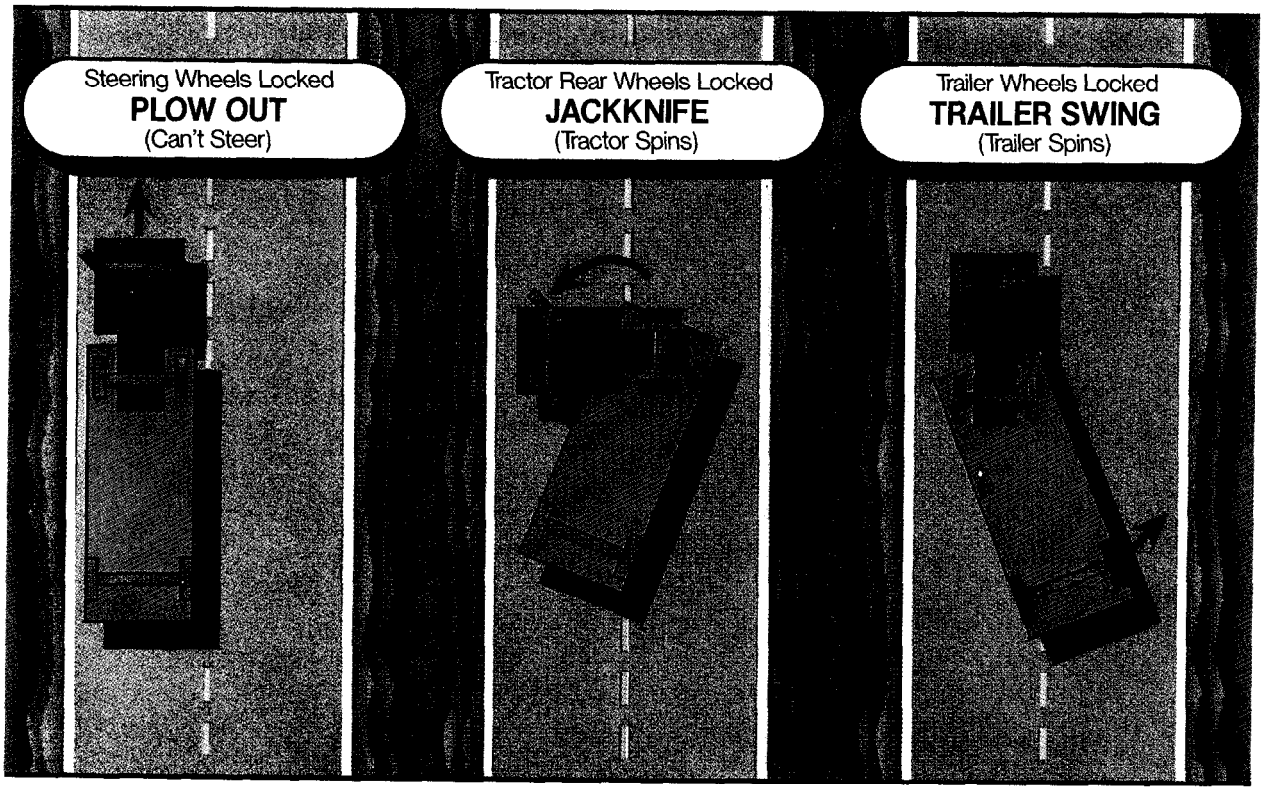
Pulling the trolley valve may result in trailer-axle lockup, causing the trailer to slowly swing out of lane. So drivers must watch for evidence of trailer swing in the rear view mirror. They usually can straighten out the combination before on-coming motorists are treated to a stimulating side view of a 48-ft trailer.

Many drivers have heard that most jackknifes occur a split second after locking only the drive axle(s) when the vehicle is over-braked. Locking the steer axle has the same result as locking all the axles in the combination: that is, the vehicle tends to plow straight ahead.

Steer axle brakes must carry their share of the braking effort if brake temperature, stopping distance and the risk of jackknifing are to be minimized, NHTSA says. This is particularly true when: a tractor is bobtail; the combination is lightly laden or unloaded.

NHTSA opposes, but does not prohibit, the use of automatic front axle limiting valves or front brakes that are notably less aggressive than others on the combination.

Further, a limiting valve keeps a



Unbalanced braking is most dangerous when it causes tractor drive axles to over-brake, lock up and promote jackknife. Many tractors remain over-braked at high application pressure (which usually engages the most lethargic trailer brakes) because tractor axles have been over-spec'ed for the loads typically carried. Switching to less-aggressive tractor linings may provide some relief.

driver unaware of side-to-side imbalance (tendency to pull) caused by an oil-soaked, wet or maladjusted brake until he panic stops, NHTSA says. And that is the worst possible time to be alerted to a problem.

In defense of limiting valves, fleetmen point to a widely-held belief that aggressive, unlimited front brakes on a tractor without power steering may pull strongly to one side (if wet, oil-soaked or unequally adjusted) and may lock even under moderate application pressures on an icy downgrade.

Such fears often prompt drivers to rely solely on the trolley valve for wet-road braking and encourages them to back-off front brake adjustments or block front air lines.

Slow air valves

By design, some tractor's display a lightening-fast draw when shooting a slug of air to their own brakes before passing it along to the trailer. Further, some trailers resist accepting air from a tractor because they have a relay valve with a relatively high crack pressure.

Crack pressure, expressed in psi, is the air required to force open a valve.

All valves presumed to have identical crack pressures are not necessarily created equal. Even a new, high-quality valve rated at 4 psi crack pressure may open at anywhere from 3.5 psi to 4.5 psi.

In contrast, a new and high-quality valve rated at 7.5 psi crack pressure may require anywhere from 4.5 psi to 10.5 psi before opening.

A valve's crack pressure largely is determined by the stiffness of its piston-return spring. If a valve is replaced with a remanufactured unit, or other than an original equipment valve, crack pressures can vary by 6 to 9 psi because of differences between springs.

The moral of the story is that pneumatic balance is most easily achieved with use of low-crack-pressure valves and retained with OE replacement valves. It doesn't take much of a disparity in crack pressures to cause a problem.

About 95% of braking involves application pressures below 25 psi. And approximately 84% of braking is done at application pressures of 15 psi or less.

A 4 psi difference in air delivery to two axles is all that's required to generate a serious disparity in application torque-enough to cause instability, driver complaints and premature lining wear.

Ideal pneumatic balance is achieved when the air delivered to

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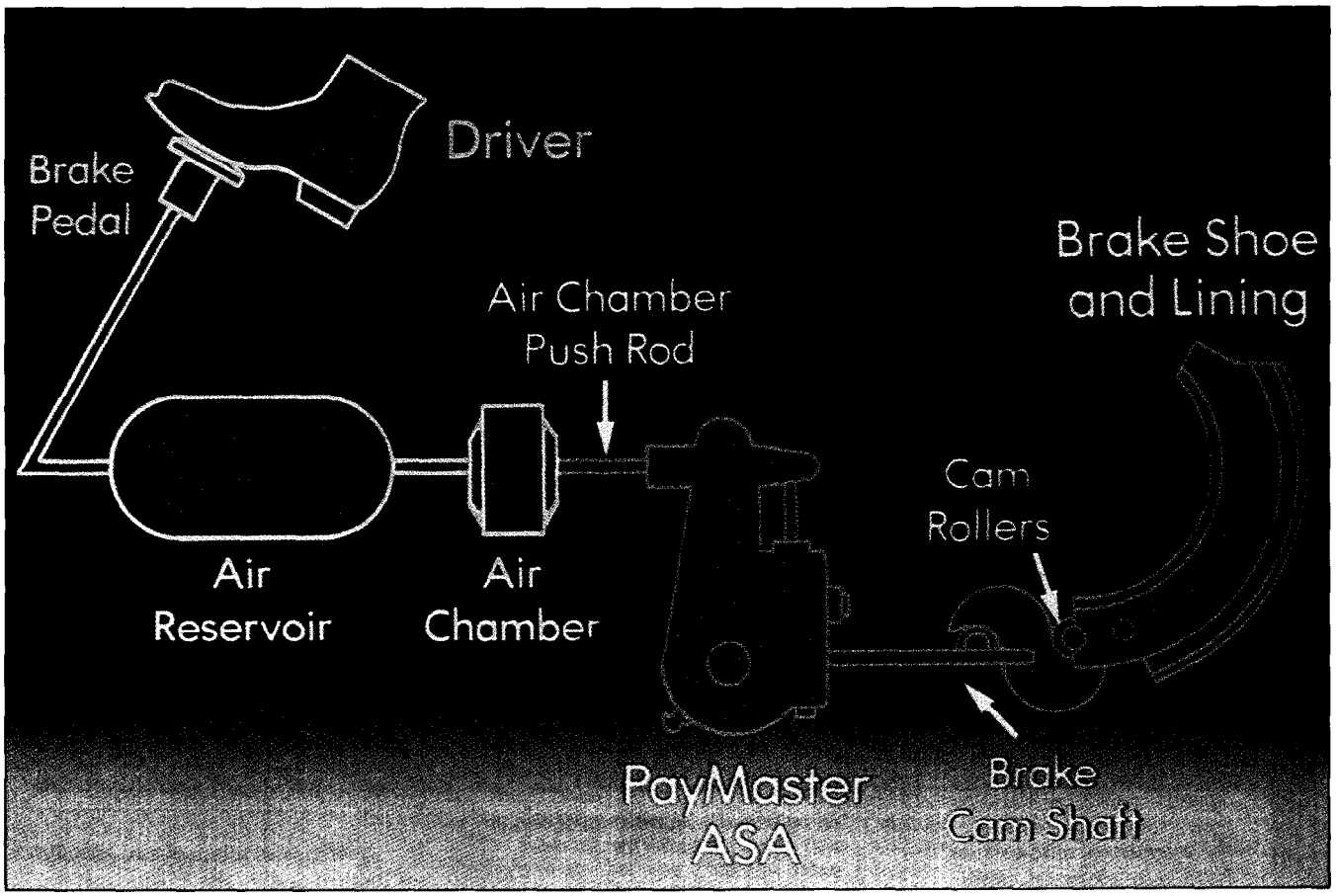


Unbalanced braking can result from many factors, including the weight of a driver's foot. Specifically, drivers can cause an imbalance by lightly dragging brakes on long downgrades, permitting either the tractor or trailer brakes to /oaf. This imbalance should be avoided by making intermittent and forceful brake applications (snubbing) on downgrades. Imbalance also can result from disparities in chamber size, type of slack adjuster, valve crack/closing pressures, lining aggressiveness, component condition and level of maintenance between tractor and trailer.

each axle doesn't vary more than 2 psi during a 10 to 20 psi application, according to engineers at AlliedSignal Automotive Truck Brake Systems Co., Elyria, Oh.

An exception to this rule would involve, for example, a tractor with a front axle limiting valve. Another exception would be the ill-advised mating of an S-cam-equipped vehicle with a wedge-braked vehicle.

Since wedge brakes have smaller chambers and require 4 to 7 psi more than S-cams to make linings contact the drum, the wedge-braked vehicle would require higher air pressure than the cam-braked vehicle for balanced braking during low-pressure applications.

At application pressures below 15 psi, a cam-type brake might generate up to 50% more torque than a wedge brake.

Double trouble

A problem with pneumatic balance is most evident with multiple trailer combinations because air pressure is diminished in the course of its long journey to the rear-most axle.

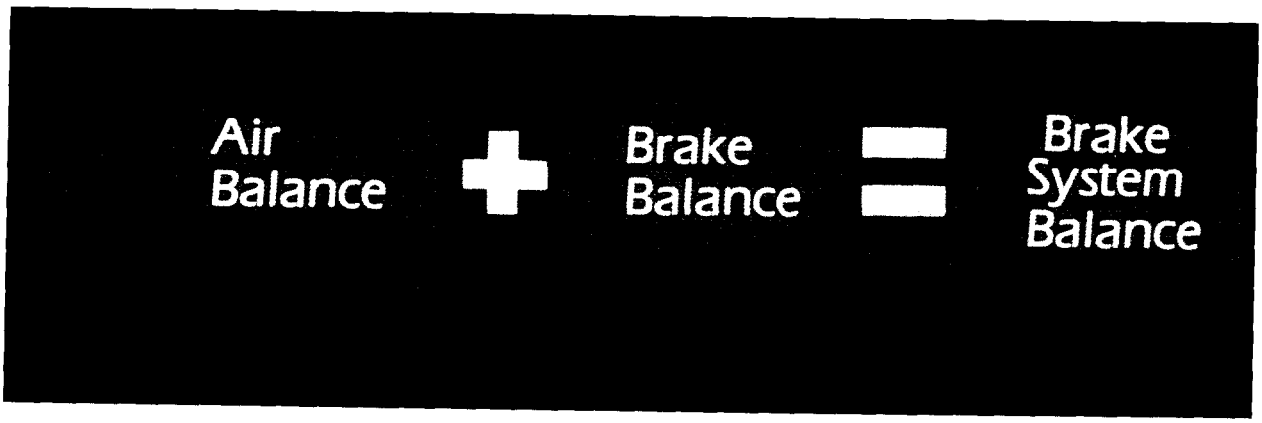
Because a multiple combination can be made up of a tractor, trailers and dolly with a hodgepodge of valves, crack pressures may vary between 4 and 7 psi and differential pressures (inlet versus outlet pressure) may vary between 3 and 7 psi.

As a solution, engineers suggest retrofitting a pressure-equalizing valve (Bendix R-8P or comparable product) to the control line of each dolly, which is less costly than retrofitting the valve to the rear-gladhand control line of each towing trailer.

The R-XP, for example. is a booster relay valve with a zero crack pressure and a zero differential pressure.

NHTSA recently issued a rule which limits the pressure difference between the control gladhand at the front of the trailer and the rear of the trailer to: 1 psi. at pressures up to 20 psi; up to 2 psi, at pressures exceeding 20 psi.

NHTSA also issued a rule, in 1991, which specifies timing requirements for the control gladhands on the rear of tractors, dollies and towing trailers. These



requirements necessitate the use of booster valves (such as the R-8P) on the rear of towing trailers.

Torque imbalance

The fact that a combination vehicle provides equal air pressure to all brakes at the same time isn't the only concern with respect to balanced braking.

As mentioned earlier. torque imbalance results from such things as brakes having better adjustment, bigger chambers, longer slacks and/or more aggressive linings than others. Most of these disparities are immediately evident.

Differences between linings are most likely to sneak up and present fleetmen with an nasty surprise.

An incompatible mix of linings can mess up torque balance. Lining friction, fade and recovery characteristics at various temperatures may vary widely. And not all linings have an equal tolerance for being water soaked.

Further, certain aftermarket linings are more prone than others to swell with heat. Swelled linings may cause tightly-adjusted brakes to drag after the treadle is released. The linings may get so chubby that they cause extremely high brake temperatures.

After the lining cools, it may not shrink to its previous dimensions. Notable and permanent lining growth may require slacks to be backed-off before the brake will release. If permanent lining growth results in substantially decreased

A problem with pneumatic balance is most evident with doubles and trip/es* because air pressure is *diminished in the course of its long journey to the rear-most axle by valves with varying crack pressures. As a solution, AlliedSignal engineers suggest retrofitting a* Bendix *R-8P pressure equalizing valve to the control line of each dolly, which is less costly than retrofitting the valve to the rear-gladhand control line of each towing trailer. The R-8P is a booster relay valve with a zero crack* pressure and a *zero differential pressure.

density, the wear rate may increase.

Growth was most commonly experienced with early versions of non-asbestos linings, and has become less of a problem in recent years.

The edge code markings on linings often wear off. That's no great loss, however, because traditional edge codes are virtually worthless. As a group, linings coded FE, FF, EE and EF may vary in frictional characteristics anywhere from .3% to 200%. Even within the same edge code, friction can vary by as much as 40%.

To maintain some degree of consistency, spec the same brand and type of lining on tractors and trailers and use the same material for relining.

Even then, the same brand and type of lining may vary in batch-to-batch aggressiveness.

In addition, the geometry of relined exchange shoes should be checked with appropriate gauges before installation. It only takes a few seconds and is a worthwhile precaution.

Torque degradation

Even if tractors and trailers initially are well matched, torque balance can degrade over time. For example:

- Linings may be contaminated by leaky, improperly-installed wheel oil seals or ill-advised and generous greasing of the cam assembly.

A leaky seal on new equipment calls for a spot check of other units, since assembly-line errors could be responsible.

A leaky seal on older equipment may indicate a need for better oil seals or mechanic retraining. If the problem persists, consider spec'ing grease seals.

- Drums can become deeply scored or bell-mouthed, preventing proper contact with the lining. Even new replacement drums can be bell-mouthed or eccentric, requiring that they be trued in a lathe.

In some cases. radius grinding of linings may be required for a good fit. Mild heat checking is acceptable, but scrap any drum with deep cracks.

- Brake shoe return springs can stretch. Even if they look okay, replace the springs at every reline or braking can become a drag. The same admonition applies to rollers (never grease them) that have become flat-spotted.
- S-cams can become so worn

Continued

that brake torque is thrown out of whack. Worn camshafts and their splines and bushings also degrade performance.

Pay special attention to the condition of the bushing, because it's responsible for centering the cam and shoe assembly in the drum. Ideally, the bushings should be replaced at every reline.

- Bent spiders degrade lining-to-drum contact. A heat-and-hammer approach to removing anchor pins may have warped the spider.
- Valves can slow down or fail to operate because of gum and carbon build-up from air contaminated with water and oil vapor...especially, if tanks are not routinely drained and an air dryer isn't used.
- Retrofitting brake chambers or slack adjusters of the wrong size is dangerous. For example, brake engineers relate the horror story of a tractor, used to pull trailer loads of dynamite, that was discovered to be equipped with three different sizes of automatic slacks after a driver reported "really scary braking."

Problems also might result from mixing two brands of automatic slacks on the same unit, due to differences in performance, even though they're the same size.

Automatic slack adjusters can malfunction or wear out, especially if nobody bothers to lubricate them.

First, measure for excessive push rod stroke as brakes are applied. Inspect the assembly for excessively worn holes in the yolk and slack adjuster, worn clevis pins and general looseness.

Slacks must be mounted at the proper angle, as determined by use of installation templates that vary by application and brand of slack.

In practice, 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.

- Retrofit of remanufactured or aftermarket air valves can destroy pneumatic balance.

For one thing, the crack/release pressures of relay or quick-release valves fitted with aftermarket springs can vary considerably.

Just because a valve "looks right" or "will fit" hardly indicates it's a suitable replacement for original equipment.

Even where valves of the same make and model are used as replacements, crack pressure and pressure differentials may vary because of differences in bore size and manufacturing tolerances.

- Retrofit of low-profile tires having a radius at least 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. The change may, for example, result in locking the wheels of lightly-laden trailers in the course of normal braking. Further, smaller tires are mounted on smaller wheels which rotate faster at a given road speed and, therefore, cause linings to engage the drums at a higher rpm and run much hotter when braking on downgrades.

Going to the next smallest chamber will reduce torque about 20%. And changing to a less-aggressive lining--or, with engineering approval, placing some sort of pressure modifier in the system--often will do the trick.

- Drums can be damaged by consistent overheating, localized wear from lack of uniform lining contact, or exposure to abrasive material.

Drums with a mirror-like finish should be roughed up with 80-grit emery cloth and, if accompanied by glazed linings, should trigger a quest for a more suitable friction material.

If it appears that foreign abrasive material is causing excessive wear along the edges of the trailer lining contact area, or in areas coinciding with lining rivet holes, remove the lower dust shield to provide an exit. When checking a drum for excessive wear, its inner diameter shouldn't be more than .120 in. more than the original spec.

When resurfacing drums, the finished ID shouldn't be over .080 in. beyond original spec.

If it's likely that abrasive dirt is entering the drum because dust shields were removed (to assist lining inspection and drum cooling), consider retrofitting a shield.

Shields may improve braking performance in rainy weather because most road splash is prevented from reaching the linings.

Testing brake balance

While brake imbalance is clearly indicated by uneven lining wear and driver complaints of trailer bumping, its cause may prove to be elusive.

That's because most fleetmen lack the specialized diagnostic skills and sophisticated test equipment required to isolate the cause(s) of imbalance.

In contrast, many makers of brake system components and linings are well-equipped to conduct on-site testing and offer suggestions.

For more information

The following technical publications are available from The Maintenance Council. ATA , 2200 Mill Rd., Alexandria, Vu. 22314:

- *Recommended Practice 612 (in three sections) on testing of timing, pressure balance and torque balance.*
- *Recommended Practice 619A entitled "'Air System Inspection Procedure."*
- *Recommended Practice 629 entitled "Brake Lining Contamination."*
- *Recommended Practice 625 entitled "'Brake Drum & Lining Compatibility. "*

For information on availability and cost, contact TMC's assistant technical director Robert Braswell at 703-838-I776. ❑

The Rockwell Brake Shoe System

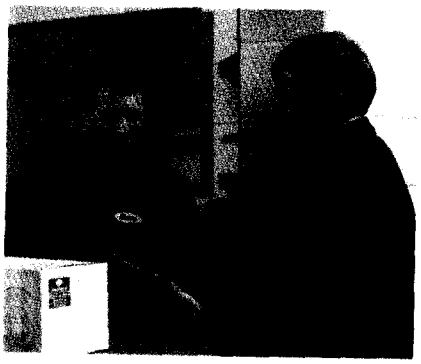
Rockwell understands the hassle and frustration sometimes encountered during brake replacement. That's why we've developed our new and easy-to-use brake replacement system.

Here's how the system works:

1. Just look for the Rockwell parts identification tag on your new or authorized relined Rockwell brake shoes. This tag is your assurance that you're installing OEM quality lining and replacement parts. The same parts that were originally spec'd for your vehicle.

And beginning this year, all Rockwell brake shoes supplied on new vehicles and in the aftermarket will carry the Rockwell identification tag.

2. The tag identifies the correct replacement part number.



3. To assure you're getting the correct Rockwelloriginalreplacementpart, simply provide your Authorized Rockwell Parts Source with the replacement number off the tag. They'll do the rest.

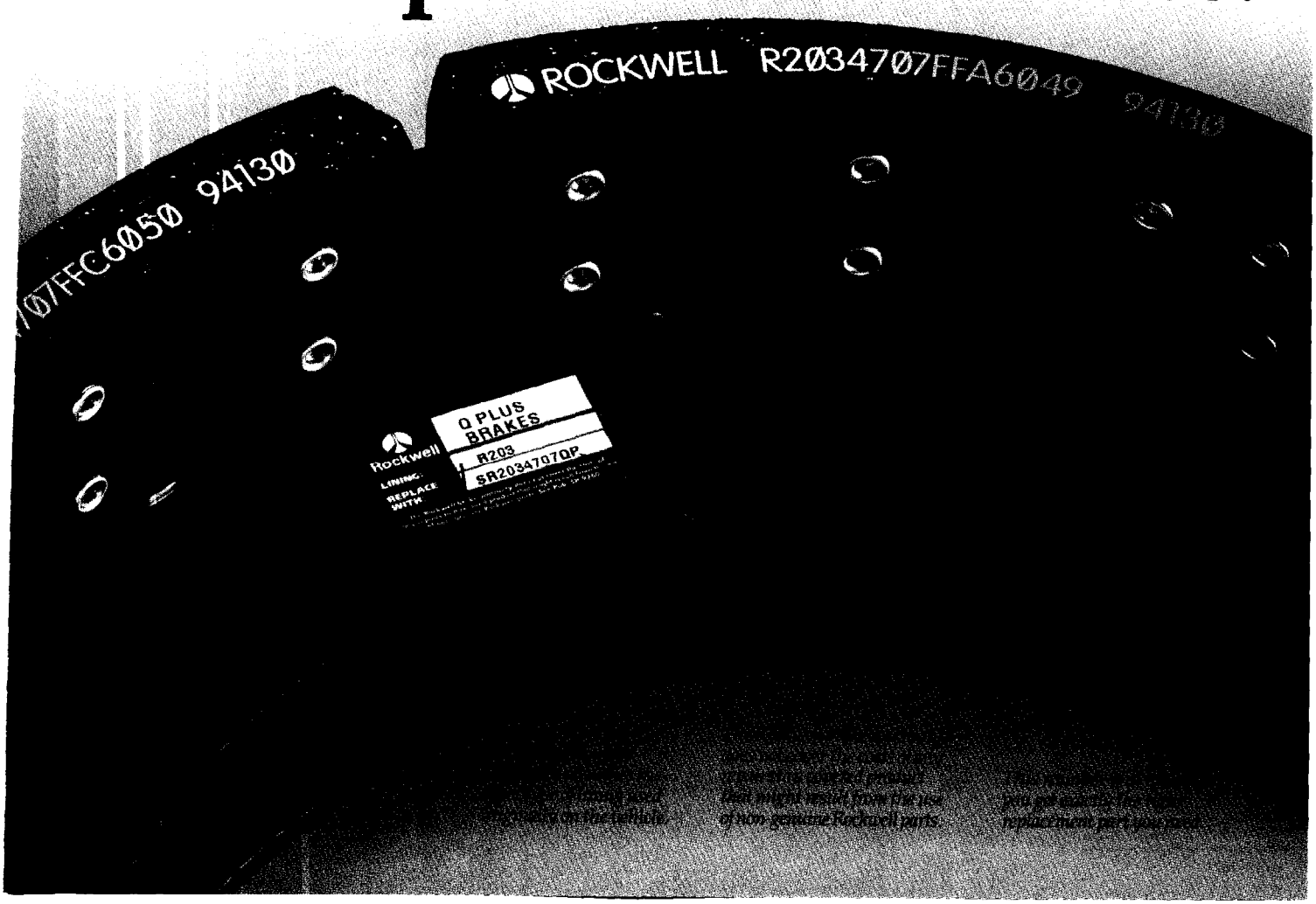
4. If you don't have an identification tag on your brake shoe, a Rockwell parts specialist can assist you in quickly determining the exact replacement part that's right for your vehicle and where you can obtain it. Just call Rockwell at 1-800-469-8568 in the U.S. or 1-800-995-7625 in Canada. For more details, call our ROKFAX info-on-demand service. Dial 1-800-FONØROK (366-0765), extension TAG (824).

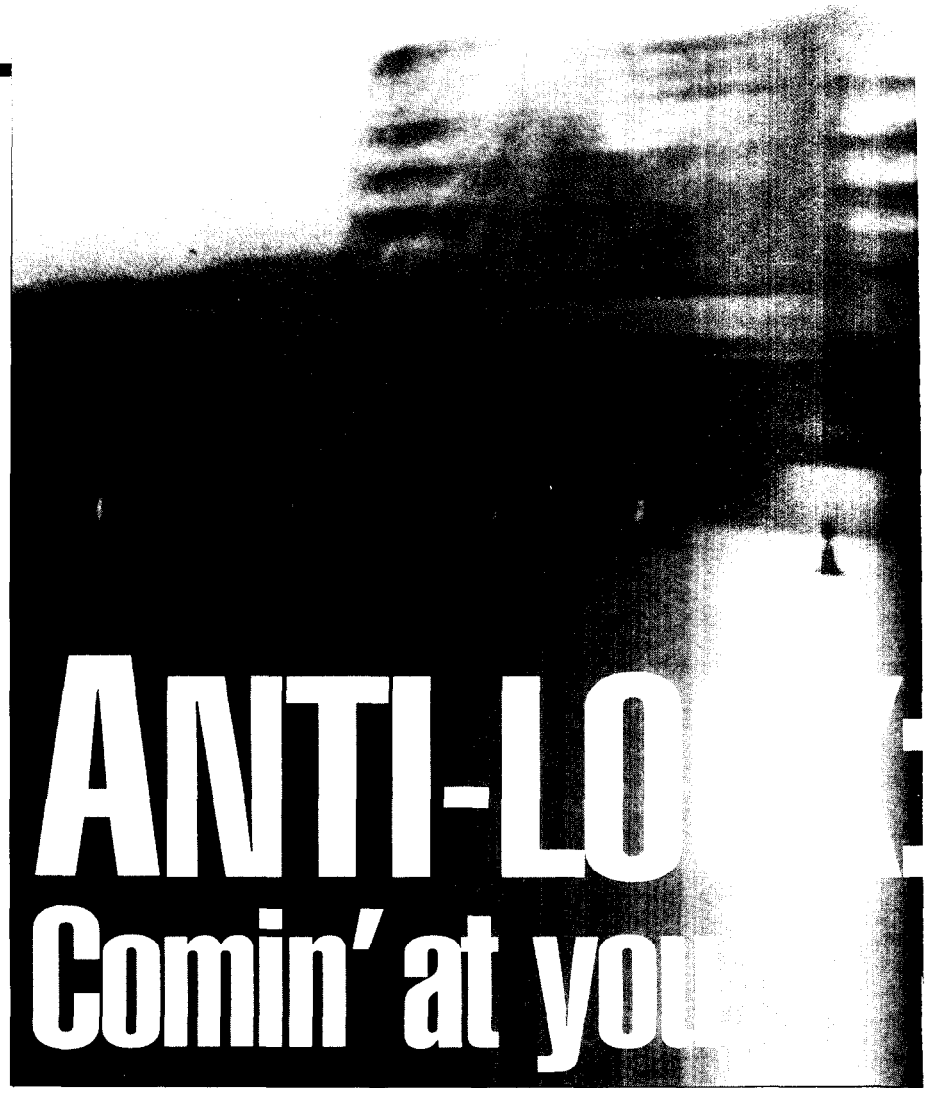
So, the next time you service your brakes, make sure you're getting the same genuine Rockwell quality lining and replacement parts that came on your vehicle.

The Rockwell Brake Shoe System is the newest member of the industry's most complete drivetrain, **Drivetrain Plus™ by Rockwell.**

Rockwell International

Finally, a method to the brake replacement madness.





ANTI-LO
Comin' at you

By PAUL RICHARDS
Technical Editor

It's happening! NHTSA has served notice that a rule requiring anti-lock brakes on heavy vehicles is close at hand. Here's the latest on what you should know about the new anti-lock.

If the National Highway Traffic Safety Administration's proposal becomes law, anti-lock braking systems (ABS) will be required on new heavy vehicles, starting with tractors, in 1996.

Anyone who plans to stay in the trucking business for a while would therefore do well to become familiar with anti-lock brake systems.

How ABS works

All anti-lock systems for air-braked vehicles work basically the same way. Inductive sensors, mounted at wheel ends or in axle housings, pick up impulses from toothed rings that rotate with the wheels (or axles). Each sensor/wheel combination is a kind of electric generator, consisting of a permanent magnet and coil.

As the rotating teeth pass a sensor, the magnetic flux picked up by the coil is intermittently altered. Alternating voltage is produced, the strength and frequency of which are proportional to wheel speed.

Wheel speed data is sent to an electronic control unit (ECU) that "knows" how fast a wheel can decelerate without skidding. Most ECUs have redundant logic to double-check input information.

When the deceleration rate approaches loch-up. the ECU sends an electrical signal to solenoid valves that reduce air pressure to the brake chamber(s) at the offending wheel(s). The new rate of deceleration is recognized by the ECU, which signals the solenoid valves to restore air pressure. This loop occurs repeatedly, as long as the deceleration rate approaches lock-up.

Although that's pretty much how the failure-prone systems of '70s worked, new-generation systerns are far more effective and reliable, thanks to advances in digital electronics, improved resistance to electromagnetic and radio-frequency interference, and better environmental isolation.

Different types of ABS

Differences among anti-loch systems involve configuration. degree of complexity and cost.

To [illegible] most effective, and most expensive form of ABS, [illegible] system, each wheel is individually monitored and controlled, to take advantage of whatever level of adhesion is available to it.

This is especially helpful in the event of a panic stop when there is a split coefficient of friction (split-mu) on the road, such as a wet shoulder and dry crown. The system will modulate the wheels on the wet side to avoid lock-up, and will go for maximum deceleration on the dry side. However, this will occur gradually, to avoid throwing the truck sideways or wrenching the steering wheel from the driver's hands. In engineering terms, this is a modified individual control, designed to limit steering and yaw moments.

The number of channels in an individual-wheel-control system refers to the number of individual brakes its ECU is capable of independently controlling. For exam-/k. a system that can independently accommodate all the brakes on a steer axle and tandem is referred to as a six-channel system. A four-channel system can also be applied to a three-axle vehicle, but the front and rear wheels on either side of the tandem would be braked simultaneously, rather than independently.

A select-low system typically is installed on drive axle(s), although the technology is adaptable to steer and trailer axle applications as well. In a select-low system, sensor\ at each axle end feed wheel-speed data to the ECU. When an impending skid condition is sensed at either the left or right wheel, the brakes at both wheels are modulated. rather than just those on the wheel chat was about to lock. Advantages to this type of arrangement include simplicity and low cost.

Since the drive axle(s) has a great impact on vehicle stability, a select-low system helps a driver retain control during emergency braking.

One disadvantage is that. if the system is applied only to the drive axle, the front axle can still loch. Another disadvantage is that. in split-mu situations, stopping distances may be longer than with an individual-wheel-control system. That's because the whole axle is braked as though both wheels were on the slippery surface, even though higher adhesion may be available on one side.

Which type is best? "We have found, generally, that the more exotic and expensive the system. the better the performance. says Dick Radlinski, president. Radlinski Associates, Marysville, Oh., and former chief of NHTSA's Crash Avoidance Research Branch. "Within the individual-wheel-control group, there's not much differ-

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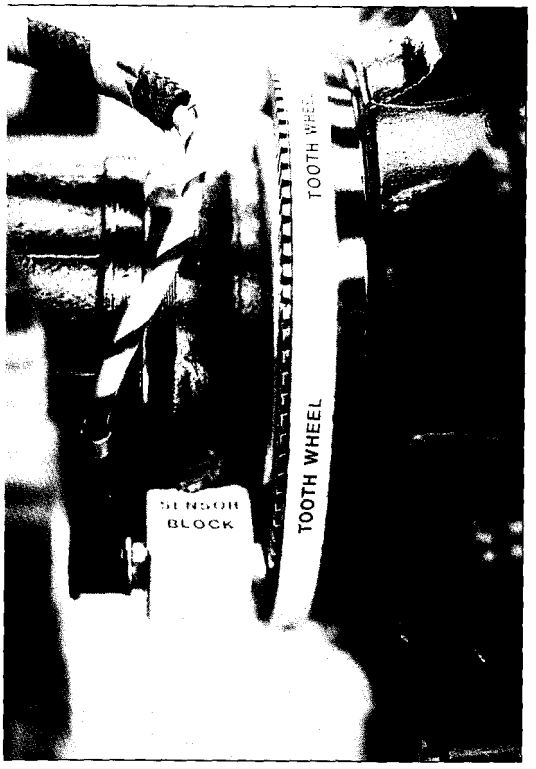


Typical tooth-wheel and speed sensor installation. Rotating tooth-wheel sets up electrical current in sensor, the strength and frequency of which are proportional to wheel speed. Sensors also can be installed in axle housing, with teeth on differential or axle shafts.

ence in performance between a four-channel and a six-channel system. But a six-channel setup is disproportionately more expensive."

Anti-spin

Anti-spin, also called traction control or ASR, is an option available with individual-wheel-control anti-lock systems. Just as wheel deceleration can be individually controlled to avoid a skid, acceleration can be checked to avoid spinning a wheel.

When an anti-spin-equipped vehicle accelerates on a slippery surface, the brakes are intermittently applied to any drive wheel about to exceed its acceleration threshold. If too much power is applied by the driver, the ECU can communicate with a vehicle's engine computer (if equipped) to reduce power to an appropriate level.

Diagnostics

The new anti-lock systems all have some degree of self-diagnostic capability. For example, when a vehicle equipped with Rockwell WABCO's ABS is started, the system checks itself by cycling all valves and illuminating dash-mounted indicator lights. If everything checks okay, the lights go out once the vehicle starts rolling.

In the event of a fault, one indicator light stays on, and the affected part of the system reverts to conventional brake system operation. A specialized tester is then used to pinpoint the problem.

Some ECUs can blink-out trouble codes on the dash warning light without the use of a tester.

Another example of full self-diagnostic capability is found in AlliedSignal's Bendix anti-lock system. All operative and diagnostic electronics are built into a derivative of the Bendix R- 12 relay valve. If there's a problem, the valve-mounted ECU will light an LED that identifies the problem area.

Trailers

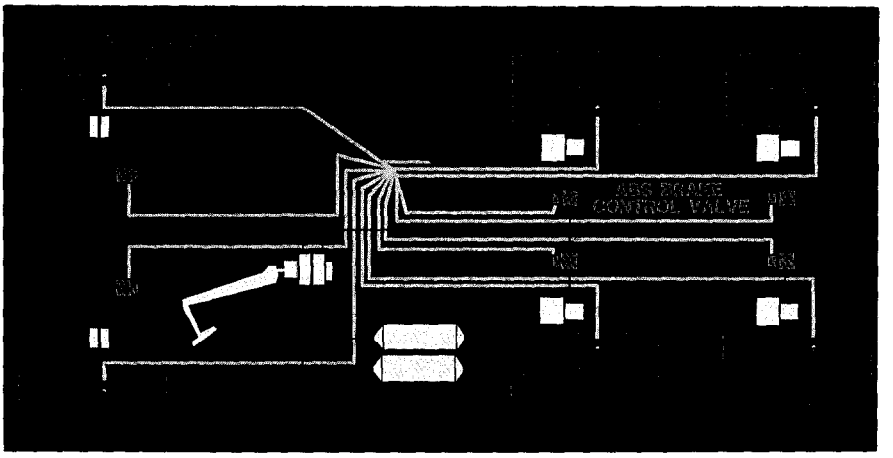
Although ABS works well when installed only on the tractor of a tractor/trailer combination, further safety benefits and improved tire life can be realized by adding ABS to trailers.

"Our drivers love the (Bosch) anti-lock systems we retrofitted on our Heil Challenger tank trailers," attests Mike Crabtree, equipment superintendent for Commercial

Retarder interface

No matter how sophisticated an anti-lock system is, it can't prevent or stop a skid induced by a retarder. Remember, using a retarder on a slippery surface, whether a vehicle is equipped with ABS or not, can cause the drive wheels to slip.

"That's why a retarder interface is needed," notes Charlie Schott, manager, fleet sales and service, Rockwell WABCO, Troy, Mich. "When ABS is actuated, the retarder has to be cut out of the circuit if a skid is to be avoided. We always install a relay for that purpose."



Rockwell WABCO ABS operation (typical of a/i systems). Sensors, excited by rotating tooth wheels, send wheel-speed data to ECU. ECU "knows" how fast wheel can decelerate without skidding, and signals solenoid valves to reduce air pressure at wheel(s) about to lock.

Anti-lock brake systems for air-braked trucks, tractors and trailers are currently available-through OEMs, or for retrofit-from these suppliers:

AlliedSignal Truck Brake Systems
(Bendix brand)
901 Cleveland St.
Elyria, OH 44036
216-329-9000
FAX 216-329-9557

Robert Bosch Cor.p
Automotive Group
2800 S. 25th Ave.
Broadview, IL 60153
708-865-5200
FAX 708-865-6430

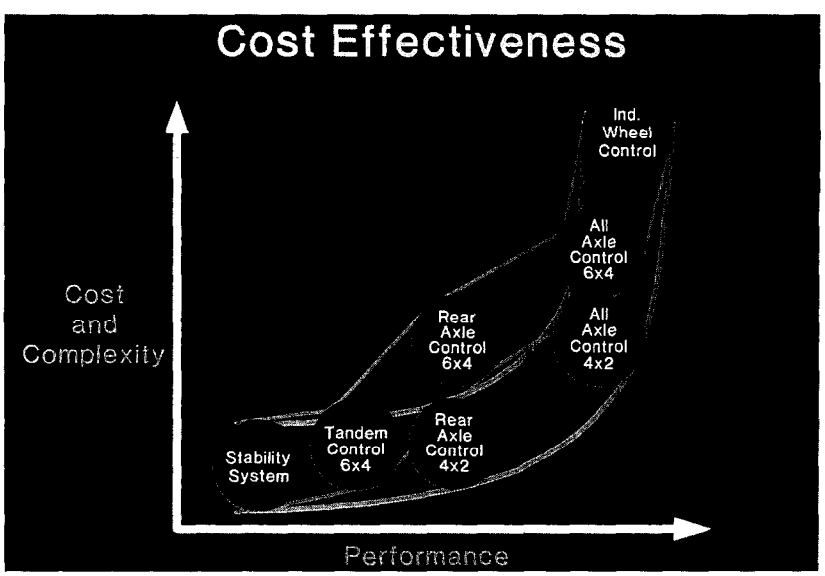
Midland-Grau Heavy Duty Systems
10930 N. Pomona Ave.
Kansas City, MO 64153
800-643-2374
816-891-2470
FAX 816-891-9447

Rockwell WABCO Vehicle Control Systems
2135 W. Maple Rd.
Troy, MI 48084
800-535-5560
81 o-435-8001
FAX 81 o-435-8002

Transport Inc., Belleville, Ill. "In fact, two drivers swear the systems saved them from being involved in serious accidents.

"Plus, we're getting 15,000 to 20,000 more miles out of the average tire on the anti-lock-equipped trailers," he adds. "And brake drums and linings are lasting longer. The payback period is hard to figure, but ABS is definitely worthwhile. We don't spec anything without it."

A debate regarding trailer anti-lock involves how the systems will be powered. Joachim Sedlmayr, supervisor, application engineering, Robert Bosch Corp., Chicago, says there ideally should be dedicated wiring for ABS.



AlliedSignal's* assessment *of relative merit and cost of various* types *and configurations of anti-lock. The greater the cost and complexity, the better the performance.

In Europe, a separate tractor-trailer anti-lock connector is used. However, there is a strong feeling in the U.S. that an additional connector is unacceptable, and anti-lock systems sold here must be able to be powered from the stoplight circuit. It's okay, however, to use a separate connector if a user so desires.

Recommended Practice 119 published by The Maintenance Council (TMC) of American Trucking Associations outlines a test procedure to ensure that circuit can provide sufficient current for anti-lock systems.

The problem with stoplight power is that it's not a constant voltage source. That means, once the brake pedal is depressed, the ECU must power-up, recognize an impending skid and react. Today's ECUs can do that, but it's not ideal.

"You can run ABS from stoplight power," explains Bosch's Sedlmayr. "But you're not getting any feedback from the system. If there's an ABS problem, a driver won't know it until he hits the brakes. There's got to be a compromise."

That compromise may come in the form of an interchangeable, seven-pin-type connector with a halo of additional pins around the seven.

"For a time, there will be two solutions," says Sedlmayr. "Some systems will run off stoplight power, and others will have dedicated wiring."

Government testing and fleet experience

NHTSA has conducted an extensive, tractor anti-lock fleet evaluation. The evaluation involved 200 ABS-equipped-tractors in fleet service, monitored over a two-year period. All available brands of ABS were represented.

Robert Clarke, chief of NHTSA's Heavy Vehicle Research

Continued

Driving ABS: Not as simple as ABC

There's little doubt that ABS is capable of enhancing vehicle control during panic-braking situations. But ABS doesn't turn Freightliners into Ferraris, and it shouldn't be used as an excuse for anything less than cautious, professional driving. Thus, driver training in ABS use is a good idea.

Some OEMs and ABS suppliers advise drivers not to modulate the brakes on ABS-equipped vehicles, but to make steady applications.

According to the American Trucking Associations (ATA), Alexandria, Va., the owner's manual supplied with a member's 1993 tractor states: "During emergency or reduced-traction stops, fully depress the brake pedal until the vehicle comes to a safe stop. Do not pump the brakes."

One reason for this may be that ABS does not function as effectively when the driver is also pumping the brakes.

Also, "If a driver finds himself in a situation where such modulation is necessary, ABS can do a better job," notes Charlie Schott, manager, fleet sales and service, Rockwell WABCO, Troy, Mich. "A system like ours can rapidly modulate wheels individually, where the best a driver could hope to do is modulate all wheels at once. at a much slower rate, thereby increasing stopping distance."

"Keep in mind that modulating doesn't just mean pumping the brakes," counters Larry Strawhom, ATA vice president, engineering. "It also means applying just enough air pressure for the job at hand and bringing a vehicle to a safe, controlled stop."

ATA member fleets have been training drivers to continue modulating their ABS-equipped brakes just as they have been doing in stops with non-ABS brakes. The reasons are:

- Drivers will be driving ABS-equipped tractors in combination with trailers (sometimes doubles and triples) not so-equipped and, possibly, vice-versa;
- If, during normal braking, drivers use the additional performance ABS affords, ABS will be precluded from providing any additional safety benefit in an emergency. The additional performance, says ATA, should be reserved as a margin of safety to assist in unforeseen and unavoidable situations:
- Drivers are going to be switching between ABS-equipped tractors and non-ABS-equipped tractors and must maintain their modulating skill. They also must remember, in a panic situation, whether the tractor and/or trailer has ABS;
- ABS cannot guarantee that a vehicle always will remain controllable. Using a retarder on a slick surface or taking a turn too fast, for example, can result in a loss of vehicle control, despite the wonders of electronics.

"ABS is not a substitute for common sense," notes Rockwell WABCO's Schott. "We advise drivers to exercise the same caution they would use when operating a non-ABS-equipped vehicle. We certainly don't want them to over-drive the brakes, whether ABS-equipped or not.

"And if a driver is into a full-ABS panic stop, and his non-ABS trailer starts to swing out, there's no reason he can't let up on the brakes a little to bring the trailer back into line-if he has the time. He'll be giving up some ABS benefit, in terms of stopping distance, but, hopefully, he'll correct the trailer swing."

"Ultimately, it may turn out that a steady, full-treadle application is the way to drive ABS," muses ATA's Strawhom. But for that to happen, all tractors, trailers and dollies would have to be ABS-equipped. And these systems would have to be 99.9% reliable, which studies show they are not."

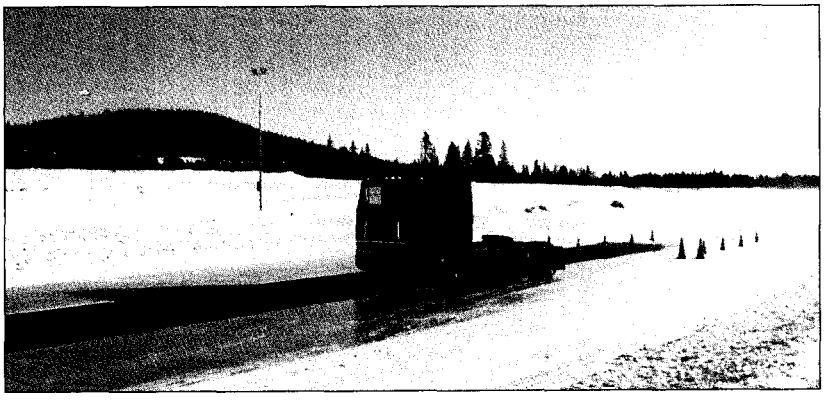
Div., reports that 92% of the drivers involved showed moderate to high acceptance of the systems, and none were hostile toward them.

Trip recorders on the test vehicles showed that anti-lock systems were activated an average of once every 17,000 mi during the summer, and once every 4,500 mi in winter months. There were 20 reports of ABS helping avoid accidents.

From a maintenance standpoint, Clarke said the systems performed well, with only 48 trucks requiring attention, and an average component replacement rate of less than one per vehicle.

A two-edged sword in maintaining ABS, notes Clarke, is that when ABS fails, it fails soft. That is, the truck reverts to normal braking. Therefore, there is little incentive for a driver to complain of ABS problems, and even less for a maintenance shop to tie a vehicle up for ABS repairs.

Most failures noted during the test period, Clarke continues, were results of improper installation and/or adjustment, and physical interference with other vehicle components.



ABS testing on split-coefficient-of-friction (split-mu) surface. Individual-wheel-control systems excel in this situation, since each wheel is allowed to utilize whatever level of adhesion is available to it..

AlliedSignal's Bendix anti-lock, including full, self-diagnostic capability, is built into derivative of familiar R-12 relay valve.

Midland's chassis-mounted ECU makes retrofit easier. Diagnostic reader can be included in ECU as an option for full, self-diagnostic capability.

"Wiring problems are the main contributor to our ABS failures," agrees Mark Siemers, president, Wayne Transport Inc., Invergrove, Minn. Wayne Transport participated in the government testing, and anti-lock systems were hastily installed, without proper attention IO detail, to meet test deadlines.

"I want to emphasize that the units work fine," adds Siemers. "It's poor wiring that was the source of our complaints. Since then, the wiring has improved, and connectors are better environmentally-protected."

Maintenance considerations aside, the ability to justify the cost of ABS to upper management will play a crucial role in determining whether fleets will voluntarily accept the systems.

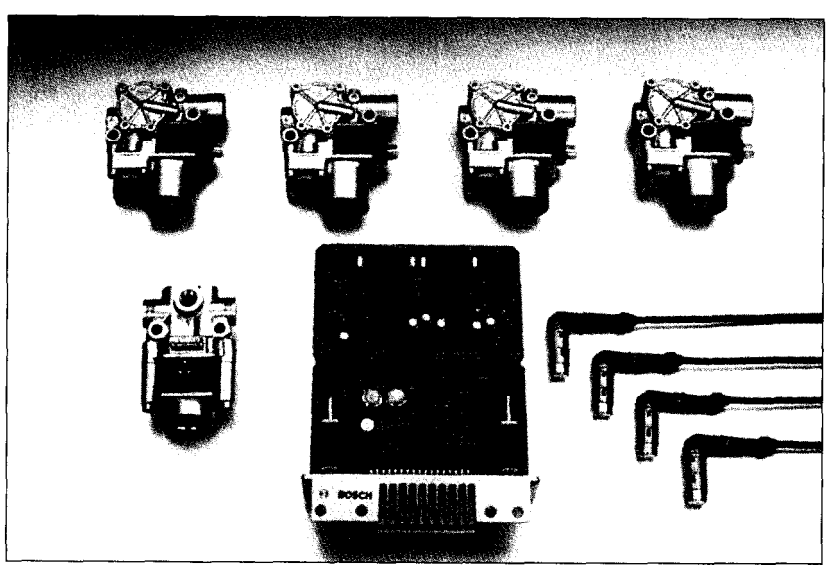
But if ABS does what it's supposed to, some accidents will be eliminated. And it's hard to put a price tag on an accident that never happened.

"Cost-justification of ABS is difficult," attests Joe Zielkowski, maintenance supervisor, Chrysler Transport Inc., Detroit. "How do you know if an accident has been avoided? Most drivers won't tell you if they had a close call."

There has been hope among fleets and ABS manufacturers that insurance carriers will offer substantial premium discounts for ABS-equipped vehicles. But, so far, such discounting has been the exception rather than the rule.

"Insurance companies base their rates on their experience with a carrier," notes Dave Hammes, chairman of TMC's ABS task force. "If you have fewer accidents, it may keep your premiums from going up, but they won't give you anything up front."

While the jury is out on widespread, voluntary acceptance, ABS legislation is a certainty. That in mind, NHTSA's Clarke recommends that fleetmen start spec'ing ABS. "There are more advantages than disadvantages to ABS," he maintains. "So why not start gaining experience with it now?"❑



Bosch ABS with anti-spin consists of solenoid valves, anti-spin valve (lower left), ECU and speed sensors.

Editor's note: The photos and illustrations in this article were provided by AlliedSignal Truck Brake Systems, Elyria, Oh., Robert Bosch Corp., Chicago, Ill., Midland-Grau Heavy Duty Systems, Kansas City, Mo., and Rockwell WABCO Vehicle Control Systems, Troy, Mich.

Let's cut to the chase. If you're not using automatic brake adjusters (ABAs), you should be. The truck is safer when all the brakes are better adjusted, all the time. That's what ABAs bring to the party.

Whether it's done manually or automatically, keeping brakes properly adjusted ensures safe, sufficient braking will be there when the driver needs it. ABAs adjust the brakes while the vehicle is being used, thus helping to maintain optimum vehicle braking capability at any given instant in time.

The benefits are obvious. Widely available statistical evidence, and common sense, overwhelmingly favors the use of ABAs for all but a very few specialized operators. Ironically, brakes out of adjustment continues to be the most frequent violation cited at roadside safety inspection stations.

That in itself is old news. But with good performing ABAs so widely available today, there's no good reason for it anymore.

Historically, it's not uncommon to find 40% or more of all vehicles inspected to have at least one brake out of adjustment. That figure drops to 20% or less when inspection data isolates vehicles equipped with automatic brake adjusters. But, historically, roadside safety inspections were rare occurrences.

No more. The federal Motor Carrier Safety Assistance Program (MCSAP) provides millions of dollars for states to conduct standardized vehicle and driver safety checks based on critical items inspection procedures developed by the Commercial Vehicle Safety Alliance (see updated CVSA brake standards elsewhere in this book).

More than 1.6 million CVSA inspections were conducted in 1990. Six thousand persons have been trained as inspectors in the past several years. That's why fleet operators today are incurring higher costs in out-of-service citations and in lost driver productivity, resulting from these ever more frequent vehicle safety inspections.

Also, responding to your complaints and mounting regulatory pressure, ABA suppliers have upgraded their products to make them more durable and easy to install correctly.

There it is. You're getting hit more often today with fines and trip delays for brakes out of adjustment. The product the

work better and last longer than they did several years ago. Street prices for an ABA can be twice as high as a typical manual adjuster, but hey, they're twice as likely to get you through a roadside safety inspection, and they make your trucks safer. That can mean fewer accidents.

With all this in mind, why then

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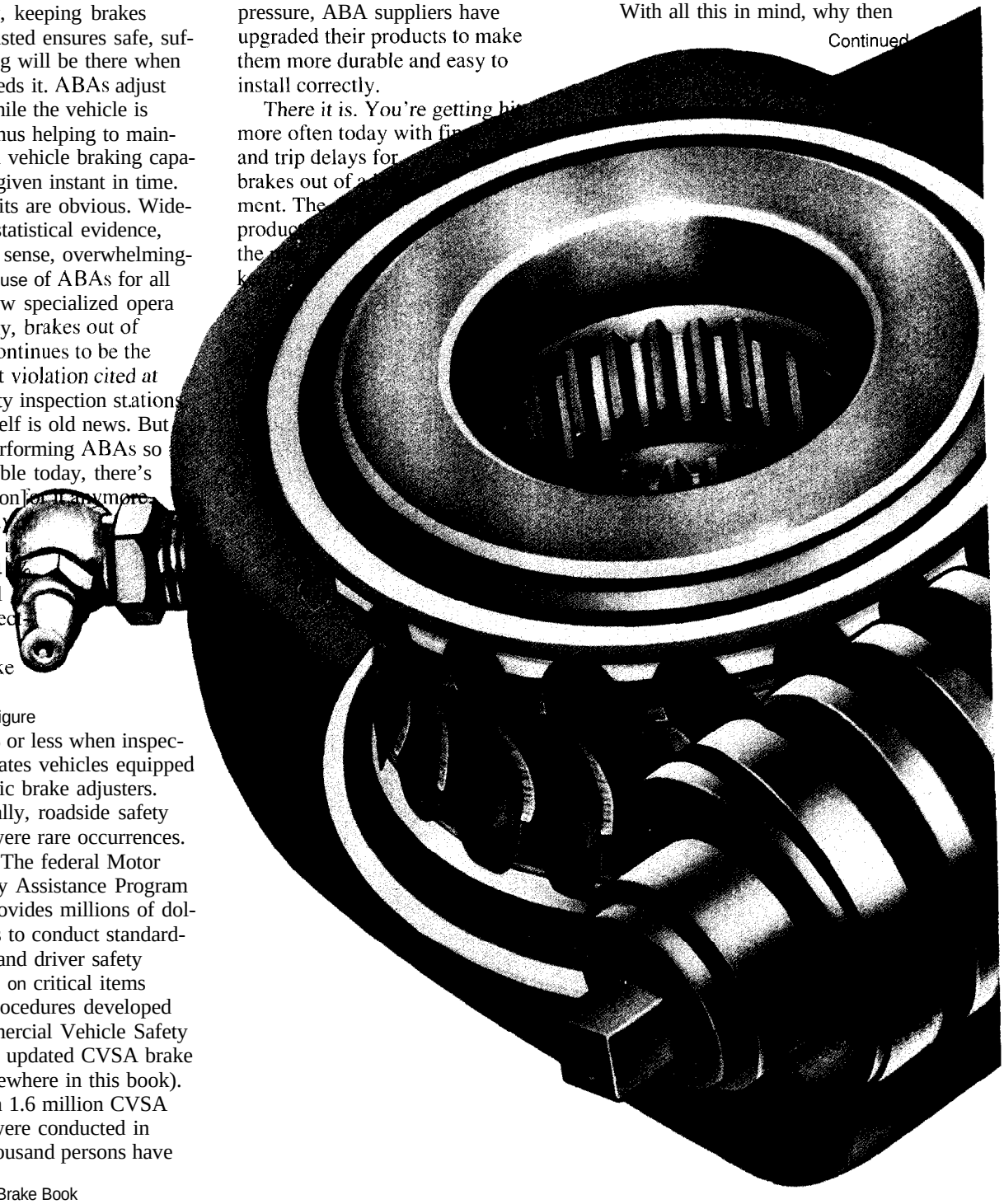
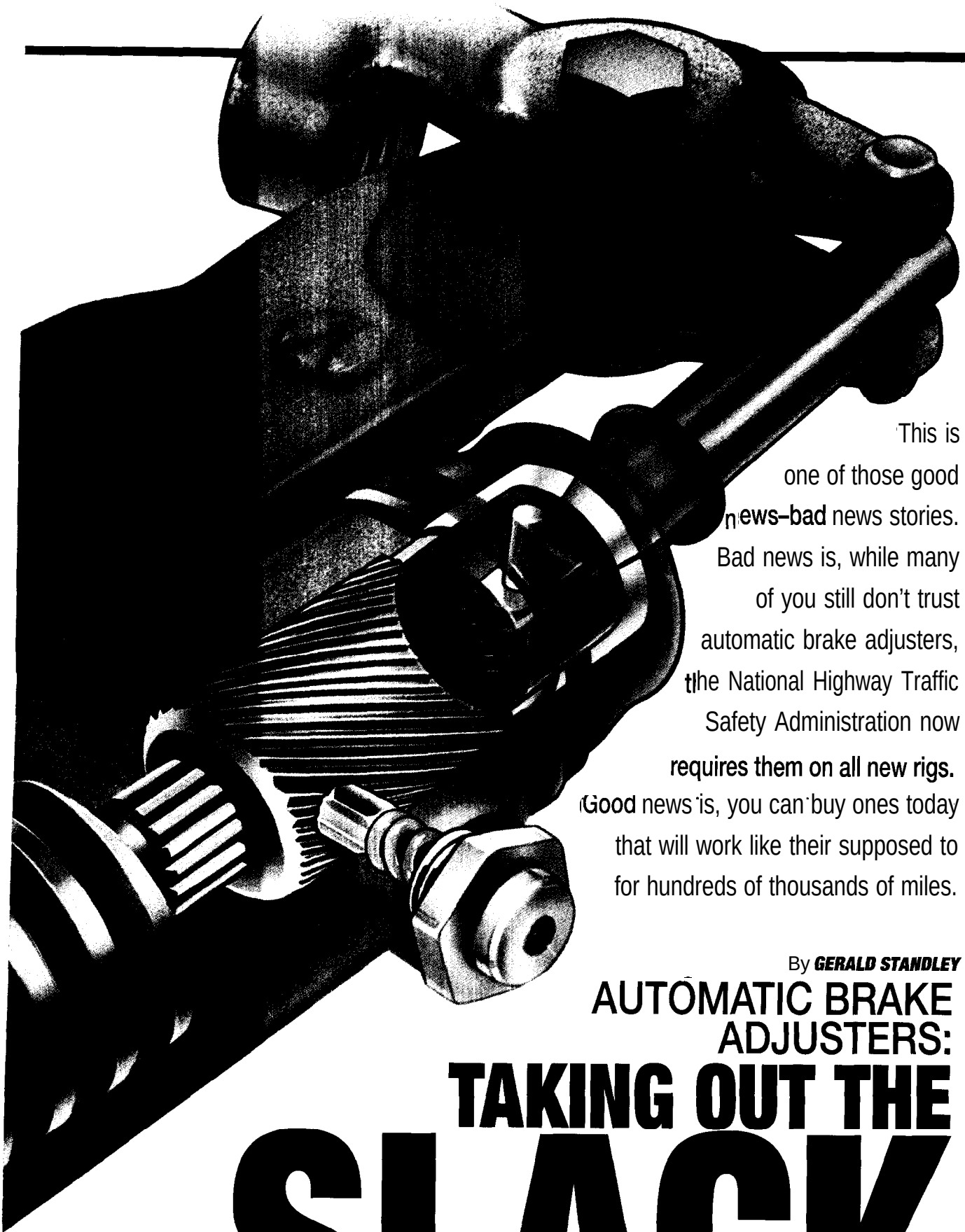


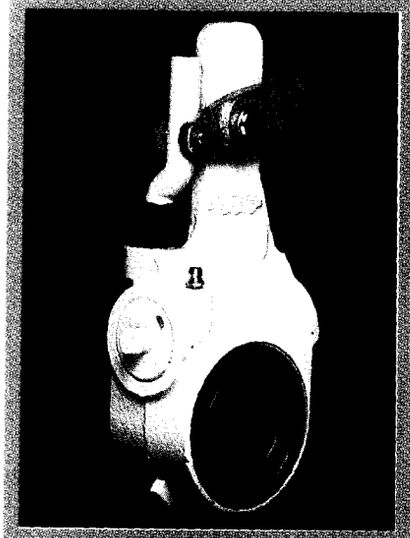


This is one of those good news–bad news stories. Bad news is, while many of you still don't trust automatic brake adjusters, the National Highway Traffic Safety Administration now requires them on all new rigs. Good news is, you can buy ones today that will work like their supposed to for hundreds of thousands of miles.

By ***GERALD STANDLEY***

AUTOMATIC BRAKE ADJUSTERS:

TAKING OUT THE SLACK



GUNITE

The Gunite clearance-sensing automatic brake adjuster was introduced to the commercial fleet market in 1985. The unit adjusts at the early part of the brake application stroke, when system pressures are low. While Rockwell and Bendix ABAs incorporate features to prohibit a reversing action of their adjusters, Gunite and Haldex designs capitalize on the fact that they do not prohibit such action (see explanations in the story text). The most notable durability improvements that Gunite has made in recent years are to the clutch mechanism, adjusting link, quick connect clevis and arm hole bushing.

are 80% of you not using automatic adjusters'!

Roadcheck '90, a three-day commercial vehicle safety inspection blitz conducted by U.S. and Canadian officials in May 1990, randomly selected 38,797 trucks at 285 locations throughout the U.S. and Canada. Of those, 29,700 (77%) were checked for the existence of ABAs. Only 6,094 (20%) trucks had ABAs installed.

Maybe more of you will use ABAs if you better understand what they can and cannot contribute to your equipment expectations. That's what this article aims to do. Once you understand how ABAs work, and how the different brands stack up, you'll feel more confident making the right decision-to use ABAs.

Stroke- vs. clearance-sensing

There are five ABA suppliers: Rockwell Automotive, Troy, Mich.; Bendix Heavy Vehicle Systems, Elyria, Oh.; Haldex, Corp.. Blue Springs, MO.; The Gunite Corp., Rockford, Ill. and Crewson Brunner, Inc., Buffalo, N.Y. All but the latter have had ABA's in the market for years, Each design has been incrementally improved, primarily for performance consistency and durability.

Two ABA design approaches are stroke-sensing and clearance-sensing.

Clearance-sensing designs (Haldex, Bendix, Gunite, Crewson Brunner) maintain a specified shoe-to-drum running clearance at minimum push rod stroke. Running clearance is typically the ,020 to .030-in. gap between the brake lining surface and the drum.

Generally, an internal clutch senses the load that develops as the lining contacts the drum and either slips or disengages the mechanism, a design feature intended to prevent over adjustment during normal operating conditions.

Rockwell's is the only stroke-sensing design. It seeks to maintain optimum chamber push rod stroke, which gets used up in three ways:

(1) Running clearance uses up approximately 1/2- to 5/8-inches of stroke.

(2) More stroke is needed to account for system elasticity-the result of brake lining compression, air chamber mounting bracket deflection and such.

(3) Dynamic changes that occur to a brake in service require more chamber push rod stroke, such as lining wear and brake drums heating and expanding, then cooling and contracting.

The competitor's knock on Rockwell's Paymaster design is

MDSU/Legal stroke limits

The maximum push rod stroke allowed by a CVSA inspector varies by chamber size. A vehicle is placed out of service if 20% of the brakes are out of adjustment (1/4-in or more beyond the legal limit).

Chamber Type	Stroke (inches)
9	1.375
12	1.375
16	1.75
20	1.75
24	1.75
24"	2.00
30	2.00
36	2.25

*Long stroke design.
Stroke measurements are taken at SO-90 psi brake application pressure.

HALDEX

Haldex extends performance durability by using a hardened adjuster body. It's value shows in their six-year/750,000 mile on-highway warranty. One year/ 250,000 miles more than any other. The Haldex uses a coil spring rather than disc springs to load the adjusting mechanism. This feature eliminates wear related to internal clutch slippage. Newer Haldex units feature an integral installation indicator, which provides an easy visual check for correct installation. Haldex allows users to specify running clearance to optimize application-specific performance, such as inner-city refuse and transit operations. This is accomplished through a selection of clearance notches that are factory installed.

that an ABA should ideally compensate only for increased running clearance. stroke-sensing adjusters can be fooled by unavoidable dynamic changes in the braking system like deflection and elasticity that do not result from increased running clearance, but from braking load.

What that means to you is exercise care in specifying new or replacement brake components, so as not to substitute items like light weight brake drums, for instance, which can increase brake system deflection during high braking load events, such as in a panic stop.

While panic stops are not that frequent overall, their importance is obvious. In that kind of situation, a stroke-sensing adjuster will adjust if the longer stroke requirements resulting form the load-related deflection exceed the pre-set stroke limit. It does that because the stroke-sensing mechanism cannot distinguish added stroke needed during high pressure stops from legitimate added stroke needed when running clearance exceeds the pre-set limit. However, the Rockwell unit only takes up .002-in. per adjustment, so it's only as big a deal as panic stops are frequent.

Clearance-sensing adjusters can't over-adjust under those same circumstances because a load/force sensing clutch disengages the adjusting mechanism when the lining contacts the drum. That's why excessive stroke that may result from greater deflection during a hard stop does not normally cause a clearance-sensing unit to adjust.

Of concern to users of all ABA brands is the difficulty of providing proper adjustment of running clearance on new, unburnished brakes. This is done to allow for things like green lining swell. Rockwell ABA installations are set up at .030-in. running clearance to allow for that (see "Ten Tips" box). The problem resolves itself, for the most part, as the lining wears and conforms to the shape of the drum, at a relatively low mileage.

But as an increasing number of fleets opt for "extended life brakes" lining swell takes on more importance in the maintenance picture picture. OE-quality linings on new vehicle brakes reportedly have manufacturing controls to minimize green lining swell. If you substitute low-quality aftermarket linings at replacement time, you may also be installing a dragging brake problem.

All ABAs adjust the brake when system air pressure is low (10 psi or less), either at the end of the release stroke or the beginning of the apply stroke. Since each mechanism can be fooled by dynamic changes in the brake, making adjustments when system pressures are low minimizes this occurrence.

The Rockwell ABA senses the need for adjustment on the apply stroke and makes the adjustment during the end of the brake release stroke. That's important. If a stroke-sensing ABA adjusted on the apply stroke, it would have to turn the adjusting mechanism when the linings are in contact with the drum.

Hot as a burning wheel

In a well-maintained brake system, any ABA that is installed correctly should be able to do its job most of the time. The sales rhetoric

Continued

in which ABA suppliers smear each other's design trade offs is as hot as a burning wheel.

Whether the stroke or clearance-sensing design is superior is a complex argument best reserved for engineers. Depending on how you use your vehicles and what you require from your brake adjusting mechanism, however, the trade offs can have definite cost-of-ownership and downtime implications.

To select the design type that represents the best investment for your operation, you must understand how those trade offs will play out in your operation, with your vehicles and your maintenance scheme. For instance, clearance sensitive adjusters might exhibit better severe service performance, while the stroke-sensing brand might prove more cost-effective in moderate service.

In the real world of heavy truck operations, there are hot expanding brake drums and cold contracting ones, drums out-of-round, spongy linings, distorted chamber brackets. There are extreme variations in the performance of brake system maintenance and in driver habits that affect braking. There are over-zealous salesman creating false cost-savings expectations. That's not a friendly environment for a small piece of iron that carries such a big load of responsibility.

In Roadcheck '90, 16% of the

TEN TIPS FOR THE SALES CALL

Today's ABAs all are improved versions of earlier models, but don't be oversold on their merits,. Use this advise from experienced equipment managers and field service reps to make a better informed purchase decision.

(1) ABAs are not the answer to a maintenance man's dream. Don't think you can install them and forget them. Plan to incorporate them into your preventive maintenance schedules for inspection and maintenance, just like any other component.,

(2) Never mix the ABAs and manual slacks on the same vehicle. Avoid mixing ABAs from different manufacturers on the same vehicle; *never* on the same axle. Incorrect factory installation of ABAs is a common problem on new vehicles. Add this item to your 'pilot and pre-delivery inspections.

(3) If you're retrofitting from manual to automatic adjusters, make sure mechanics receive thorough training and familiarity with the ABAs. Compare installation requirements and interchangeability with the manual slacks on vehicles and suspensions that *you* are using, not on a promotional brochure's "typical" vehicle,

(4) ABA bodies are larger than manual adjuster bodies. Make sure suspension clearance exists when the adjuster body is rotated at maximum chamber stroke, Some ABAs fit under certain suspensions better than others. Some require left- or right-handed versions with an offset clevis, or offset arm, to fit. The penalty is in additional part numbers, inventory management and field problems if the wrong part is installed.

(5) Myth: Switching to ABAs guarantees reduced brake maintenance cost. *Reality:* Switching from manual adjusters to ABAs may reduce certain brake maintenance expenses by lowering the incidence: of human intervention in brake adjustment, 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 i&eases the importance of optimum brake system maintenance and performance. ABA use tends to amplify weaknesses in brake maintenance procedures. If ABAs can be expected to work properly, brakes must be maintained at a high level. This may increase brake maintenance expenses in some fleets, but the trade-off is a safer vehicle, less unscheduled downtime and more confidence in a critical maintenance and vehicle performance function.

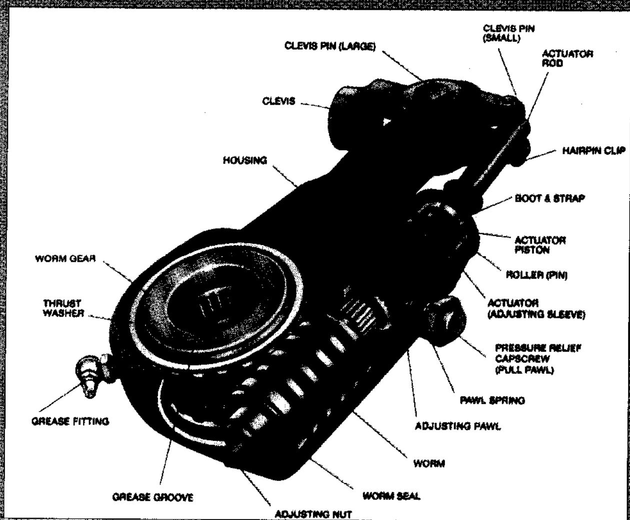
(6) Ask for evidence of the ABA's track record in different climates and geographic regions in vocations similar to yours. One brand might exhibit better severe service performance, while another might prove more cost effective in moderate service.

(7) Internal contamination is death to an adjusting mechanism. Ask how the unit is sealed to prevent moisture intrusion and internal corrosion. If the salesman can't talk credibly about this, he doesn't know his stuff.,

(8) If you operate in rough terrain or mountainous regions, pay attention to over adjustment characteristics and find out how the design compensates to minimize it. Some are less susceptible than others. Ask about the capability of some adjusters to m&e limited correction for over adjustment (controversially referred to as "backing off").

(9) If retrofitting, it's okay to shop for price, but don't, buy on price alone. Prices can differ dramatically, especially from local distributors. Run a few, and keep a close watch on their performance, before committing to a large purchase.

(10) Compare preventive maintenance requirements and field repairability features among the different brands. Some units may require special lube. Depending on the severity of your vehicle duty cycle or maintenance operation, field repairable units may be desirable. Also, if you have problems resulting from corrosion of camshaft splines, you might desire an automaticbrake adjusterthat sends some grease to those splines whenever the adjustor is lubricated,



ROCKWELL

A selection of pistons for this stroke-sensing ABA lets you specify running clearances for a particular application. Design improvements: color coded boot straps to allow easier piston identification; improved gear face seals to help decrease internal contamination and corrosion; revised grease channeling, including the camshaft splines; seal and bearing surface refinements to improve lubrication and reduce wear and internal corrosion. The complete pull pawl assembly now is available as an [illegible] to older Rockwell versions. This prevents damage to [illegible] March 1992, which resulted from the need to remove the pawl to [illegible] the unit in the reverse direction.

vehicles equipped with ABAs had one or more brakes out of adjustment. Roadcheck '91 data was worse. It shows 21% of the trucks and 22% of the trailers equipped with ABAs had one or more brakes out of adjustment.

If you calculate that one-fifth of the ABAs weren't doing the job, you were right, then again, maybe you were wrong. This is where it gets tricky.

ABAs sometimes take the heat for component problems elsewhere in the brake system. Improper installation, inadequate brake maintenance, even poor visual inspections, can result in problems unrelated to adjuster function-like deformed brackets or worn cam bushings-manifesting themselves in the inability of an adjuster to keep the brake tuned with precision. Three common problems that can lead to excessive stroke conditions are: wear at quick-connect collars, clevis pin bushings and camshaft splines. No adjuster can compensate for maintenance neglect or fickle performance characteristics elsewhere in a heavy truck or bus air brake system.

When it is the ABA's fault, however, you can count on one of several causes, especially when it's been in service a long time. Excessive premature wear and internal contamination are the two most notable problems shared by users.

As an ABA ages in service, the wear increases on tolerance-sensitive surfaces. So then does the running clearance that ABAs are supposed to maintain. The result is, more stroke is required for the lining to contact the drum. At excessive stroke conditions, lining-to-drum contact may not be sufficient to generate adequate braking force.

If even a small amount of water gets sucked into an adjusting mechanism, especially in the winter, it causes corrosion, or can freeze-up internal tolerance-sensitive surfaces and inhibit or prevent adjustments until the ice thaws. Remember these adjusting mechanisms perform within that tight window of tolerance which corresponds to running clearance of .020-to .030-in, depending on the brand.

"Internal wear in any adjuster will result in longer stroke," says Gerald Rodell, technical service manager for Haldex. "This normally determines the useful life of an adjuster."

Haldex takes durability a step beyond the others by using a specially hardened adjuster housing. This extra durability step shows up in the Haldex's six-year/750,000 mile on-highway warranty. That's one year and 250,000 miles more warranty than any other brand.

Over adjustment: still a hot topic

All ABAs will over adjust given the right set of circumstances. As stated, it's important to understand that the cause sometimes may not be a malfunction of the adjuster, but of other brake systems components. Two ABA brands, Haldex and Gunite, have a capability to make a "limited correction" and back off from a slightly over adjusted condition. This apparently occurs only at the high normal range of brake application pressures, 20 psi or greater.

If you're not getting the lining

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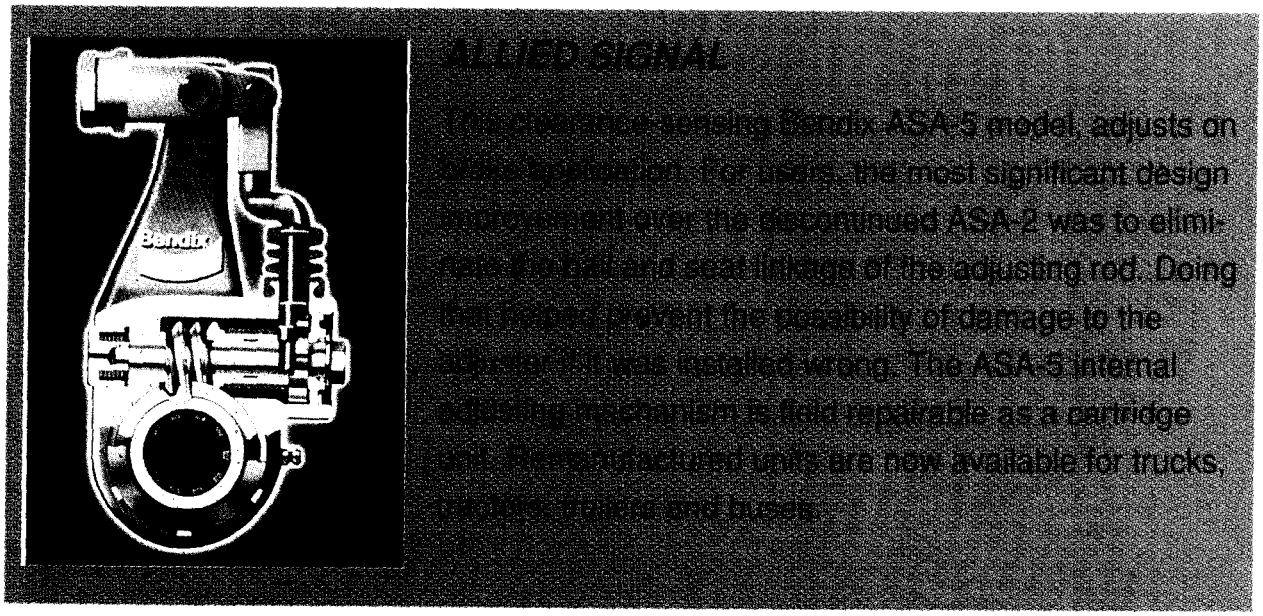


life you're after, don't blame the lining until you check your brake adjustment. Typically, over-adjustment leads to dragging brakes that may or may not be noticed by the driver. Here is one over adjustment scenario that is not so typical:

A tractor-trailer is negotiating a long, curving downhill grade. The vehicle is not equipped with a retarder. So, the driver has no choice but to repeatedly apply the brakes, known as "snubbing", in order to maintain safe control of the vehicle (See the companion story in this issue, *The truth about downhill braking*).

It doesn't take long in this severe mode of brake service for one or more brake drums to overheat and expand. This physically increases drum diameter. In extreme or prolonged conditions, it can lead to longer push rod stroke to achieve the needed braking force. When that happens, the ABA interprets it as a need for brake adjustment and obliges. Now, when the drums cool down, the brakes are over adjusted and dragging.

The result is most often unscheduled downtime while the driver manually re-adjusts the brakes. That's when the drums don't get too hot. When drums with dragging brakes get really hot, which they do at the bottom of a long mountain grade, the result can be wheel bearings welded to the axle or, in extreme cases, tire fires.

The limited correction capability of the Haldex and Gunite units is controversial because the natural fear is the adjusters might back off to a no-brake condition.

That won't happen, according to Haldex president, Charles W. Kleinhagen, whose engineering background includes director of engineering at Gunite, and a chief engineer at Eaton.

"During a typical adjustment," Kleinhagen explains, "the unit adjusts to some value of 100%. When the adjuster backs off, it does so only a small increment of original adjustment. With the expanded brake drums cooling down, the adjuster would continue to back off each time the brakes are applied, until adjustment is needed. Then, the adjuster readjusts at an incremental value many times greater than what it has backed off,"

So, yes, it backs off, but when it backs off to the point where the brake would need adjustment, the mechanism senses this and re-adjusts. It will not back off and reach an excessive stroke condition, much less a no-brake condition, according to Kleinhagen.

Gunite's director of engineering, Bill Ott, says tests run for a major tractor OE indicate that even with the adjustment mechanism intentionally disabled, the ABA will not back off to a no-brake condition. "What it does instead," Ott explains, "is to reach a point where there are insufficient internal reaction forces for the back-off feature to operate. At that point the unit operates as if it were a manual adjuster. Again, this is with the adjusting mechanism intentionally disabled."

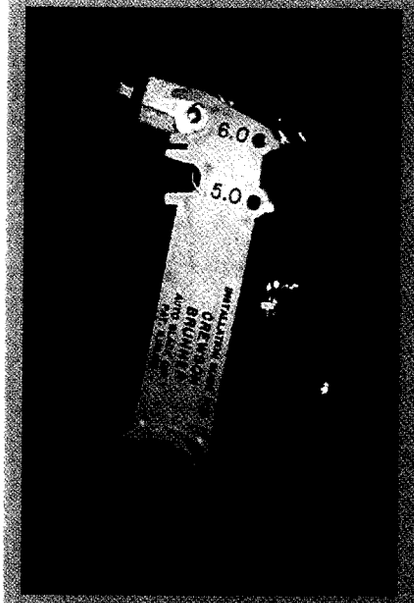
Wheel lock-up and tire fires aside, the typical result is lightly dragging brakes which cuts lining life and causes drum cracking.

Over adjustment will be an issue as long as there are adjusters—manual and automatic. But this should not steer you away from ABAs.

In terms of frequency of occurrence, over adjustment is a small problem. But it can be hard to pinpoint and has expensive consequences. With proper driver and/or mechanic training, it's a condition that is easily remedied, since all of the devices have a manual adjust capability. Of course, the best solution is to avoid it altogether with savvy spec'ing.

Closing the credibility gap

It's been a wicked ride for designers, marketers and users of heavy-duty automatic brake



CREWSON BRUNNER

Best known as a manufacturer of S-Cam shafts, manual slacks, brake shoes and other parts, Crewson Brunner introduced their ABA to users in May 1993. This is a clearance sensing mechanism similar to the others with link rod actuation, except this one adjusts on the release stroke. Crewson Brunner offers a novel tool aimed at making installation and setup easy, especially for the unwary (see rigid green template shown at left). The plastic template takes the place of the ASA during installation setup. If used properly, according to CB officials, using the template will transfer any trial and error to the template instead of the adjuster.

adjusters. Early field experience was a litany of problems caused by inflated performance claims, installation errors, inadequate sealing, corrosion, unacceptable wear of tolerance-sensitive parts and performance variations among same-brand units.

On the supplier side, designers and marketers had much to learn about the severity and variability of the operating environment in which ABAs were expected to perform with precision, 100% of the time. for hundreds of thousands of miles. On the user side, inadequate brake system maintenance and widespread misunderstanding of the cost benefits ABAs could provide created elevated expectations that ABAs could not fulfill.

The learning curve has been punctuated by a maze of conflicting user reports, over-zealous sales reps and widespread misunderstandings about the finite role of infinite importance that ABAs would play in the vehicle braking and brake maintenance scene.

So, that brings us to today, when the concept of air brake automatic adjustment still suffers needlessly from a credibility gap with users. But that gap is closing.

As of October 20, 1994 the NHTSA requires new equipment to have ABAs.

If projections about fleet retrofitting of automatics are only half true, huge numbers of fleets are switching to automatics.

While ABAs are relatively small chunks of iron on a big truck, their role is critical. That's why these small devices have drawn attention and controversy far out of proportion to their relative size, cost and complexity to the vehicle.

Like the fingers of your hand serve your body, ABAs are critical links to the safe operation of the big rigs that roar down our roads. You can take fingers for granted, but when you smash one the entire body wails. When you take heavy truck brake adjustment for granted, the body that wails may belong to someone else.

For additional reading

1. "Pinpointing Braking Failures," article by Steve Howse, technical service manager for Gunite. Appeared in the "Maintenance Manager," Summer 1991 edition, published by The Maintenance Council of the ATA, 2200 Mill Road, Alexandria, Va., 223 14. Tel: 703-838- 1763.

2. The Maintenance Council's RP 609, a Recommended Practice for "Manual and Automatic Slack Adjuster Removal, Installation and Maintenance."

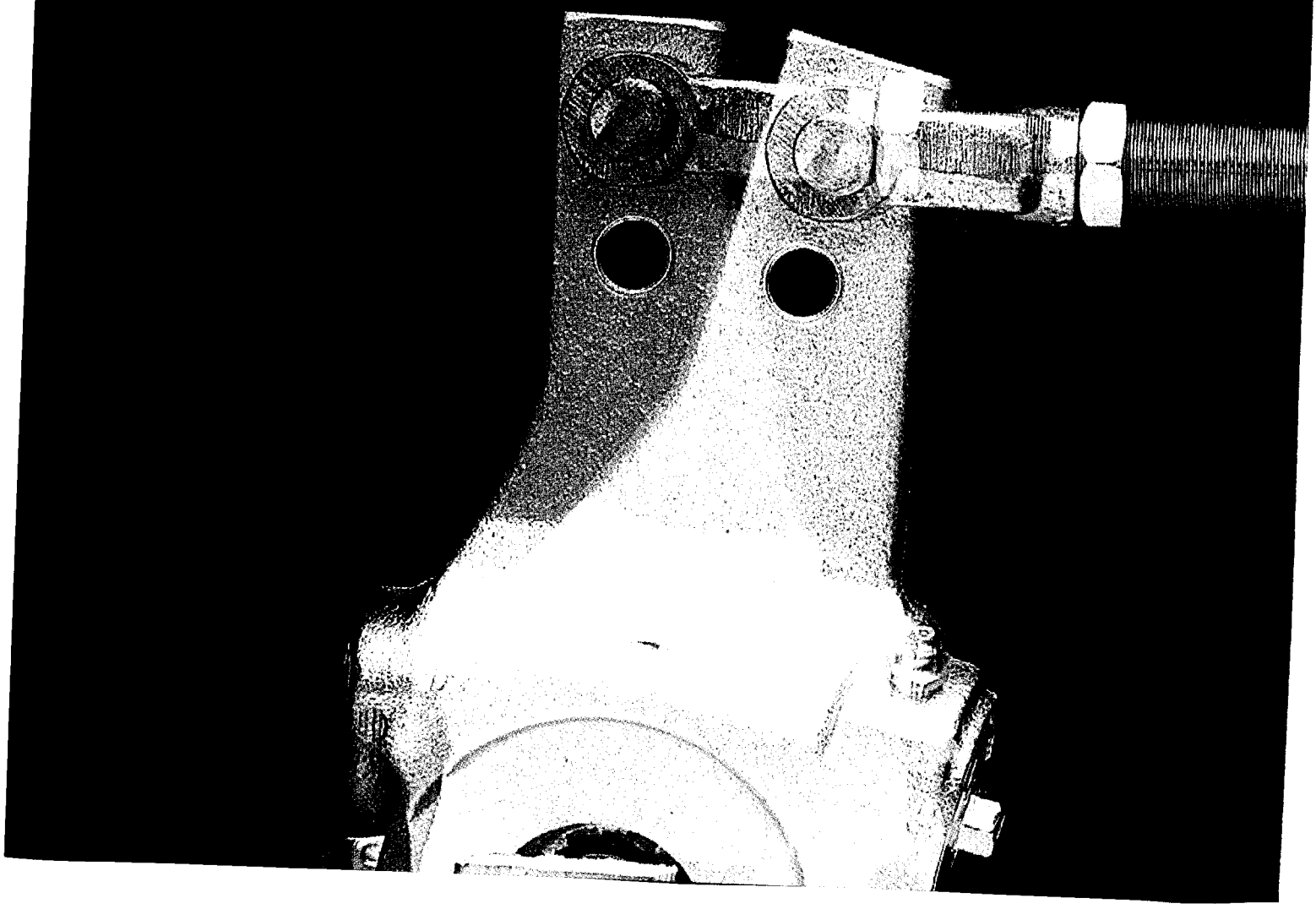
3. NHTSA's final report, "Automatic Slack Adjusters for Heavy Vehicle Air Brake Systems," (DOT HS 807 724), can be obtained from the National Technical Information Service, U.S. Department of Commerce, Springfield, Va., 22161. Tel: 703-487-4650.

4. See the next chapter in this book on Long-Stroke Chambers. It's a point-counterpoint debate in which two of trucking's top "technobrains" wrestle the merits of long-stroke air brake chambers.❑

DIFF'RENT STROKES

Are long-stroke brake chambers the solution to the trucking industry's poor record of brake maintenance? Or are they a needless expense that will serve only to line manufacturers' pockets and cause confusion in the shop and at roadside inspections? Pros and cons of long-strokes are presented here by CCJ's Rich Cross (acting as safety advocate) and Paul Richards (acting as devil's advocate).

By **PAUL RICHARDS**
Technical Editor
and **RICH CROSS**
Senior Technical Editor



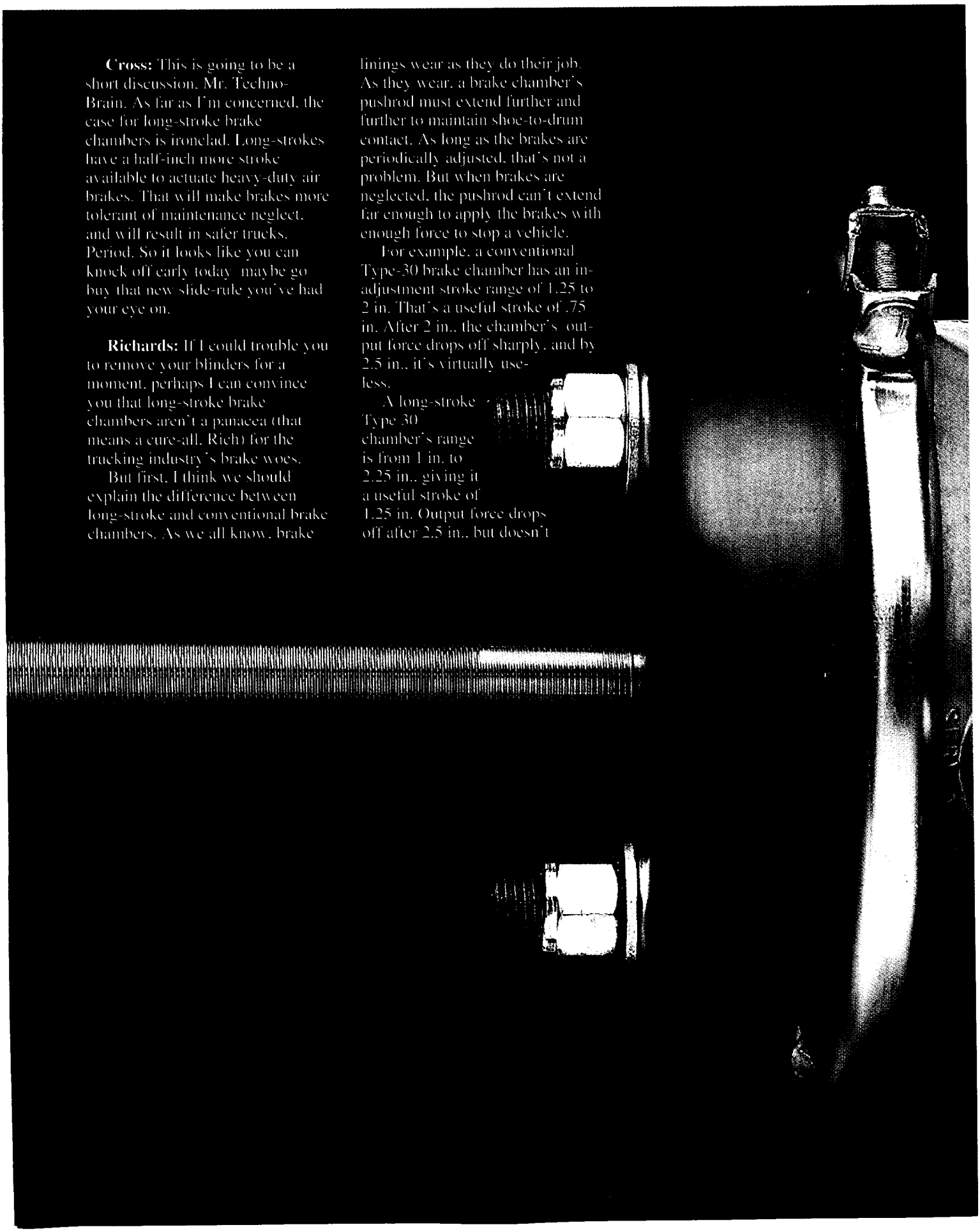
Cross: This is going to be a short discussion, Mr. Techno-Brain. As far as I'm concerned, the case for long-stroke brake chambers is ironclad. Long-strokes have a half-inch more stroke available to actuate heavy-duty air brakes. That will make brakes more tolerant of maintenance neglect, and will result in safer trucks. Period. So it looks like you can knock off early today - maybe go buy that new slide-rule you've had your eye on.

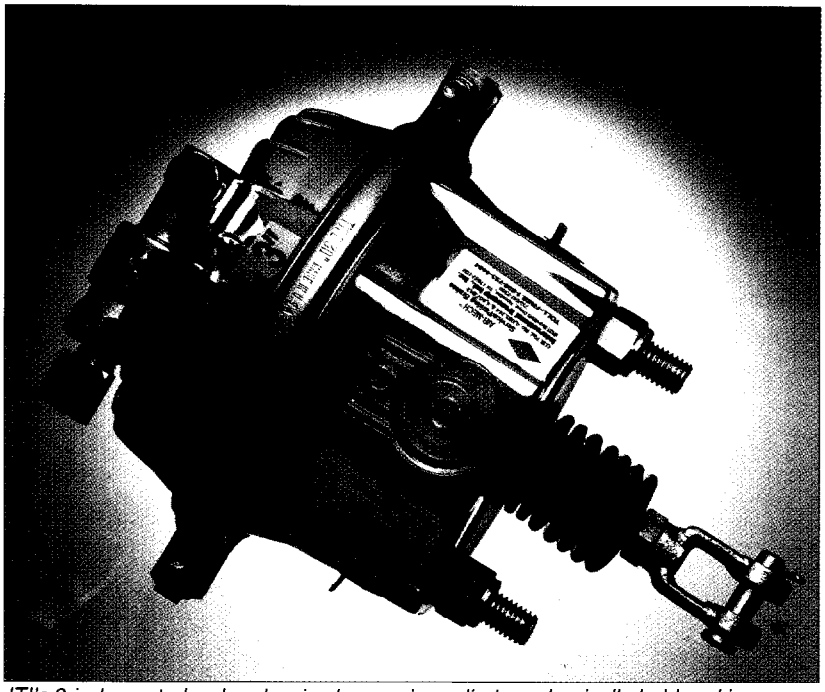
Richards: If I could trouble you to remove your blinders for a moment, perhaps I can convince you that long-stroke brake chambers aren't a panacea (that means a cure-all, Rich) for the trucking industry's brake woes.

But first, I think we should explain the difference between long-stroke and conventional brake chambers. As we all know, brake linings wear as they do their job. As they wear, a brake chamber's pushrod must extend further and further to maintain shoe-to-drum contact. As long as the brakes are periodically adjusted, that's not a problem. But when brakes are neglected, the pushrod can't extend far enough to apply the brakes with enough force to stop a vehicle.

For example, a conventional Type-30 brake chamber has an in-adjustment stroke range of 1.25 to 2 in. That's a useful stroke of .75 in. After 2 in., the chamber's output force drops off sharply, and by 2.5 in., it's virtually useless.

A long-stroke Type 30 chamber's range is from 1 in. to 2.25 in., giving it a useful stroke of 1.25 in. Output force drops off after 2.5 in., but doesn't



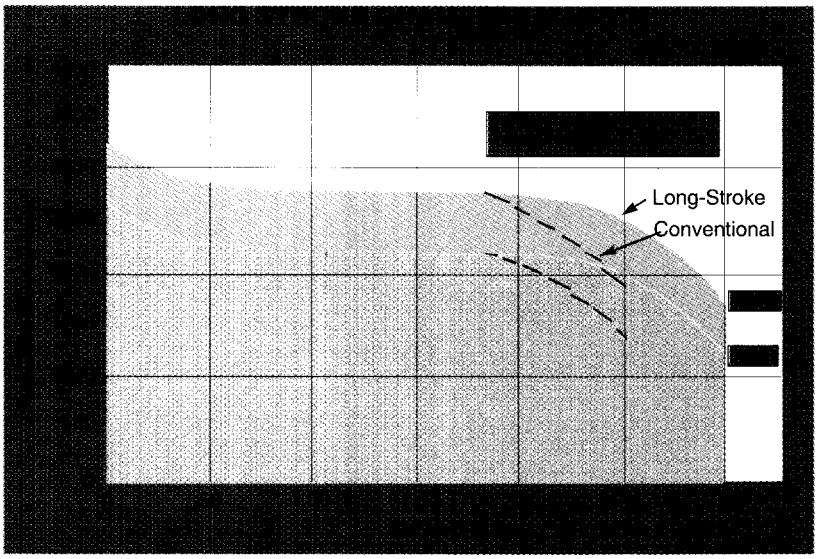


ITI's 3-in. long-stroke chamber is also an air-applied, mechanically-held parking brake. It's .75-in. longer and 1-lb, 4-oz heavier than their standard unit.

disappear until the pushrod extends to 3 in.

Again, as long as brakes are kept properly adjusted, either type of chamber will work, and I don't see the need for the extra half inch.

Cross: Have you been snorting brake dust again? It's easy for you to sit in your office and say brakes should be properly adjusted. But in the real world, maintenance often slips through the cracks. Just look at the National Transportation Safety Board's (NTSB) findings from last year's study. The Board monitored truck safety inspections in Florida, Pennsylvania, Oregon, Illinois and Texas. The inspections involved 1,520 randomly-selected five-axle tractor-trailers. Of those vehicles, 85 1 (56%) were placed out of service for brake-related defects. And 46% of those 85 1 vehicles were cited for bad brake adjustment. And, guess what? Fifteen percent of the rigs that were equipped with automatic brake adjusters (ABAs) had brakes that were seriously out of adjustment. Those are rigs whose owners cared enough about safety to spec ABAs, and 15% *still* failed. How can you say the industry couldn't use an extra margin of safety?



Rockwell graph compares output force, at *stroke, of conventional and long-stroke, Type-30 chambers.*

Richards: That isn't exactly what I said. Maybe whoever made the brake adjusters that didn't work would benefit from your "extra margin." But in the case of fleets with sloppy maintenance practices, hey, they'll just wind up getting cited for being out of adjustment at 2.5 in., instead of at 2 in.

And that's assuming brake inspectors will be able to tell the difference between a conventional chamber and a long-stroke. Obviously some type of positive identification will be necessary.

Cross: Dick Radlinski, chief of the National Highway Traffic Safety Administration's (NHTSA) Vehicle Stability and Control Branch advocates leaving the out-of-service criteria alone, and I agree with him. Leave the limit at 2 in. for a Type-30 long-stroke, even though it could safely go to 2.5 in., and you have a double safety factor.

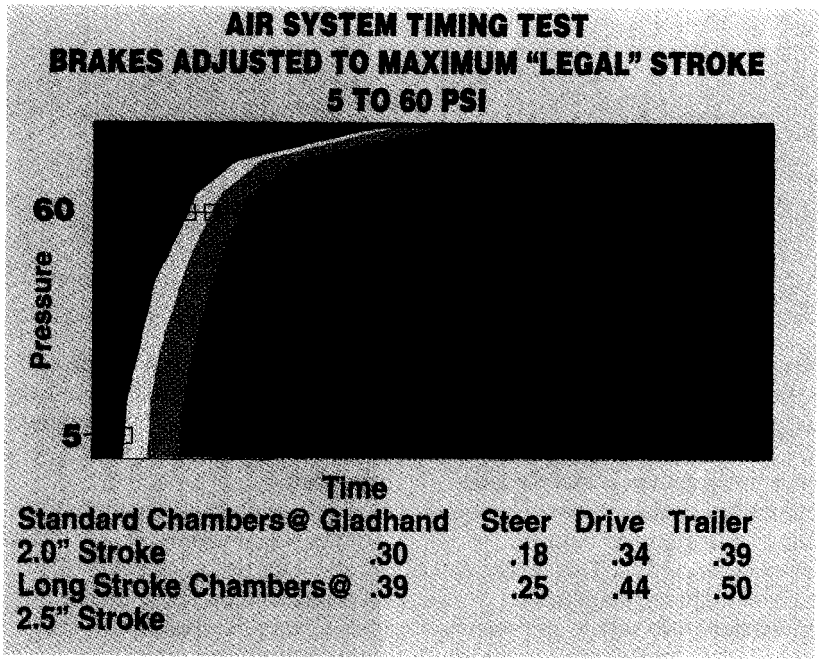
Richards: If you don't increase the out-of-service limit, where's the incentive to buy these little marvels? You're saying: "Hey, everyone, I've got this really neat new brake chamber. It may be more expensive than what you're using, and it's bound to confuse your mechanics and screw up your inventories, but at least it offers no practical advantages." I'm sure they'll sell like hotcakes.

Cross: If you don't consider saving human lives on the highway an advantage.. .

Richards: Whoa, let's not get bent out of shape. I've no objection to highway safety. That's why I'm all for proper brake maintenance.

And, I'm not saying long-stroke chambers are a terrible idea. It's just that there are practical considerations that may make them more trouble than they're worth.

Take air reservoirs, for instance. Right now, NHTSA says you have to have reservoirs capable of holding 12 times the volume of air in your brake chambers. Well, long-stroke chambers have more volume than conventional chambers, so using them means carrying more or bigger air tanks. That's an expense fleet operators aren't going to appreciate.



Results of Eaton apply timing test show long-stroke chambers are about 1/10 sec slower at maximum stroke.

Cross: Don't play dumb with me. You know very well that the American Trucking Associations (ATA), Alexandria, Va., has petitioned NHTSA to revise FMVSS- 12 1 reservoir size r-equirements. They maintain that the current requirement is conservative, and that today's reservoirs will be more than adequate to handle long-strokes. It seems a reasonable request, and I'm betting NHTSA will go along with it.

Richards: Okay, you got me. But what about the effect on apply and release timing? Since long-strokes have more air volume, they'll take longer to fill and exhaust. And after all we've written about brake balance, you know it doesn't take much to mess it up. According to Jim Clark, chief engineer, brake products, Eaton Corp.. Kalamazoo, Mich., apply timing would be slowed by about a tenth of a second with long-stroke chambers.

That may not sound like much, but if it's a trailer that's delayed, and it winds up pushing a tractor through a wet curve, it's jackknife city.

Cross: According to ATA engineering director Larry Strawhorn, the effect on timing should not be critical. Besides, it would only be a factor if the brakes were out of adjustment. When brakes are properly adjusted, the air volume in a long-stroke chamber would be the same as that of a conventional chamber.

Richards: So you would advocate always keeping brakes in proper adjustment?

Cross: Of course.

Richards: So we really have no need of long-stroke chambers, have we?

Cross: I'm getting a headache.

Look, a conventional, Type-30 brake chamber, at any application pressure, bottoms-out at slightly beyond 2.5 in. of stroke, and output force becomes negligible. In comparison, according to Mark Naedler, senior engineer, International Transquip Industries in Houston, a 2.5-in. stroke on a Type-30 long-stroke still yields a force of 1,420 lb at 60 psi.

Richards: Great. That's probably enough to roll over the cam-shaft.

Cross: Paul, after you fell off that turnip truck, did it back over you? Camshaft rollover is not a function of pushrod stroke. Ask a brake engineer-I did. Rockwell International's Prakash Jain assures me that cam rollover is dependent on lining clearance, thickness and

"Long strokes will make brakes more tolerant of maintenance neglect, and will result in safer trucks."–Cross

"I'm not saying long-stroke chambers are a terrible idea, but there are practical considerations that may make them more trouble than they're worth."–Richards

drum diameter. Camshaft rollover due solely to extended stroke is a myth.

What I was getting at, before your interruption, is that the long-stroke has enough reserve to stop a truck, where a conventional chamber wouldn't. That means that vehicles that are marginally maintained will still be able to stop, even if their brakes aren't properly adjusted. And it certainly won't hurt fleets with good brake maintenance programs.

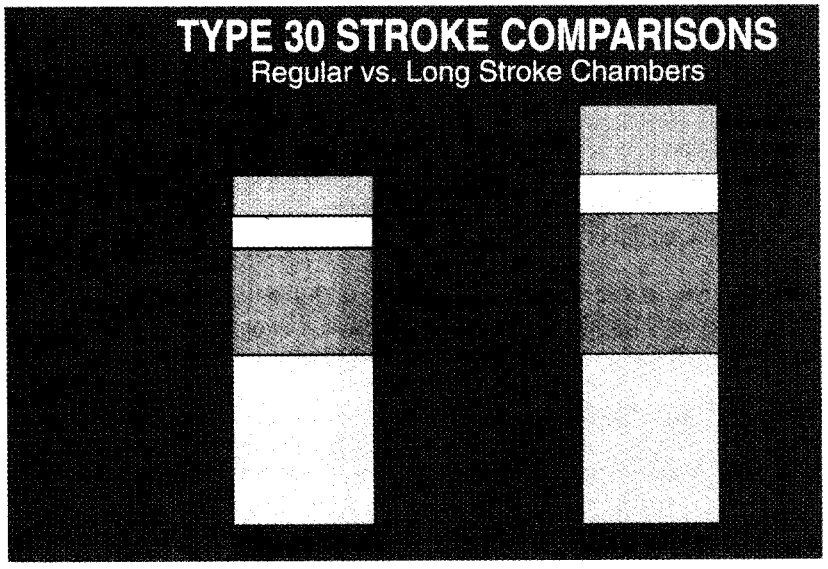
Richards: You are wrong, asbestos-breath. They'll be the ones paying for someone else's problem.

Long-stroke chambers are going to be larger and heavier than conventional chambers. Chuck Kleinhagen, president of Haldex Corp., Blue Springs, MO., tells me he's seen clearance problems, in some drive-axle applications, with ABAs at the 2.5-m. limit of travel. That's with a conventional brake chamber.

In those cases, Rich, there's simply not enough swing clearance to allow the use of an extra 1/2 in. of travel-at least not without redesigning the chamber bracket, axle and/or suspension.

Furthermore, if the bracket has to be moved further from the cam centerline, there'll likely be more bracket deflection, and much of the advantage of the extra stroke may be lost.

In any event, there's a lot of engineering and manufacturing work needed to make these things fit. And I don't think a fleet operator with a good brake maintenance program should have to help absorb those costs. In fact, I haven't talked to *any* fleet operators who want long-stroke chambers.



NTSB's comparison of stroke characteristics of conventional and long-stroke, Type-30 brake chambers.

Cross: As far as I know, there's only one Type-30 long-stroke on the market right now, and it's smaller than a conventional chamber.

Richards: Good try, but the old bait-and-switch won't work. You're talking about the IT1 unit. That's an air-applied, mechanically-held brake. I've heard it's a good system, but you're comparing apples and oranges. Long-strokes with spring brakes are going to be larger than what we have today.

Cross: Okay, I know that MGM of Southfield, Mich., is going to come out with a long-stroke early this year. And according to vice president of engineering Graydon Choinski, it will be less than 2-lb heavier and only about 1.5-in. longer than conventional chambers. He says there should be minimal packaging problems.

Richards: Ultimately, it's still going to cost the fleet operator more money. And a question we have to ask is, who will benefit? Will it be the fleet operator? Or will it be brake component suppliers whose products will have more margin for design and manufacturing error?

I'll concede that long-stroke brake chambers *could* contribute to safety. And, certainly, they'll be available to those who choose to use them.

But I think even you would agree that they're not a substitute for knowledgeable brake spec'ing and responsible maintenance. ❑

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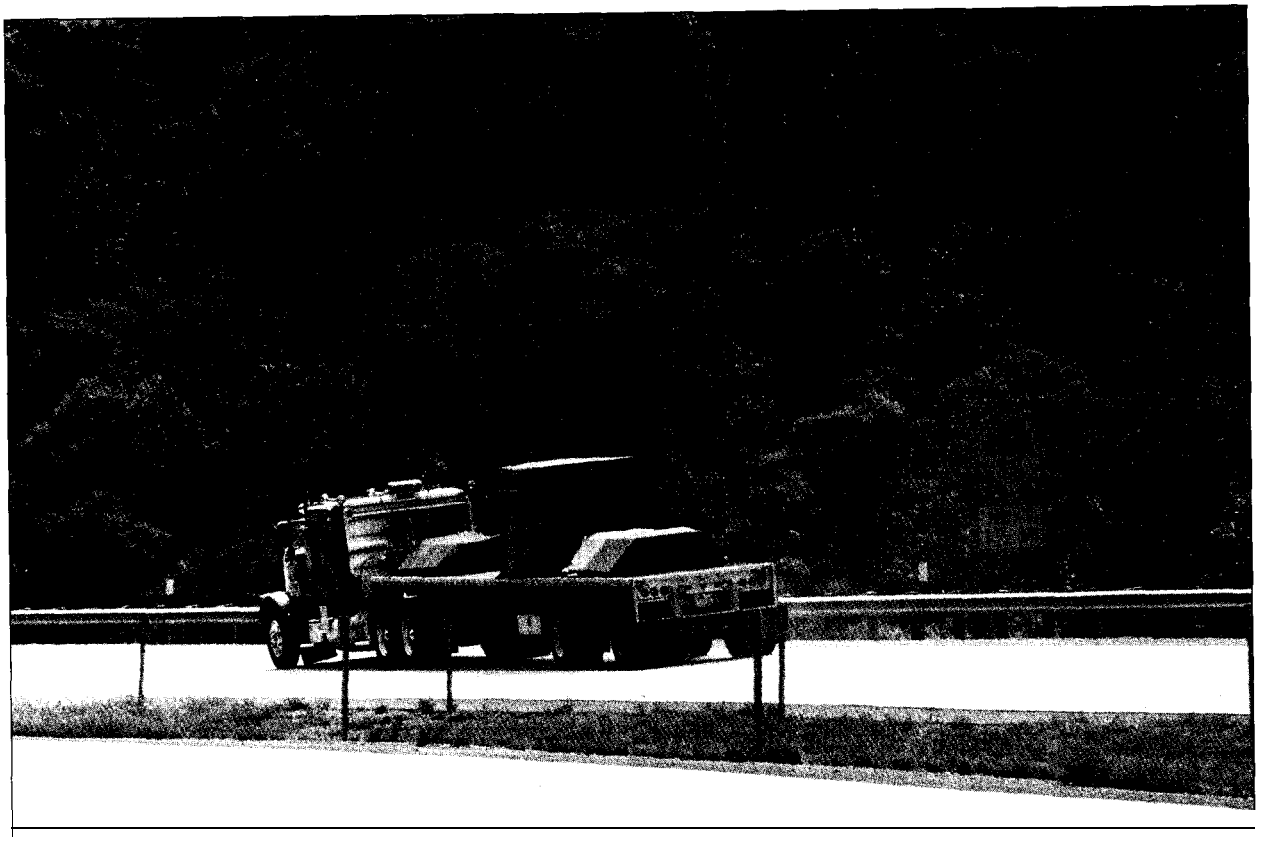
The truth about DOWNHILL BRAKING

Millions of truckers have been given bad advice about safe braking on downgrades. This story reveals the truth, as documented by the results of federally-funded tests obtained exclusively by Commercial Carrier Journal.

By RICH CROSS
Senior Technical Editor

For years, virtually every tractor-trailer driver *in* the country was taught that the safest method of descending a hill is light, steady braking.



But that's wrong, according to tests conducted in 1991 by the National Highway Traffic Safety Administration (NHTSA) and the University of Michigan's Transportation Research Institute (UMTRI).

Sustained downhill braking, under the best of circumstances, can be a nervous exercise, even for experienced drivers.

In some instances, light, steady braking engages the tractor brakes but not the trailer brakes. As a result, the tractor brakes start to overheat and fade. So the driver presses harder on the pedal, thereby engaging the trailer brakes. And if the rig hasn't picked up too much speed, the driver may regain safe control.

In the worst-case scenario, both the tractor and trailer brakes fade, sending a terrified driver freewheeling down a mountain highway to his grave.

From the source's mouth

The source of the dangerous advice to rely on light, steady braking is the first edition of the federally-funded "Model Driver's Manual For Commercial Vehicle Driver Licensing" (CDL Manual) provided to all states in 1989 by the U.S. Department of Transportation.

According to that edition of the CDL Manual: "The right way to go down long grades is to use a low gear and go slow enough that a fairly-light, steady use of the brakes will keep you from speeding up.

"Some people believe that using the brakes hard going downhill but letting up on them from time to time will allow them to cool. Tests have shown this is not true.

"Brakes cool very slowly, so the cooling between hard brakings is not enough to prevent overheating. Also, the vehicle picks up speed when the brakes are let up, which means more hard braking to slow it back down.

"Braking in this way, on-and-off, builds up more heat than the light, steady method does. Therefore, go slow enough, use the right gear, and maintain light, steady pressure on the brakes."

Just the opposite is true, however. Federally-funded testing, jointly conducted in August 199 I by NHTSA and UMTRI, proves conclusively that intermittent, moderate braking (snubs) is the safest method.

Here are summary findings of the NHTSA/UMTRI tests, as revealed in a letter to CCJ by Richard Radlinski, former head of the Vehicle Stability & Control Division of NHTSA's Vehicle Research & Test Center (VRTC) in East Liberty, Ohio:

"At the request of the Federal Highway Administration, VRTC participated with UMTRI in a research program to study downhill braking methods used by tractor-trailer drivers," Radlinski explains.

"VRTC instrumented an 80,000-lb, five-axle tractor-trailer with equipment to continuously measure brake chamber pressures, strokes and temperatures in the linings and drums. Vehicle speed, deceleration and distance traveled also was measured. Over 40 channels of data were recorded.

"The vehicle was set up so that pneumatic valves could be quickly changed between test runs, to represent three different levels of pneumatic balance between the tractor and trailer that might occur in real-world braking. The three levels of balance ranged from good to very poor.

"Tests were run on I-64 in West Virginia, descending Sandstone Mountain. This is an extremely severe grade with two run-off ramps. Runs were made down the grade at each of the three balance conditions, using both the constant-drag method of braking and the snub method. Continued

"Since most drivers don't know how well-balanced their vehicle is, the snub method is the safest approach."

"In each case, panic stops were made at the bottom of the grade to measure stopping capability after the descent. Some runs were made with the brakes fully adjusted. In other cases, brakes were deliberately backed off," Radlinski says.

Truth about downhill braking

According to Radlinski and UMTRI researchers, the following conclusions were drawn after analyzing the test data.

If a tractor-trailer's brakes are well balanced, it doesn't matter which braking method is used, Radlinski says.

However, if a tractor-trailer's brakes are not well-balanced, intermittent, moderate applications (snubs) produce the lowest peak temperatures and best temperature balance among the axles.

In sharp contrast, constantly dragging the brakes of a poorly-balanced combination vehicle will overheat those brakes which apply at lower application pressures while under-utilizing those requiring higher pressures to actuate.

'Since most drivers don't know how well balanced their vehicle is, the snub method is the safest approach," Radlinski declares. "The driver should select a gear so that, at governed engine speed, the vehicle tends to remain at (or below) the posted speed limit for trucks," he says.

"If speed increases, he should then snub the brakes moderately, slowing the vehicle to 5-6 mph below its target speed. Typically, braking effort should approximate that used to make a normal, controlled stop at a traffic light.

"With a fully-loaded combination vehicle and an application pressure of 20-30 psi, it should take about three seconds to decrease speed by 5-6 mph.

"The driver should then release the brakes and let the vehicle accelerate back up to governed speed. Subsequently, he should repeat the snub-and-release sequence, as required, until the grade levels off and the vehicle stops accelerating," Radlinski explains.

"There's also evidence, from other research, that the snub method can minimize the likelihood of drum cracking," he says.

Basically, light and steady braking may cause certain brake linings to skim and super-heat high spots on the surface of a brake drum. Sudden cooling, when the brakes are released, may change the metallurgy of those high spots and promote cracking.

Finally, Radlinski notes that brakes that aren't properly adjusted for minimum stroke can dramatically increase stopping distance.

In pursuit of faulty advice

Apparently, the source of the CDL manual's bad advice about braking is a nationally-distributed magazine article (not CCJ's) about a brake test conducted in 1969 by an unidentified public utility company on the West Coast.

At least, that's the informed speculation of Fergus Savage, manager of fleet safety programs for the Insurance Corporation of British Columbia, Vancouver.

The article reports that snub braking, which it describes as the most common method for downgrades, should no longer be used. Instead, light and steady braking is the only safe method, the author firmly states.

Most notably, the article contains numerous comments by a witness to the test, identified as Ray Flick of the California Highway Patrol (CHP), who retired in 1977 and is now deceased.

CCJ was told, by Savage and others, that the decades-old magazine article probably found its way into the material used by the Essex Corporation in Goleta, Calif., to compose the CDL manual under contract to the Federal Highway Administration (FHWA).

During a telephone interview with CCJ, Essex researcher Dennis Wiley recalled that the admonition to use light and steady braking on downgrades was based on testing by the CHP.

Wiley could not recall, however, when the test had been conducted. Nor could he recall where that specific source material had originated, or where Essex had filed it.

It gets better.

According to Captain Larry Rollin, the CHP has never participated in a downhill-braking test.

Until 1991, the only downhill-braking tests since 1975 (when all air brake systems were redesigned, courtesy of FMVSS-121) were those conducted in 1983 by NHTSA and UMTRI.

NHTSA's 1983 test, conducted on Savage Mountain in Cumberland, Md., suggested that brakes stay cooler when snubbed, as opposed to lightly dragged.

And that conclusion was reinforced by UMTRI's computer-controlled brake dynamometer simulation of descending Martin's Mountain in Cumberland, Md., also conducted in 1983 under contract to NHTSA.

Neither test was considered to be conclusive, which may explain why Essex, and the panel of experts it retained to review the manual, were not influenced. That panel was comprised of veteran truck drivers and experienced fleet safety experts, according to Wiley. Unfortunately, none of them waved a red flag.

Also unfortunate is the fact that neither Essex nor the FHWA asked a brake engineer to review the draft of the CDL manual's brake section before it was sent out for

printing and distribution to the states.

So, it appears that no one responsible for the information in the CDL's brake section was aware of the following information:

. Data collected by AlliedSignal Automotive Truck Brake Systems Company suggests that runaway accidents may be induced by continuously braking a combination vehicle so lightly that trailer brakes initially are not actuated.

. A widely-distributed American Trucking Associations' publication, entitled "Facts For Drivers," clearly warns truckers against sustained, light braking on downgrades.

. Engine brakes and retarders can save lives. Yet the CDL manual says very little about their existence or proper use, according to the American Trucking Associations (ATA) Senior Safety Engineer Neill Darmstadter.

. Eaton Corp. research demonstrated that light, steady braking on downgrades can promote drum cracking (CCJ, December 1989).

Questions about the CDL manual's advice on downhill braking were first brought to the attention of Dick Landis, former FHWA associate administrator for motor carriers, in December 1989.

Landis immediately assigned Bob Hagan of FHWA's Office of Motor Carriers to coordinate an investigation.

Less then one month later, on January 12, 1990, a planning session was held at the offices of Clark Martin of the American Association of Motor Vehicle Administrators (AAMVA) in Arlington, Va.

The AAMVA is responsible for making changes to the CDL manual and distributing them to the states.

Participating in the January 1990 meeting were members of AAMVA, ATA, FHWA, NHTSA and other interested parties, including this writer.

After a full briefing, participants agreed that NHTSA's Radlinski should immediately submit revised language for the braking sections, since the current language was clearly suspect.

Although Radlinski's comments were composed and submitted to FHWA a month later, on February 14, AAMVA decided to defer a decision to change the text of the CDL manual.

Instead, AAMVA merely suggested that states might wish to "include a reference to the controversy" over safe downhill braking in the margin of the braking section of the CDL manual. Not one state did this.

A frustrated Landis added (and made a priority) the task of investigating downhill braking methods to federally-funded truck brake research already underway at UMTRI and ultimately assisted by NHTSA.

As noted previously, the UMTRI/NHTSA tests proved that the braking advice in the first edition of the CDL manual is dead wrong. In response, AAMVA issued a news release, in April 1993, noting that the second edition (aka Version 2.0) of the CDL Manual would be revised to endorse the use of intermittent and moderate downhill braking as the safest method. FHWA did not issue a similar news release.

Version 2.0 of the CDL Manual was issued to the states in January 1994. However, no portion of the original or revised manual legally may be reproduced and used as driver training material by anyone without obtaining written permission from AAMVA, Suite 1100, 4200 Wilson Blvd., Arlington, Va. 22203, ❑

"There's also evidence from other research that the snub method can minimize the likelihood of drum cracking."

How to brake straight trucks and buses on downgrades

By **RICH** CROSS, Senior Technical Editor

When descending a grade, there's no question that air-braked straight trucks, transit buses and school buses should be slowed with the same intermittent and moderate brake applications recommended for tractor-trailers, according to Richard Radlinski, former head of the Vehicle Stability & Control Division of the National Highway Traffic Safety Administration's (NHTSA) Vehicle Research & Test Center in East Liberty, Ohio.

Radlinski specifically recommends the intermittent, moderate-pressure method of downhill braking for straight trucks and buses equipped with a front axle limiting valve.

A front axle limiting valve is designed to minimize the risk that even mild braking on a slippery downgrade might lock the front axle and thereby prevent steering around a curve. To achieve that goal, a ratio limiting valve reduces front-axle braking by 50% during treadle applications up to 40 psi. Braking at 40-60 psi is reduced by less than 50% while full braking is provided at any treadle pressure exceeding 60 psi.

In reality, Radlinski says, a limiting valve has the potential to increase the risk of brake fade and run-away accidents on downgrades because it lets the front brakes loaf while causing the other brakes to work harder...and therefore run hotter.

That risk is maximized by constantly braking straight trucks and buses so lightly that limiting valves aren't even actuated, he says.

Should that occur, the front brakes will not engage at all.,.until the driver perceives that his rear brakes are fading and tromps on the treadle harder. At that point, the steer-axle brake may not suffice to restrain the vehicle from losing its brakes completely before the end of the grade is reached.

Unfortunately, steer-axle brakes are prone to be intentionally backed-off and/or retrofitted with linings far less aggressive than those originally installed by the truck/bus maker, according to the National Transportation Safety Board. So front brakes can't always be counted upon in an emergency.

In any case, since most drivers won't *know* whether their bus or straight truck is equipped with a limiting valve, moderate and intermittent braking (called snubbing) is the safest approach, Radlinski says.

The braking method recommended by Radlinski for straight trucks/buses and tractor-trailers is as follows:

"The driver should select a gear so that, at governed engine speed, the vehicle tends to remain at (or below) the posted speed limit for trucks," he says.

"If speed increases, he should snub the brakes moderately, slowing the vehicle to 5 or 6 mph below its target speed. Typically, braking effort should approximate that used to make a normal, controlled stop at a traffic light.

"With a fully-loaded combination vehicle and an application pressure of 20 to 30 psi, it should take about three seconds to decrease speed by 5 or 6 mph. The driver should then release the brakes and let the vehicle accelerate back to governed speed. Subsequently, he should repeat the snub-and-release sequence, as required, until the grade levels off and the vehicle stops accelerating," Radlinski says.

Radlinski also notes that industry research has linked light and steady braking with an increased risk of drum cracking.

Lightly dragging brakes on a downgrade may prevent uniform contact between drum and linings and cause hot spots to form.on the drum's friction surface.

Hot spots get hotter, in less time, when certain low-friction (EE) linings are used.

When hot spots cool, at the bottom of the grade after the brakes are released, they may convert to a form of cast iron called martinsite The conversion process is akin to heat treating, which is used to harden metal surfaces.

Martinsitic hot spots appear as dark, hard bumps on the drum's friction surface. They can cause uneven lining wear, noisy braking and a pulsating ride when brakes are applied.

Because martinsite expands and contracts at a rate different than that of conventional drum metal, stress cracks form adjacent to hot spots.

In time, the stress cracks may become larger and travel completely through the drum wall.

Obviously, a drum in this weakened condition is prone to shatter during a panic stop. ❑

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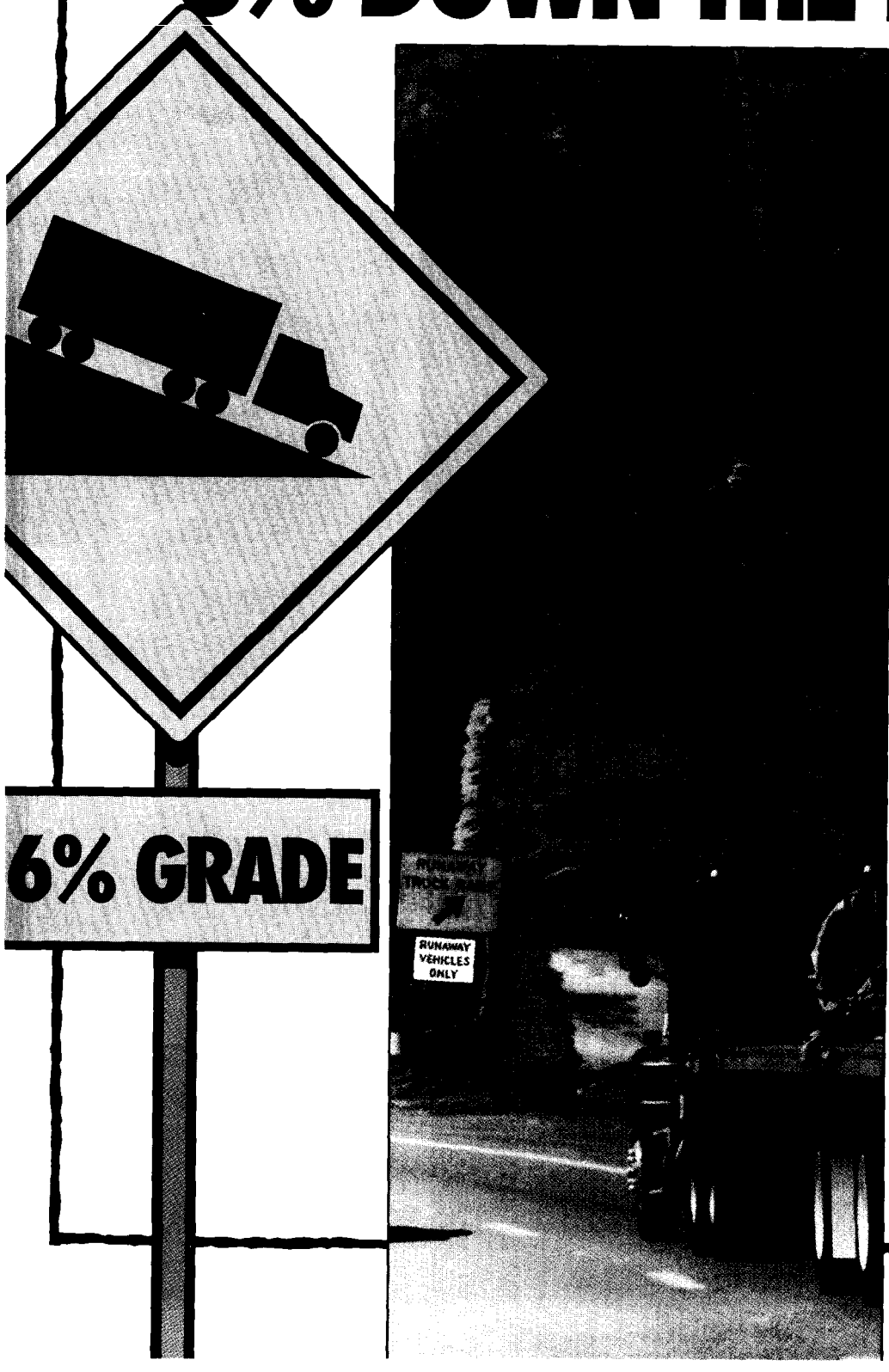

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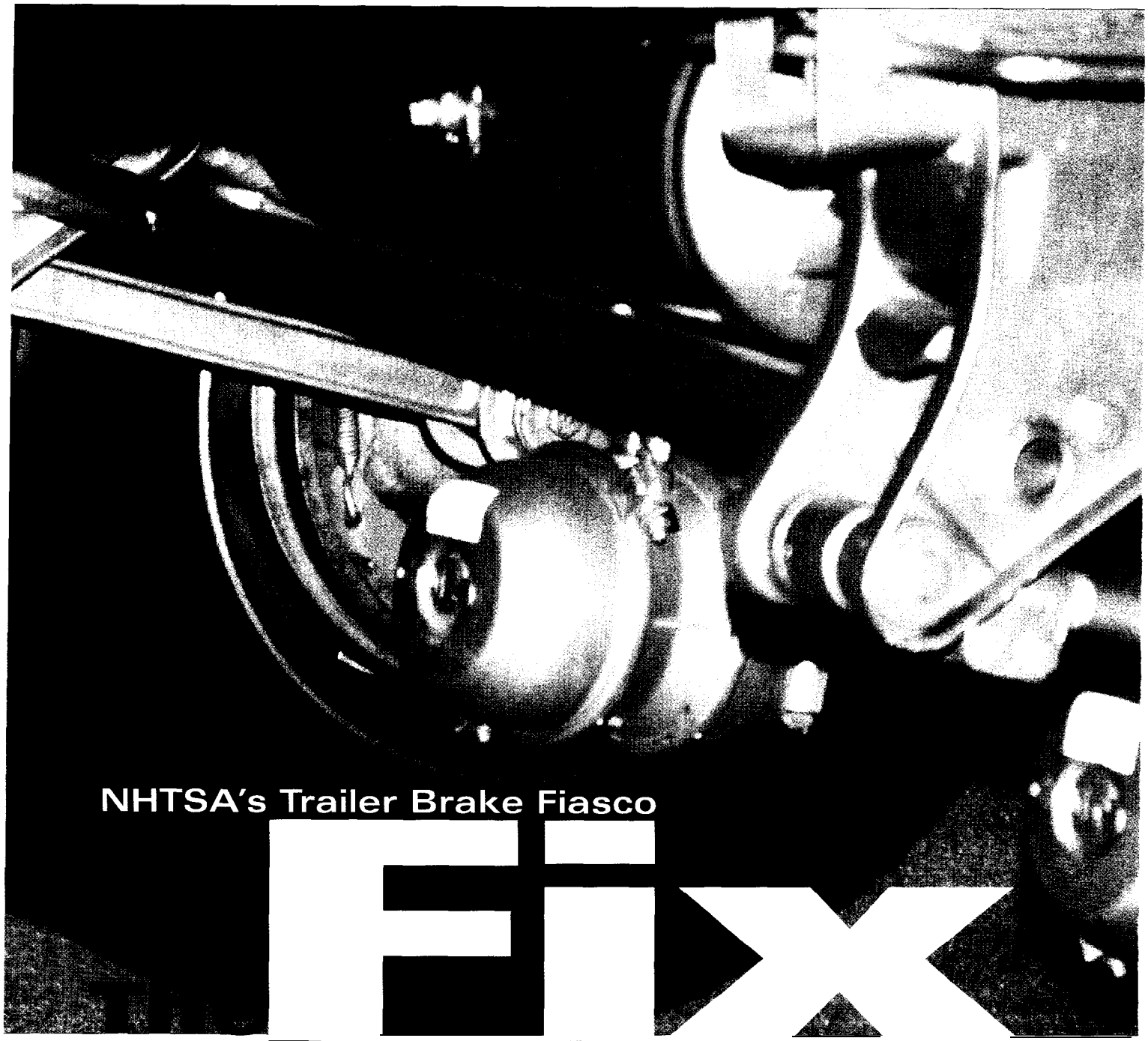


NHTSA's Trailer Brake Fiasco

Fix is in

How to modify trailer and equipment specs to counteract NHTSA's meddling in air brake system design.. .and make your trailers safe again.

By RICH CROSS, Senior Technical Editor

"Using an older tractor with a newer trailer has the potential to create some extreme problems," warns Duke Drinkard, director of maintenance for Southeastern Freight Lines, Columbia, S.C.

Specifically, he says, dragging brakes and/or reduced braking ability may result from the inability of many older tractors to quickly charge the reservoirs and release the parking brakes on a new trailer whose reserve air has bled down significantly before hook-up.

As referenced by Drinkard, "older tractors" are those with inadequate reserve air due to a compressor cut-in setting of 85 psi. or less.

And "new trailers" are those made since October 1992, the effective date of two changes to Federal Motor Vehicle Safety Standard 121 (FMVSS 121) made by the National Highway Traffic Safety Administration (NHTSA).

Those two changes are:

- elimination of the requirement for a separate trailer air reservoir dedicated to releasing and holding off spring-type parking brakes;
- a new requirement for a protected air line on the trailer which, in theory, prevents spring-type parking brakes from dragging by holding them off with at least 70 psi (even if a trailer's service brake air reservoir is empty). The requirement also applies to trailers retaining a dedicated parking brake reservoir.

Problem is, some makers of trailer brake control valves decided to protect that 70-psi line with valves requiring a lot more than 70 psi to open.

Depending on the make/model of trailer brake control valve, tractors now must provide 75 to 105 psi to access that protected line and start to charge a trailer. Before revision of FMVSS 121, tractors only had to provide 50 to 55 psi for the task.

Accordingly, makers of trailer brake control valves had to decide how to allocate a tractor's often-inadequate reserve air to a trailer upon hook-up.

Some valve manufacturers chose to make parking-brake-priority (PBP) systems, which prioritize delivery of air for quick release of a trailer's parking brakes. Charging a trailer's service reservoirs to provide braking ability is a secondary concern. Therefore, a PBP system may allow a trailer with little or no braking ability to be towed onto a highway.

Other valve manufacturers chose to make service-brake-priority (SBP) systems, which ensure that a trailer's air reservoir is adequately charged, thereby providing braking ability, before permitting its parking brakes to be released. Unfortunately, some SBP systems may permit spring brakes to drag, perhaps causing a tire fire.

Details about problems with new trailer brakes are available by requesting a copy of CCJ's December 1993 feature entitled, *NHTSA Rule Degrades Trailer Brake Safety.*

Seeking solutions

Southeastern Freight Lines' Duke Drinkard chairs a "Matching Air Brakes" industry task force charged with finding solutions to problems with brake systems on new trailers. The task force was established by the S-6 Chassis Study Group of The Maintenance Council (TMC) of the American Trucking Associations (ATA), Alexandria, Va.

In October, 1994, during TMC's meeting in San Diego, Calif., Drinkard's task force distributed draft copies of a proposed recommended practice (RP).

The proposed RP suggests that problems with new trailers can be minimized by modifying existing equipment, and by using custom specs for future equipment purchases.

According to task force member Sid Williams, an air brake expert employed by ATA's engineering department, voluntary industry compliance with the finalized RP should increase the operational safety of new trailers without calling upon NHTS A to further modify FMVSS 121. Continued

Williams says that NHTSA, his former employer, would require at least two years of additional rule-making to revise the trailer-brake portions of FMVSS 121. That is, assuming NHTSA could be talked into considering such a project, which seems doubtful. For now, NHTSA remains preoccupied with finalizing rulemaking to mandate the use of anti-lock brake systems on commercial vehicles.

Instead of attempting to involve NHTSA, Williams says, fleetmen immediately can start to correct design problems through savvy spec'ing of new tractor and trailer brake systems, plus modification of existing equipment, as tentatively proposed by TMC's draft RP.

At the same time, the Society of Automotive Engineers (SAE), Warrendale, Pa., reportedly will be called upon to develop two standards that would reinforce TMC's RP.

Specifically, Williams says, SAE may decide to pursue a standard that prescribes a time limit for a new tractor's gladhand to open a simulated trailer's pressure-protection valve and charge the trailer's service reservoir to a given pressure. Voluntary compliance by tractor makers would prompt modified designs for less-restrictive air lines, air line fittings and air valve orifices.

In addition, SAE may develop a standard that limits the time for a new trailer's empty reservoirs to be charged to a specified pressure, and its parking brakes released, by a simulated tractor. Again, voluntary compliance by trailer makers also would prompt the use of less-restrictive air systems, and air valves requiring relatively low actuation pressures.

Now, let's examine some purported shortcomings of tractor-trailer air brake systems that TMC's forthcoming RP and new SAE standards collectively may help to eliminate.

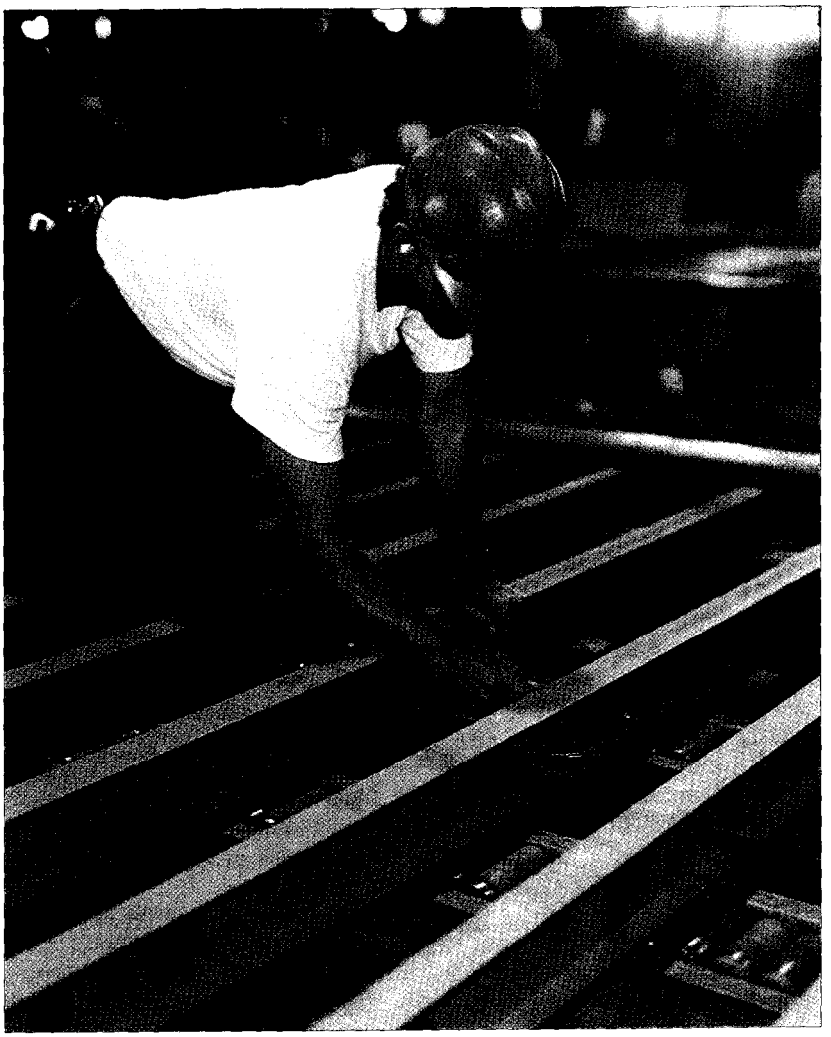
A key recommendation of TMC's draft RP is that a tractor's air reservoir be maintained at a minimum of 125 psi, so that it can provide a volume of air sufficient to quickly open a trailer's protected line and release its parking brakes.

Currently, FMVSS 121 only requires that tractor makers use a compressor cut-in setting above 85 psi-although NHTSA has implied (July *20,* 1994, *Federal Register)* that it may raise that requirement to a minimum of 100 psi.

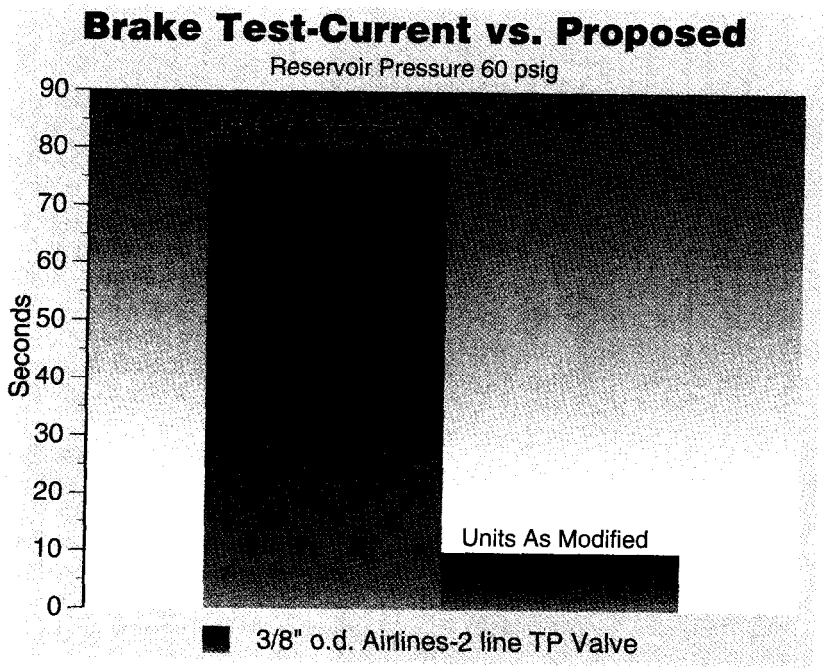
In any case, maintaining 125 psi typically requires that the air compressor governor cut-in pressure be set at 105 psi. To do so, back off the locking nut on the compressor governor and rotate the set screw clockwise-initially, not more than a quarter turn.

Proper adjustment is attained when the compressor automatically cuts out at a tractor dashboard air gauge reading of 125 psi.

Some "non-adjustable" Bendix compressor governors are fitted with a hard-to-remove plastic cap that you can pry off, exposing the set screw. If you crack a plastic cap, replace it with a rubber cap that's available from Bendix.



To reduce* air-up *fime, trailers made by Greaf Dane, Savannah,* Ga., now *have a 1/2-in.-OD supply line as standard equipment Fleefmen are advised to spec 1/2-in.-OD supply lines on new trailers and to consider refrofiffing such lines fo existing trailers.



This chart illustrates that if may require nearly 80 seconds for a tractor with a two-line tractor protection valve to bring a frailer's empfy, 2,800-cu-in. service brake reservoir to 60 psi (where the frailer has a 3/8-in.-OD "supply" air line). In confrasf, a tractor with a three-line tractor protection valve (which sends air directly fo the frailer) can fill a frailer's reservoir to 60 psi in about 10 seconds (where the frailer has a 1/2-in.-OD supply line). Reducing the time required to air-up a depleted frailer reservoir helps to ensure that service brakes are operational and that parking brakes will not drag.

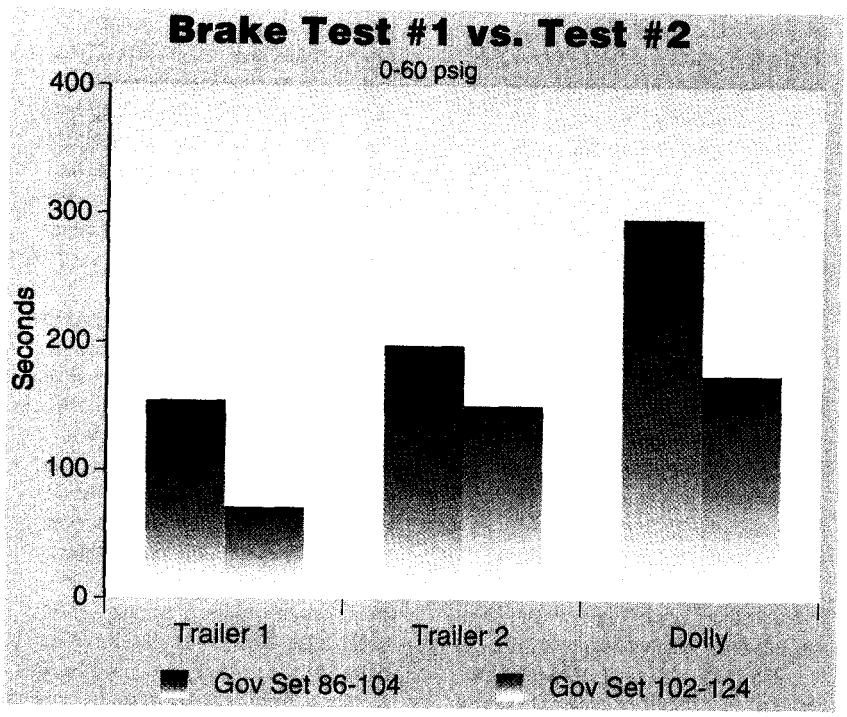


Chart shows that, for example, setting the governor of a tractor's compressor to cut-in at a reservoir pressure of 102 psi (and, therefore, shut off at 124 psi) greatly will reduce air-up time for a twin 28-ft trailer combination.

A second recommendation is retrofitting 1/2-in.-OD (3/8-in.-ID) air line as a replacement for all red-coded supply lines smaller than 1/2-in. OD. That provides a 50% increase in line size, compared with the 3/8-in.-OD (1/4-in.- ID) supply lines commonly used as original equipment. This modification, upon hook-up, should help to move a greater volume of tractor air into the trailer(s).

Drinkard is retrofitting larger supply lines to all of his trailers as they come into the shop for service. Typically, he says, about 38 ft of supply line must be replaced, at a material cost of 71¢ per foot, which totals about $27. About 45 minutes is required for the job, at a local labor rate of $25 per hour. So the combined cost of parts and labor for the job typically is less than $50, he says.

Retrofitting larger supply lines to trailers is not an illegal modification of original safety equipment, says ATA's vice president of engineering Larry Strawhorn. "It's perfectly legal because you're not replacing any of the blue-coded control lines that affect brake timing," he explains.

Great Dane Trailers, Savannah, Ga., already has switched to 1/2-in.-OD supply line as standard equipment, according to Jim Hofstetter, the company's director of product engineering and safety.

Hofstetter also notes that Great Dane now uses valves that are ported for non-restrictive compatibility with the larger supply line. Further, by bending air lines during routing, Great Dane also has minimized the number of 90-degree fittings. In fact, Hofstetter says, "we probably don't have any more than one or two 90-degree fittings anywhere in our air system."

Will other trailer makers quickly switch to 1/2-in.-OD supply line as standard? For some insight, Don Vierimaa, vice president of engineering for the Truck Trailer

Continued

As illustrated, a typical two-valve tractor protection system restricts air flow to a trailer. In contrast, custom-spec'ing a three-valve system provides an extra dash knob, for sending air directly to the trailer after hook-up.

Manufacturers Association (TTMA), Alexandria, Va., suggested that CCJ contact Arnold Przepiora, chairman of TTMA's Undercarriage Committee and manager of component engineering for Fruehauf Trailer Corp., Southfield, Mich.

Przepiora tells CCJ that Fruehauf would have no problem with providing 1/2-in.-OD supply line to any customer who requested it. But the question of switching to 1/2-in.-OD supply line as standard equipment has not yet been raised within the company, he says.

Questioned about Fruehauf s use of 90-degree-bend fittings, Przepiora makes the point that such fittings add material cost and labor cost to trailer assembly, compared with looping air lines. So, once again, Fruehauf gladly would honor customer requests to limit 90-degree bends within their air systems, he says.

Another recommendation of the draft RP is the use of minimum legal-size air reservoirs on trailers. That's because larger-than-required reservoirs may take a very long time to build pressure, according to hundreds of tests conducted by Drinkard's task force.

For trailers, the minimum reservoir capacity required by FMVSS 121 is eight times the total volume of the unit's brake chambers. Typically, that's only about 1,440 cu-ft capacity for a single-axle trailer, Drinkard says.

New equipment specs also should call upon tractor makers to avoid unnecessary use of 90-degree-angle air line fittings which restrict air flow. That tactic already has proven helpful to concerned fleets, including Miami-based Ryder Truck Rental which carefully specs virtually every piece of a tractor-trailer's brake system.

A major recommendation of the draft RP is spec'ing tractors so that trailer supply line pressure is sourced as directly as possible from the tractor's reservoir. Drinkard says that goal readily could be achieved by spec'ing a three-line-type tractor protection system.

Basically, he says, a three-line system has merit because it routes air directly from the tractor reservoir, through the tractor protection valve and on to the trailer supply line. With a three-line system, air flows into a trailer fairly quickly.

In contrast, a two-line system—which, today, tends to be standard equipment on tractors-typically routes tractor air through highly-restrictive valving (mounted to the underside of the dashboard) before passing it along to the tractor protection valve and trailer. With a two-line system, air flows into a trailer less rapidly.

So, can a fleetman still spec a three-line tractor protection system? To find out, CCJ called Al Zwicky, applications engineer for Peterbilt Motors Co., Denton, Tex.

According to Zwicky, three-line systems still are listed as an option, in Canada and the U.S., for Peterbilt tractors. In fact, a three-line system costs only about $100 more than a two-line system, he says.

Summing up the situation, Drinkard claims that the fill rate of an otherwise highly-restrictive trailer air system could be increased nearly 800% by simple engineering changes. Those changes include more directly routing air from tractors to trailers, using larger supply lines and less-restrictive valves on trailers, minimizing the pressure required to access trailer control valves, avoiding excessively large trailer reservoirs and minimizing the use of 90-degree fittings.

"If this is done and valve manufacturers keep a tighter tolerance on crack pressure, the trailer brake regulation as it stands today will no longer pose problems. And we even may be able to make spring brake release time, and trailer fill rate, faster than they were before the regulation," Drinkard claims.

"With a little cooperation between valve makers, tractor OEMs and trailer OEMs, we can have a better brake system...without bringing the federal government back into the game to confuse the issue and create more dangerous, unacceptable situations." he concludes. Cl

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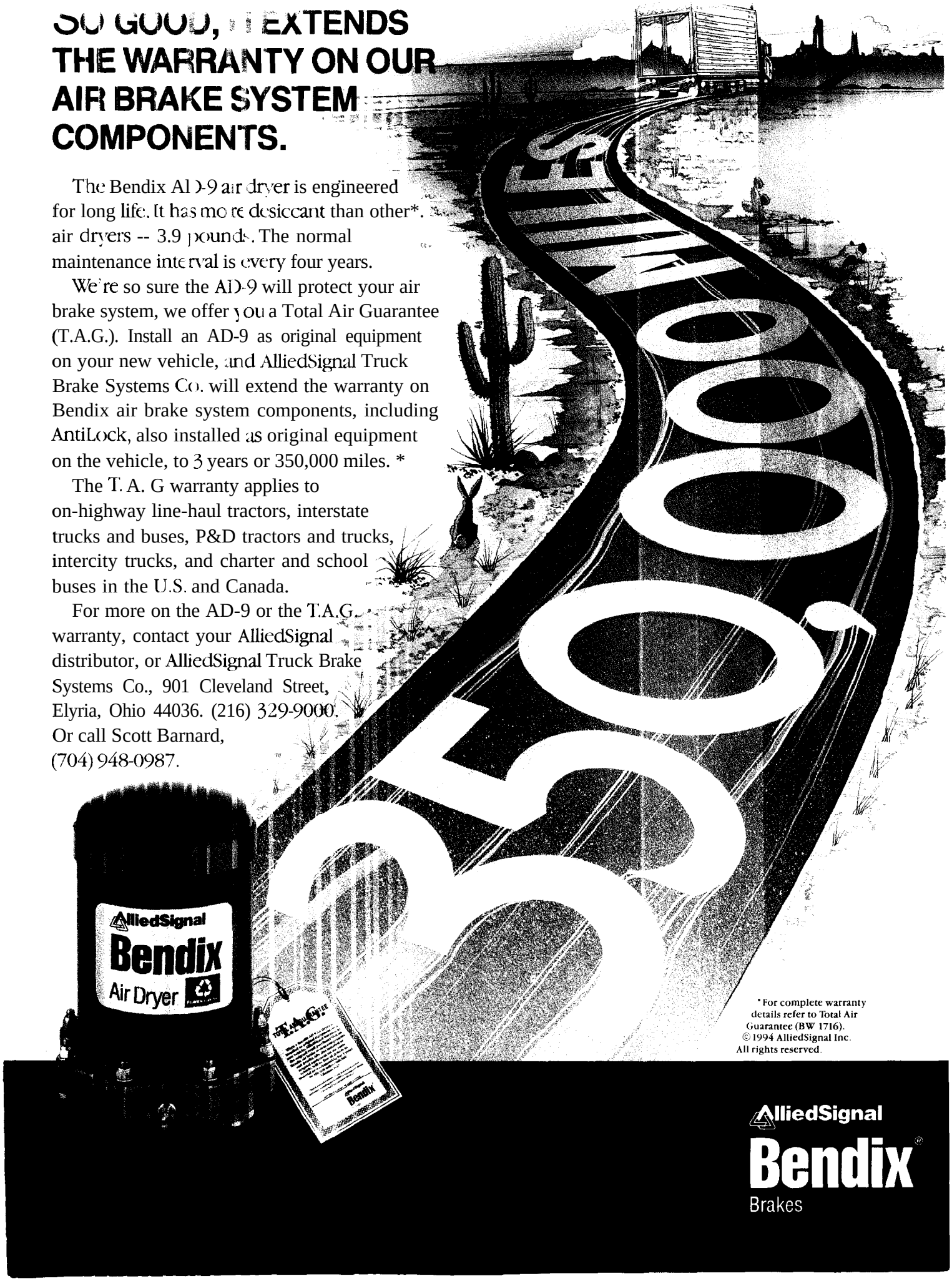

*For complete warranty details refer to Total Air Guarantee (BW 1716).

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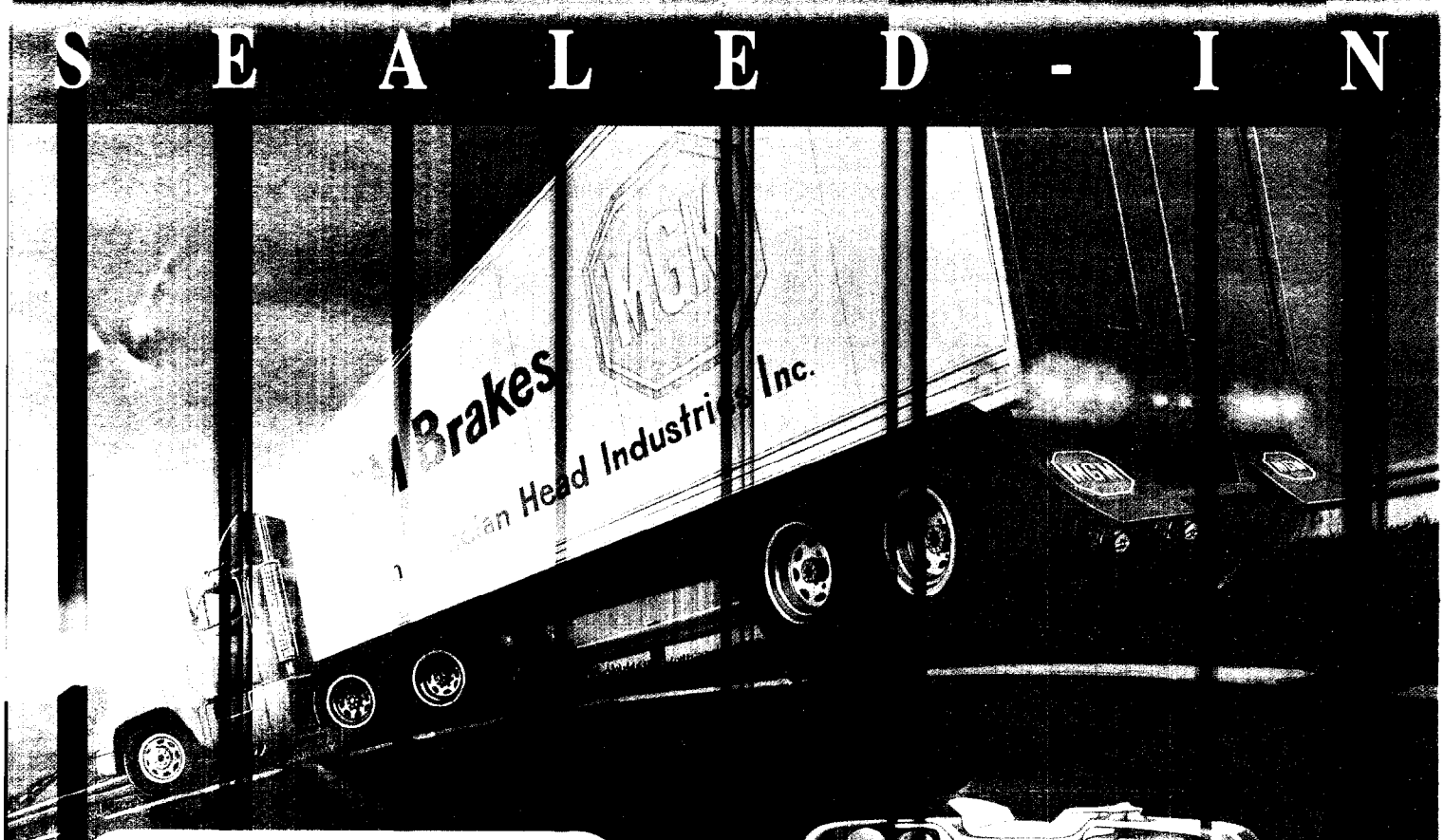

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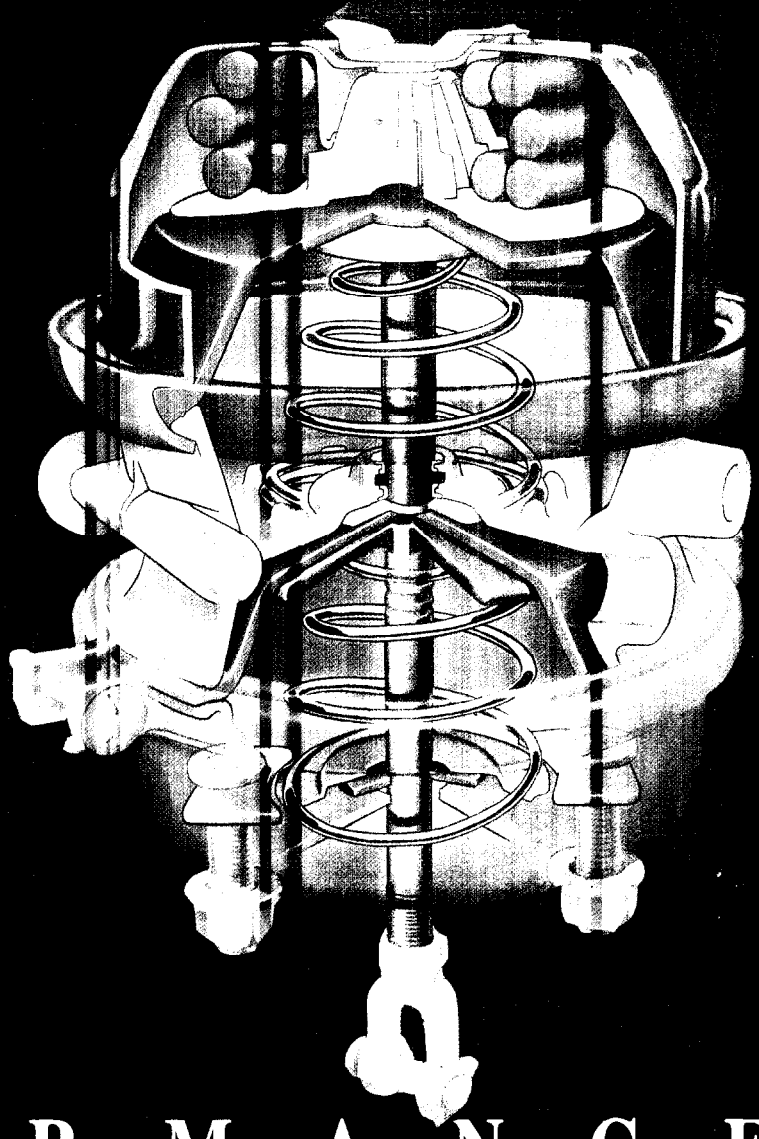


P E R F O R M A N C E

The pros & cons of FRONT BRAKE LIMITING VALVES

It's not a question of whether heavy trucks should have operable steer-axle brakes, but of how much work those brakes should do.

By PAUL RICHARDS
Technical Editor

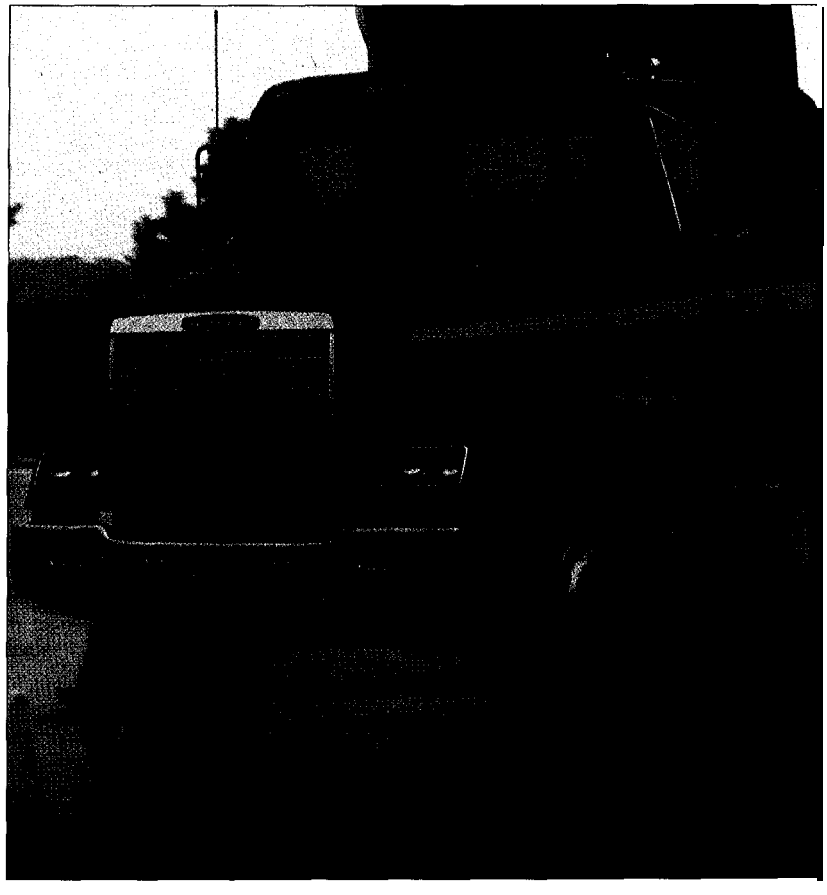
A few years ago, the debate of whether or not front brakes are beneficial was rendered academic. Lawmakers were sufficiently convinced that they *are* beneficial, and front brakes were mandated.

A still-active debate is whether or not front-brake involvement in the stopping process should be limited. As in any worthwhile controversy, there are plausible positions on each side.

The argument for using limiting valves centers on the concern that too much front-axle braking could cause front-wheel lockup.

A limiting valve reduces pressure to the front axle during all but the highest-pressure brake applications. This, say proponents of the devices, reduces the chance of the front wheels locking before those on the drive axle(s), yet allows full performance when needed.

"They can give you the best of both worlds," says Larry Strawhorn, director of engineering, American Trucking Associations. "But you have to consider what kind of front brake you're using." A small brake, he says, is already limited by its size, so a limiting valve may not be necessary. But with large front brakes, Strawhorn is in favor of the valve.



***Regardless of your position on front-brake limiting valves, "Never use one in conjunction with a bobtail-proportioning valve," cautions Prakash Jain, director of technical support, stopping systems, Rockwell International, Troy, Mich. "If* you do, bobtail braking performance will be seriously compromised."**

Dick Radlinski, president, Radlinski Associates, Marysville, Oh., and former chief of NHTSA's Crash Avoidance Research Branch, is not. He's admittedly more concerned about the possibility of locking a drive axle. "Lock the drive axle and **you're** on your way to a jackknife" he maintains.

Continued

"Lock the steer axle, and you just plow straight ahead."

A classic rebuttal by those who support limiting valves is: "Sure, you'll plow straight off a mountain." But NHTSA studies indicate that the argument over which is the better axle to lock has little to do with the front brake limiting controversy. "We have found that, with typical front brakes and no limiting valves, the drive axles still lock first," reports Radlinski.

Addressing a related issue, NHTSA data suggests that wet stopping distances are better without limiting valves. In one test, six Teamster drivers and six owner-operators made a series of best-effort stops in five vehicles, with and without limiting valves. The stops were made on a wet Jennite surface, going straight, on curves and while changing lanes.

"Stopping distances were consistently shorter without limiting valves," claims Radlinski. "That's because the front brakes were able to contribute more at the moderate pressures needed to keep the drive axles from locking. University of Michigan studies, performed on ice, have produced similar results."

Another reason not to use limiting valves, according to Radlinski, is that they can mask a side-to-side imbalance condition. Since most stops are low-pressure, and since a limiting valve minimizes front brake activity at low pressures, an oil-soaked or maladjusted brake may go unnoticed by a driver until he panic stops-the worst possible time to be alerted to a problem.

"That's true," says Strawhorn, "but if a driver's got an imbalance problem, he's got it whether or not he's got a front limiting valve. The only difference is that, without the valve, he'll have trouble with every stop. With the valve, 90% of his stops will be trouble free."

Okay, what about a long downgrade, where a driver may (incorrectly) use a prolonged, light brake application to keep a safe speed? "With a limiting valve," asserts Radlinski, "the front brakes will be doing little or no work, which will result in increased drum temperature and wear at the drive axle and trailer brakes.'

"True again," says Strawhorn. "But the front brakes will stay cooler and better able to help out in a panic stop if the need arises. And again, we are not talking about *large* front brakes, which can absorb a high percentage of the energy generated by the truck decending the grade."

"What really frustrates us," says Radlinski, "is that we have studied the problem and made data available. Those arguing in favor of limiting valves aren't providing any concrete evidence-just opinions."

"What amazes me," says Strawhorn, "is that [those against limiting valves] aren't considering drivers. Drivers are the ones with real, on-the-road experience. No matter what you do, you just can't get that on a test track the real world has too many permutations to anticipate. We know drivers want limiting valves. I can't believe their opinions don't have some basis in fact."

"After our test," counters Radlinski, "one of the owner operators involved drove his rig right up to our garage and wanted us to remove his front-axle limiting valve. His reaction couldn't better express what we've been saying all along."

Radlinski admits NHTSA's conclusions are drawn from experience with typical front brakes. "It's conceivable," he says, "that with large front brakes and aggressive linings, some limiting may be desirable. But with today's front brakes, you're better off removing the valve in accordance with OEM recommendations."

"What drivers say they're feeling may just come from a lack of information," concedes Strawhorn. "Or perhaps their experience has shown them something we don't understand.

"But it's clear that, in the interest of better braking, steer axle brakes-which traditionally have been under-utilized-will become more aggressive.

And what drivers are feeling now, they'll feel even more in the future. So we really must understand what we're doing, and do it *right*, if we expect drivers to make appropriate use of the next-generation steer-axle brakes.

"If what drivers are feeling is real, front-axle limiting will become more important," he adds. "If it's a product of ignorance, it will be up to the industry to provide increased training."

"But," asks Radlinski, "how will the industry ever know if it's real or not if they continue to rely on anecdotal information and ignore the factual data that we and others have developed over the years?

"I challenge Mr. Strawhorn to organize an independent effort to develop factual information," he continues. "I am convinced that if they do their own testing, they will reach the conclusion that the use of limiting valves with today's front brakes is undesirable from a safety standpoint. Besides, why add over $100 of hardware and added complexity if it degrades a vehicle's performance?

"Several years ago," Radlinski continues, "one of the largest fleets in the country ran some of their own tests and reviewed what we had done. They removed limiting valves from thousands of tractors. They've had a few complaints about steering wheel pull-the vehicles have manual steering-but they're still convinced that they made the right decision. They continue to spec all new vehicles without limiting valves."

Remember, that's with today's brakes. Strawhorn notes that industry has already tried vehicles with front braking greater than today's at the Transportation Research Center in East Liberty, Oh. "On those vehicles," he concludes, "limiting valves were found to be important for control." ❑

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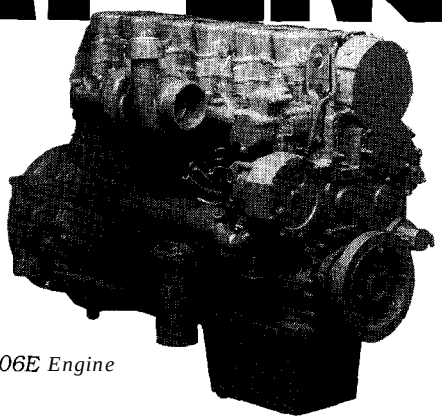

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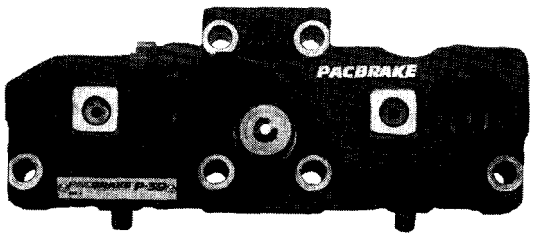

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RETARDERS:

GIVING BRAKES A **BREAK**

Often regarded merely as hill-country safety equipment, these devices can retard escalating brake maintenance costs in virtually any heavy-vehicle operation.

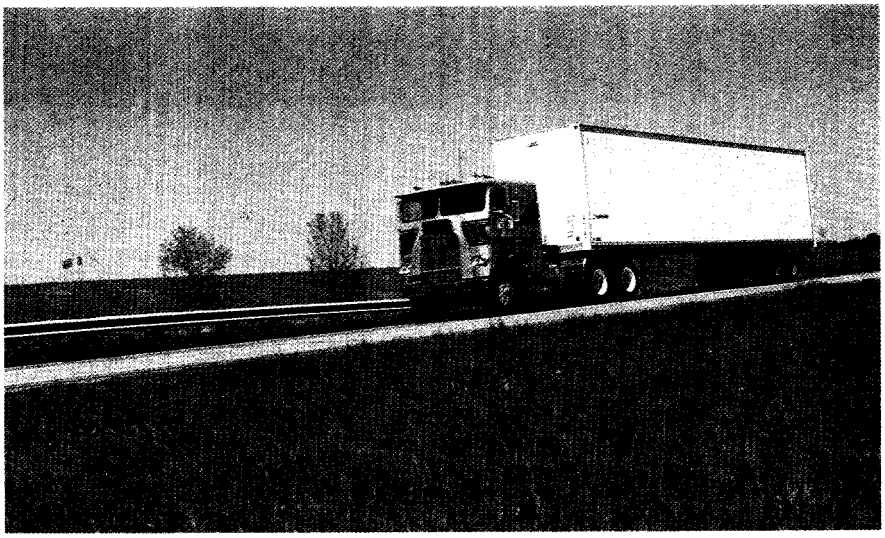
By PAUL RICHARDS, Technical Editor

It doesn't have slack adjusters, S-cams or edge codes, but a retarder will slow a vehicle, and can rightly be considered a brake. Best of all, it's a brake that doesn't wear out. Whenever it can be substituted for a service brake application, it's money that doesn't go up in brake dust.

That's not to minimize the safety aspect. It's common knowledge that proper use of a retarder can prevent brake fade and reduce the likelihood of a downgrade runaway. Studies have led the National Highway Traffic Safety Administration to report: "The presence of a retarder provides about a 3: 1 reduction in the probability of a runaway event," and the Insurance Institute for Highway Safety to conclude: "Heavy vehicles without retarders have a crash rate almost three times greater than trucks so equipped."

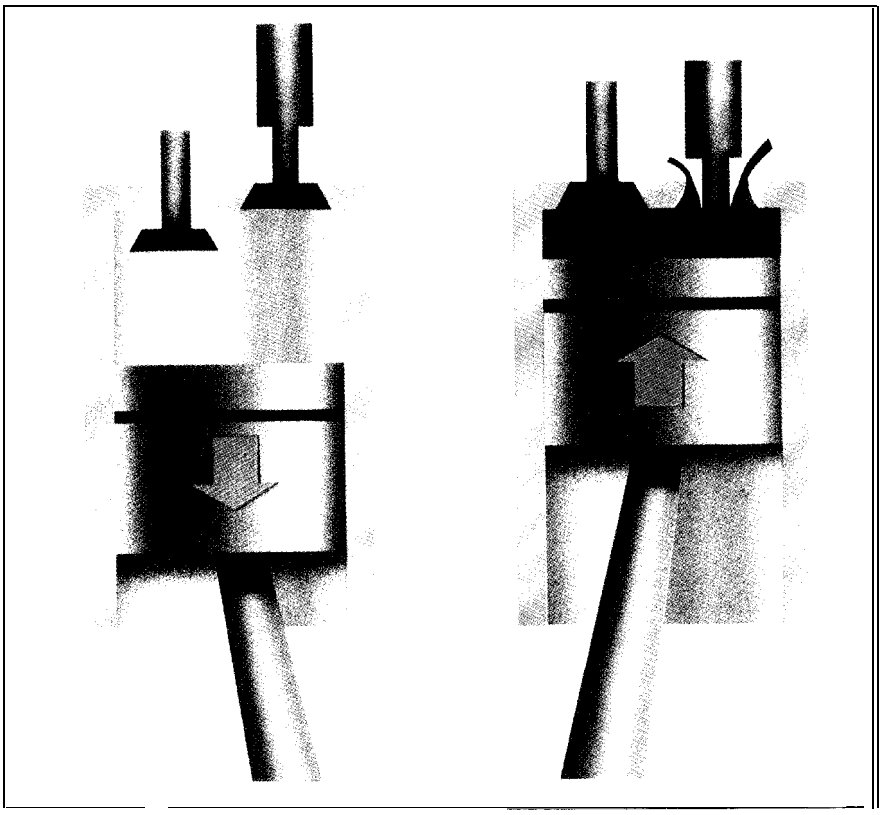
What has not been as obvious-but is becoming more so-is that retarders can more than pay for themselves, in brake maintenance savings alone, on heavy vehicles operated in any terrain.

The logical explanation for this growth is that slicked-up aerodynamics, radial tires and improved lubricants found on newer trucks have reduced natural retarding forces and placed greater demands on service brakes.

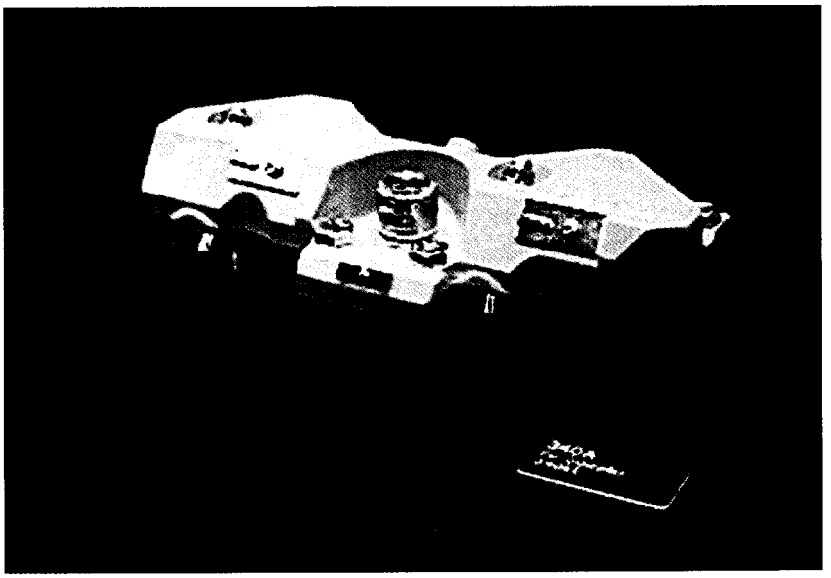


Research conducted by Rockwell International, Troy, Mich. indicates that service brakes are applied twice as often today as they were five years ago. The bottom line is that more efficient trucks are resulting in shorter service brake life, and retarders can provide a source of relief.

In many cases, the benefits of retarders can be quantified before making an investment. Jacobs Vehicle Equipment Co., Bloomfield, Conn., offers a computerized, customized, return-on-investment analysis to prospective customers. It provides, among other things, projected brake service costs for



Intake and compression strokes of engine brake-equipped diesel. Intake (left) is unchanged. Near the end of compression stroke, exhaust valve opens, dumping compressed air-and energy used to compress it.



Jacobs' Model 340A retarder for Caterpillar 3406E can produce up to 460 retarding hp.

each year of tractor and trailer service, with and without a Jake Brake retarder. It also predicts, with reported accuracy, the payback period for the retarder investment.

Four basic types of retarders exist-a discussion of advantages and disadvantages of each follows:

Engine brakes

The most commonly used of all retarders (well over 50% of the U.S. retarder market), engine brakes do their thing by turning an engine into an air compressor, driven by the road wheels.

Normally, upon deceleration, air is compressed during the compression stroke. But the energy spent doing this work is partially recovered, since the compressed air helps push the piston back down during the power stroke, even though no fuel is injected.

With an engine brake, the exhaust valve is opened near the end of the compression stroke, dumping the compressed air-and the energy required to compress it—into the exhaust system.

Engine brakes boast a light weight (100 lb or less), minimal maintenance requirements, moderate cost (around $1500), and retarding capability as high as 110% of rated engine horsepower. The degree of retarding is controlled by the driver, by means of a switch that selects the number of cylinders to be retarded.

Engine brakes can be spec'ed on most popular engines, or can be retrofit.

On the negative side, engine brakes add to mechanical complexity when doing top-end engine work and can impose extra wear on exhaust valves if overused. Also, while the sound of an engine brake at work may be music to a trucker's ears, it can be disturbing to passers-by and, in some municipalities, may draw unfavorable at-

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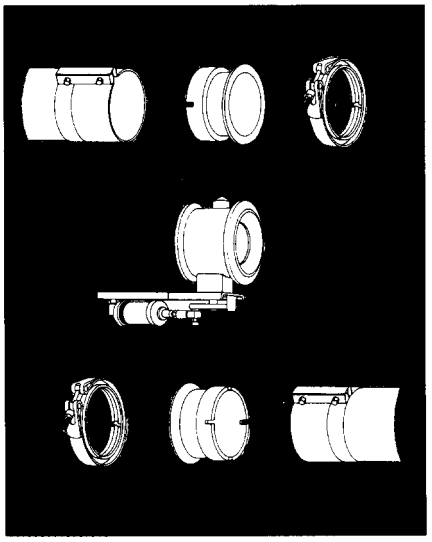
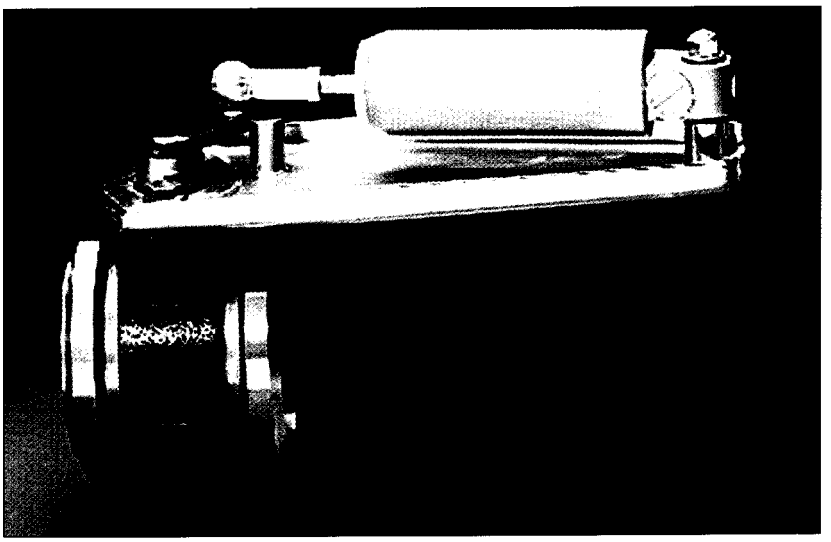


*Rockwell WABCO exhaust brake installation. Pneumatic slave cylinder closes butterfly valve when unit is activated. *Adapters and seal clamp not necessary in OEM installation.*



Depending on application and engine's rated rpm, Jacobs Extarder can produce over 200 retarding hp.

tention from the local constabulary.

For more information on engine brakes:

Cummins Engine Co. Inc.,
Columbus, Ind.
"C-Brake"
800-343-7357

Jacobs Vehicle Equipment Co.,
Bloomfield,
Conn.
"Jake Brake"
203-243-1441

Korody-Colyer
Compton, Calif.
3 10-639-95 11
800-248-4321

Mack Trucks Inc.,
Allentown, Pa.
"Dynatard"
610-439-3011

Pacific Diesel Brake Inc.,
British Columbia, Canada
"Pac Brake"
604-882-2382

Exhaust brakes

Exhaust brakes are the simplest and second most popular type of vehicle retarder. An exhaust brake consists of a valve-either guillotine or butterfly type-installed in the exhaust system, and an air actuation system. When retarding is needed, the valve is closed, allowing back-pressure to build. During each exhaust stroke with the device activated, exhaust pressure exerts a retarding force on the rising piston.

Positive features of the exhaust brake are its low weight (30 lb or less), low maintenance and lowest price range of any type of retarder.

On the down side, an exhaust brake is the least powerful type of retarder, generating an average of only 50% of rated engine power. That's because an engine can only stand so much back-pressure. Too much will float the exhaust valves open, causing serious piston damage.

Also, exhaust brakes cannot be used with two-stroke engines, and, when used on gasoline engines, they can deplete intake manifold vacuum, requiring the installation of a vacuum pump if there are any vacuum-operated accessories. Finally, modulation isn't possible with most models-the unit's either fully on or off.

For more information on exhaust brakes:

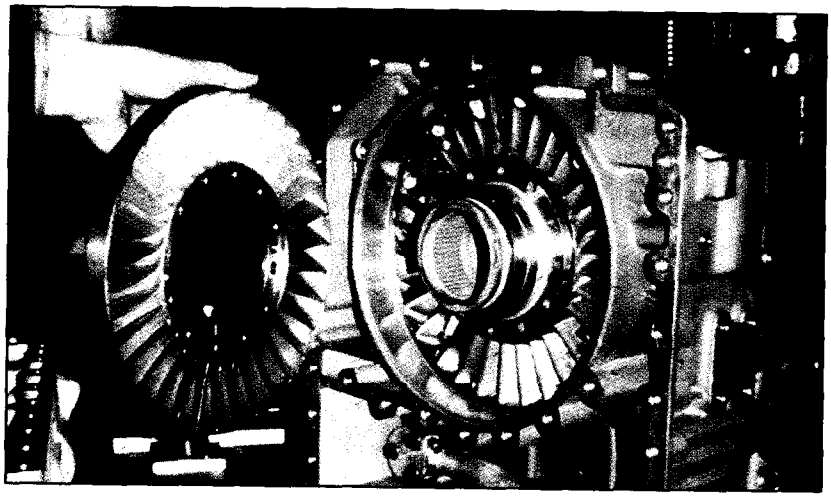
Rockwell WABCO Vehicle
Control Systems,
Troy, Mich.
800-535-5560

Williams Air Controls Div. of
Dana Corp.,
Portland, Ore.
"Blue Ox"
800-547-1889

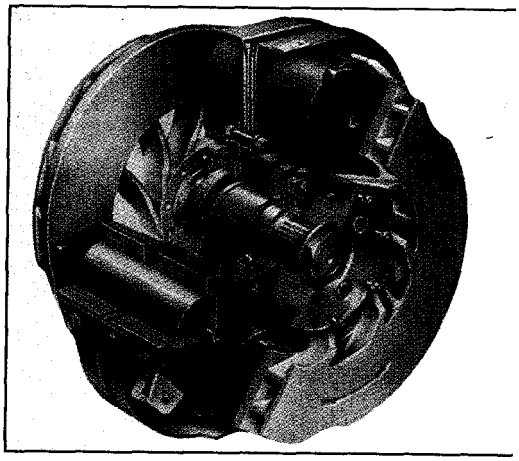
Hydraulic retarders

These slow a vehicle by shearing oil between two sets of vanes, much the same way the torque converter in an automatic transmission transfers engine power to the gearsets. In fact, heavy-duty transmissions made by Allison and ZF can be ordered with integral hydraulic retarders. Caterpillar's BrakeSaver is installed between engine and transmission.

Although they don't enjoy widespread on-highway popularity, hydraulic retarders have several advantages over other types.



Hydraulic retarder innards resemble those of a torque converter-they both use vanes to shear oil. Instead of transferring power, though, the unit absorbs energy as heat, which is returned to the vehicle's cooling system.



Telma electric retarder. When electromagnetic coils (yellow) are energized, a magnetic field envelops rotors on driveshaft. This sets up eddy currents which slow driveshaft. The number of coils energized determines strength of retarding force.

First, they are extremely powerful, the amount of retarding horsepower being limited only by the strength of the components in the retarder itself and in the vehicle's driveline. Modulation is also excellent-a driver can dial in as much or as little retarding force as needed.

However, these retarders tend to be heavier than other types and are more expensive. Also, some models incorporate a lot of piping to and from the engine cooling system to dissipate heat generated by the retarding process, thus complicating vehicle maintenance.

For more information on hydraulic retarders:

Allison Transmission Div.,
Indianapolis, Ind.
800-252-5283

Caterpillar Inc.,
Peoria, Ill.
"BrakeSaver"
(for Cat 3406B engines)
309-675-1342

ZF of North America Inc.,
Chicago, Ill.
(for ZF heavy-duty transmissions)
708-634-3500

Electric retarders

Ever notice how a car's idling engine will slow down a bit when a large electrical load is imposed on the alternator-such as turning on the headlights or rear defroster? That's because the load causes the regulator to increase field current in the alternator. The higher field current allows the alternator to generate more power, but it also makes it harder to turn.

That's the idea behind electric vehicle retarders. Metal rotors, attached to the driveline (or axle, in the Ilasa retarder), pass through several field coils. The number of coils energized determines how much braking force is delivered.

Like hydraulic retarders, electric units pack an almost limitless amount of retarding capability, and offer excellent modulation. They require little or no maintenance.

Electric retarders also have some limitations. As with hydraulic retarders, cost and weight are high.

A problem unique to electric retarders is fading-they can lose half their effectiveness when operated continuously for about 20 min. This is because they are air-cooled and can overheat.

Another temperature-related concern is that, unlike other types of retarders, electric units do not return retarding heat to the engine. This can cause the engine to cool excessively on long downgrades.

For more information on electric retarders:

Ilasa International
Marketing Inc.,
Monroe, La.
318-3235211

Klam America Co.,
Salt Lake, Ut.
800-888-333 1

Rockwell WABCO Vehicle
Control Systems, (Telma dist.)
Troy, Mich.
800-535-5560

Telma Retarders Inc.,
Hayward, Calif.
510-784-1048

The driver's role

A retarder that isn't used is not saving brakes. And one that is

Continued

RETARDER **COMPARISON** CHART

The chart below is a basic guide for comparing the important features of vehicle retarders. Consult the retarder manufacturers for detailed specs. This information was developed through industry sources and is partially based on the study, Retarders For Heavy Vehicles: Evaluation Of Performance Characteristics And In-Service Costs done for NHTSA.

FEATURE	ENGINE BRAKE	EXHAUST BRAKE	HYDRAULIC RETARDER	ELECTRIC RETARDER
Performance				
Retarding Horsepower (% of rated engine horsepower)	60% to 110%	40% to 80%	Virtually unlimited	Virtually unlimited
Retarding power source	Air compression	Air compression	Resistance to fluid flow	Eddy current resistance
Retarding torque location	Engine	Engine	Driveline or engine	Driveline or non-powered axle
Response time	0.1 to 0.2 seconds	0.2 to 2.0 seconds	0.3 to 2.0 seconds	0.1 to 0.2 seconds
Noise	Low-frequency popping	Low-frequency rumble on naturally aspirated engines	None	None
Fade	None	None	None	Up to 50% after 20-min continuous operation
Heat dissipation	Engine cooling and exhaust systems	Engine cooling and exhaust systems	Engine cooling system and/or separate oil cooler	Forced ambient air
Modulation method	Number of engine cylinders used and/or gear selection	Gear selection	Amount of fluid and pressure used	Number of coils energized
Maintain engine heat	Yes	Yes	Yes	No
Operate in neutral transmission	No	No	Yes (when installed in driveline)	Yes
Installation/Maintenance				
Application limitation	Heavy-duty diesel engines ONLY	4-stroke diesel and gasoline engines ONLY	None	None
Normally used for	On-highway	On-highway	Off-highway	On-highway (transit buses)
Routine maintenance needs	Periodic tune-up advisable	Lubrication, cleaning and inspection	Cleaning, inspection	Cleaning, inspection
Retrofit time (man hours)	3 to 7	2 to 8	14 to 20	14 to 18
Vehicle OEM availability	Yes	Yes	Some	Some
Weight (lb added to vehicle)	70 to 100	20 to 301	25 to 600	300 to 1,000

used, full force, under slippery conditions, or when running bobtail, can cause traction loss and, possibly, a jackknife. To realize the maximum benefits afforded by retarders and to ensure on-the-road safety, drivers must be instructed in their proper use.

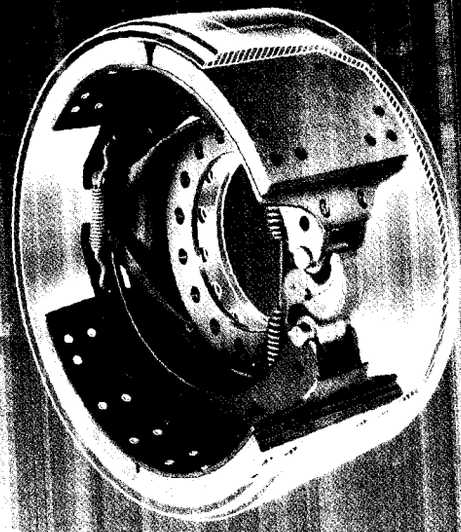
Fleetmen using retarders or about to do so are advised to educate drivers per retarder manufacturers' guidelines, and have them read NHTSA's booklet, A Professional Truck Driver's Guide to the Use of Retarders. To receive one, drop a note and a self-addressed mailing label to Bob Clarke at NHTSA, Heavy Vehicle Research Division, 400 7th St. S.W., Washington, D.C. 20590. Cl

ABS/retarder interface

No matter how sophisticated an anti-lock brake system is, **it can't** prevent or stop a skid induced by a retarder. Remember, using a retarder on a slippery surface, whether a vehicle is equipped with ABS or not, can cause the drive wheels to slip.

"That's why a retarder interface is needed," notes Charlie Schott, manager, fleet sales and service, Rockwell WABCO, Troy, Mich. "When ABS is actuated, the retarder has to be cut out of the circuit if a skid is to be avoided. We always install a relay for that purpose."

There's more to a brake lining than meets the drum.



delivers improved safety, longer lining life and reduced maintenance costs

Selecting the optimum brake lining can play a critical role in achieving your fleets goals for safety andvalue. Carlisle, with its introduction of Milestone, hasformutated a new friction material addressing the three essential elements in selecting a brake lining.. *stopping power, lining life, and drum compatibility*

Stopping Power Milestone linings exceed all existing federal, state and OEM requirements. And Milestone's excellent fade/recovery characteristics assure consistent stopping power.

Longest Lining *Life* Milestone will significantly increase your mileage between relines. In dynamometer tests against the competition's most popular comparable lining, Milestone MB-21 experienced 42% less wear than brand A,

Reduced Maintenance Costs Milestone brake linings are designed to provide excellent brake drum compatibility.. helping your fleet reduce downtime and unscheduled brake maintenance.

Customer Support Carlisle's extensive sales/service organization and Heavy Duty Brake School will help your fleet managers and mechanics understand today's sophisticated braking systems and solve braking problems.

It all adds up. Outfitting your vehicles with Milestone linings wilt help your fleet lower its cost per mile operation. Discover why there's more to a brake lining than meets the drum, call: **812-334-8730.**

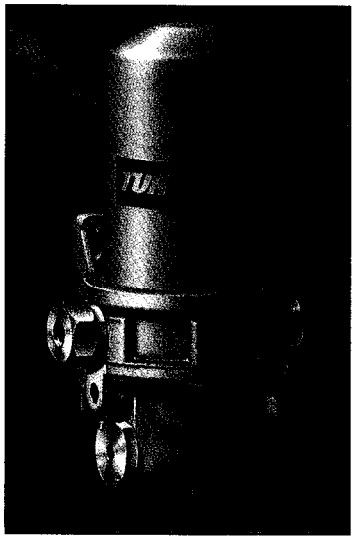
The friction experts. . .
from OEM to aftermarket

Motion Control Industries, Inc.
1031 E. Hillside Drive
Bloomington, IN 47401
812-334-8730 FAX: 812-336-3985

The **air** dryer score **card.**

	Compatible with Holset	Purge volume (cubic inches)	Desiccant (pounds)	Internal valves	Unit weight	Heater (watts)	Spin-on cartridge
CR/Holset Brakemaster" Turbo-2000	✔	460	4	✔	18.8	75	✔
Bendix AD-9"		260	4	✔	32	60	
Wabco System Saver ®		*	2.5	✔	11.9	100	✔
Midland Pure-Air+@		195	2.2	✔	18.9	60	✔

Fleets that keep tight records know that air dryers pay for themselves in reduced down-time.



But to find the one that offers you the most for your money, you have to compare a few key features.

Purge volume, for example. The purge cycle is what blows the moisture and gunk off of the desiccant and out of the system. The stronger and longer the purge, the cleaner, longer-lasting the desiccant.

In fact, what some people call a "heavy duty" air dryer is simply one with a larger purge volume.

For easy maintenance, choose one with a spin-on canister and internal turbo valves.

To avoid problems with installation and service, choose a unit with the plumbing built-m.

The Turbo-2000 was engineered for the Holset QE compressor and Cummins engine package, but it's fully compatible with all other engine designs.

For overall performance, check the desiccant. The more desiccant on-board the more moisture will be stripped from the air to protect critical brake parts.

Once you tote-up the key features, we think you'll know the score.

For a full description of the CR/Holset Brakemaster Turbo-2000 air dryer contact your distributor or call us at l-800-882-0008. CR Services, 735 Tollgate Road, Elgin, Illinois 60123-9332.

CR SERVICES

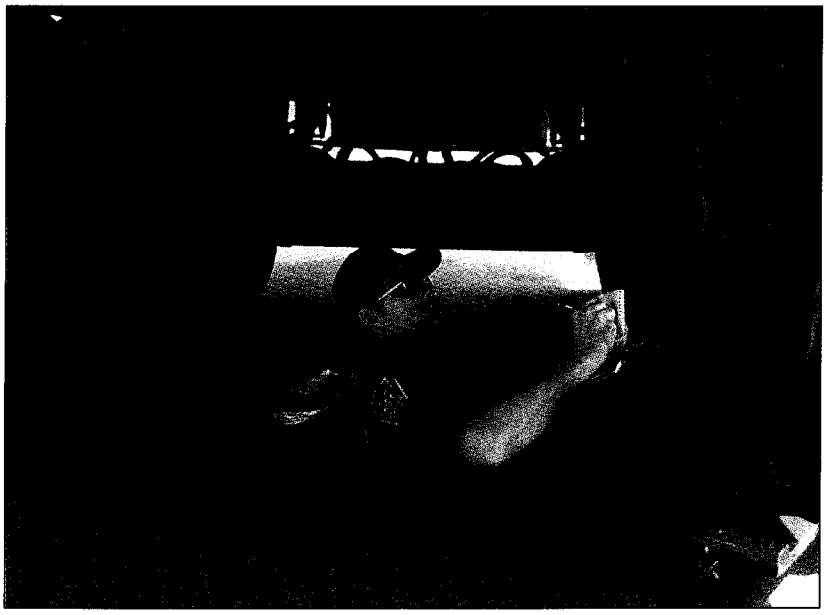
* Wabco uses available system air to purge.

Bendix AD-9 is a registered trademark of Bendix Corporation, Wabco System Saver is a registered trademark of Rockwell International Midland Pure-Air+ is a registered trademark of Midland-Grau.

BRAKE RELATED OUT-OF-SERVICE CRITERIA

North American Uniform Vehicle Roadside Inspection Criteria

By RICH CROSS
Senior Technical Editor



Criteria for placing vehicles out of service at roadside safety inspections are established jointly by the U.S. Department Of Transportation and Commercial Vehicle Safety Alliance. The following brake-related criteria are current for 1995 but subject to annual revision.

Out-of-service defects typically must be corrected at the inspection site. But an inspector may require a vehicle to be towed, transported or escorted away from the site in order to reduce a hazard to the public.

GENERAL

A vehicle or combination vehicle is out of service if 20% or more of its brakes have one of the following defects:
*any steer-axle-brake defect listed in next section;
*won't actuate effectively or friction material won't contact drum/rotor;
*evidence of current, on-going oil contamination at the lining/drum interface where lining edge is wet and there's evidence that additional contamination is likely (i.e. oil running from drum or bearing seal).
Note: neither grease on the lining edge, back of shoe or drum edge nor oil strains with no evident of fresh oil leakage are out-of-service defects;
*entire lining, segment of lining or pad is missing;
*portion/segment of lining or pad is missing, to the extent that a rivet or bolt is exposed;
*lining/pad loose on shoe, permitting about 1/16 in. movement;
*lining/pad has cracks or voids, observable on side of lining, wider than l/l 6 in.;
*lining/pad has cracks, observable on side of lining, longer than 1 1/2 in.;
*lining/pad too thin. Specifically:
(1) drum-type air brake lining less than 1/4-in. thick (or to wear indicator, if so marked) at shoe center;
(2) disc-type air brake pad less than 1/8-in. thick;
(3) drum or disc hydraulic and electric brake lining l/l 6-in. or less thick at shoe center;
*brakes missing from axle requiring brakes;
*broken or missing shoe, spring, anchor pin, spider, cam roller, push rod or air chamber mounting bolt.
*loose air chamber, spider or camshaft support bracket.
*audible air leak at chamber;
•wedge brake which, upon application, displays movement of scribe marks on linings collectively exceeding 1/8 in.;
•with engine off, reservoir at no more than 90-100 psi (dump excess pressure) and then brakes fully applied, push rod stroke 1/4 in. or more beyond readjustment limit:
*counting as one defective brake, two brakes at their readjustment limit or having a stroke less than 1/4 in. beyond readjustment limit.

Clamp-type chamber readjustment limit
Type 6 :
(4 1/2-in. O.D.)=l l/4-in. stroke
Type 9
(5 1/4-in. O.D.)=1 3/8-in. stroke
Type 12
(5 11/16-in. O.D.)=1 3/8-in. stroke
Type 16
(6 3/8-in. O.D.)= 1 3/4-in. stroke
Type 20
(6 25/32-in. O.D.)=l 3/4-in. stroke
Type 24
(7 7/32-in. O.D.)= I 3/4-in. stroke
Type 30
(8 3/32-in. O.D.)=2-in. stroke
Type 36
(9-in. O.D.)=2 1/4-in. stroke

Bolt-type chamber readjustment limit
Type A
(6 15/16-in. O.D.)=1 3/8-in. stroke

Continued

Type B
(9 3/16-in. O.D.)=l 3/4-in. stroke
Type C
(8 l/16-in. O.D.)=1 3/4-in. stroke
Type D
(5 l/4-in. O.D.)=l l/4-in. stroke
Type E
(6 3/16-in. O.D.)=l 3/8-in. stroke
Type F
(11-in. O.D.)=21/4-in. stroke
Type G
(9 7/8-in. O.D.)=2-in. stroke

Rotochamber readjustment limit
Type 9
(4 9/32-in. O.D.)=l 1/2-in. stroke
Type 12
(4 13/16-in. O.D.)=11/2-in. stroke
Type 16
(5 13/32-in. O.D.)=2-in. stroke
Type 20
(5 15/16-in. O.D.)=2-in. stroke
Type 24
(6 13/32-in. O.D.)=2-in. stroke
Type 30
(7 l/16-in. O.D.)=2 1/4-in. stroke
Type 36
(7 5/8-in. O.D.)=2 3/4-in. stroke
Type SO
(8 7/8-in. O.D.)=3-in. stroke

Long-stroke chamber readjustment limit
Type 16
(6 3/8-in. O.D.)=2-in. stroke
Type 20
(6 25/32-in. O.D.)=2-in. stroke
Type 24 (below 3-in. max stroke)
(7 7/32-in. O.D.)=2-in. stroke
Type 24 (3-in. max stroke version)
(6 7/32-in. O.D.)=2 1/2-in. stroke
Type 30 (clamp-type chamber)
(8 3/32-in. O.D.)=2 1/2-in. stroke
Type 30 (tie-rod-type chamber)
(6 1/2-in. O.D.)=2 l/2-in. stroke

STEER AXLE
•no effective braking action. Also applies to dolly and front axle of full trailer;
*on power unit, difference in chamber size or slack adjuster length;
•on power unit, evidence of current , on-going oil contamination at the lining/drum interface where lining edge is wet and there's evidence that further contamination is likely (i.e. oil running from drum or bearing seal).
Note: neither grease on the lining edge, back of shoe or drum edge nor oil strains with no evident of fresh oil leakage are out-of-service defects;
*entire lining, segment of lining or pad is missing;
*portion/segment of lining or pad is missing, to the extent that a rivet or bolt is exposed;
*lining/pad loose on shoe, permitting about 1/16 in. movement;
*lining/pad has cracks or voids, observable on side of lining, wider than 1/16 in.;
*lining/pad has cracks, observable on side of lining, longer than 1 1/2 in.;
•for drum brake, shoe with continuous lining less than 3/16-m thick or to wear indicator, if so marked;
*for drum brake, two-pad shoe with lining less than l/4-in. thick or to wear indicator, if so marked;
•for air disc brake, pad less than 1/8-in. thick;
*for hydraulic disc brake and electric brakes, lining thickness of l/l 6 in. or less.

PARKING
*inoperable breakaway braking system on trailer, as evidenced by failure of trailer brakes to apply when parking brake control is actuated.
*non-manufactured hole/crack in spring-brake housing.

DRUM/ROTOR
*external crack opens upon brake application (short, hairline heat checks don't count);
*portion of drum/rotor missing or in danger of falling off.

HOSE
*damage through outer reinforcing ply. Rubber impregnated fabric cover is not reinforcement ply. Thermoplastic nylon may have braid reinforcement or color difference between cover and inner tube. Exposure of second color warrants out-of-service judgment;
*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 securing with hose clamps).

TUBING
*audible leak at other than proper connection;
*cracked, heat-damaged, broken or crimped.

LOW-AIR WARING DEVICE
*both the audible and visual warning devices are missing, inoperative or do not actuate at 55 psi and below or 50% of governor cut-out pressure, whichever is less.

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

TRACTOR PROTECTION VALVE
*missing or inoperative.

AIR COMPRESSOR
*loose mounting bolts;
*cracked/broken/loose pulley;
*cracked/broken mounting bracket/brace/adapter.

AIR RESERVOIR
*separated from original attachment points

ELECTRIC BRAKES
•20% or more of brakes on vehicle or combination don't work;
*missing or inoperative breakaway braking device.

HYDRAULIC BRAKES
•no pedal reserve, engine running;
*master cylinder below 1/4 full;
*inoperative power assist;
*hose seeps or swells under pressure;
*any visually-observed brake fluid leak upon full brake application.
*missing/inoperative break-away braking device;
*hydraulic hose worn through outer cover to fabric layer;
*fluid line/connection is broken, restricted, crimped or cracked.
*failure/low-fluid warning light is actuated or inoperative.

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

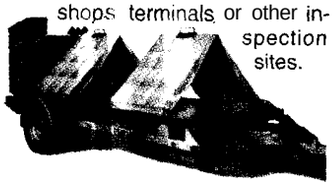
CAN YOU STOP ON THIS?

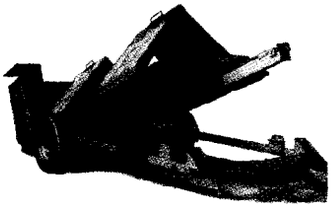
There's An Easy Way To Find Out With The Most Complete Brake Tester In The World!

Using the Transadyne® Roller Brake Dynamometer, in just five minutes you can diagnose a tractor/trailer for:

✔ Brake Imbalance ✔ Dragging Brakes ✔ Broken Spring Brakes ✔ Air System Problems
✔ Tractor/Trailer Incompatibility ✔ Oil Soaked Linings ✔ Cracked Drums ✔ Defective Valves
✔ Worn/Tight End Bearings ✔ Deficient Parking Brake Force

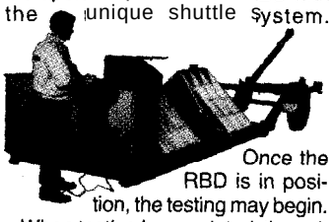
The portable Roller Brake Dynamometer (or RBD) is towed behind a half-ton vehicle, providing easy movement between maintenance shops, terminals or other inspection sites.





Using only one driving lane or shop bay, a single operator easily unloads the self-propelled RBD from the trailer.

Using the hand held control unit, the operator positions the RBD with the unique shuttle system.



Once the RBD is in position, the testing may begin. When testing is completed, the unit can be moved under its own power.

The dynamometer rollers turn the vehicle wheels at low rpm, and the lights signal the driver to apply the brakes.

TRANSADYNE®

Roller Brake Dynamometer

Test your brakes where it counts - Where the rubber meets the road!

The testing is completed in a matter of minutes on a tractor-trailer unit. The on-board computer provides complete brake system analysis with easy to read reports.

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HICKLIN ENGINEERING, INC. 3001 NW 104th Street, Des Moines, Iowa 50322

HICKLIN ENGINEERING

Roller Brake Dynamometer

Recommended Practice

RP 619A **VMRS 13-01 O-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.

GENERAL GUIDELINES

Personnel will exercise care to:

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

EQUIPMENT

The following equipment will be needed:

1. Two 0 to 150 psi air gauges with drain cocks
2. Two 50 cubic inch tank test units (see **Fig. 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

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. Fill in top 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.)
4. Forcombination vehicles only, place the tractor protection control lever or knob (trailer air supply or trailer emergency valve) in the emergency position and install a 50 cubic inch tank test unit in the supply (emergency) and control (service) lines at the gladhands; open shut-off valves on test units, and connect trailer gladhands.
5. For vehicles without an attached trailer, also connect a 50 cubic inch test unit to the supply (emergency) and control (service) lines at the gladhands with the shut-off cocks closed.
6. Place the tractor protection control (trailer air supply or trailer emergency valve) back in the normal position and release any other brakes that may be applied. The transmission of the

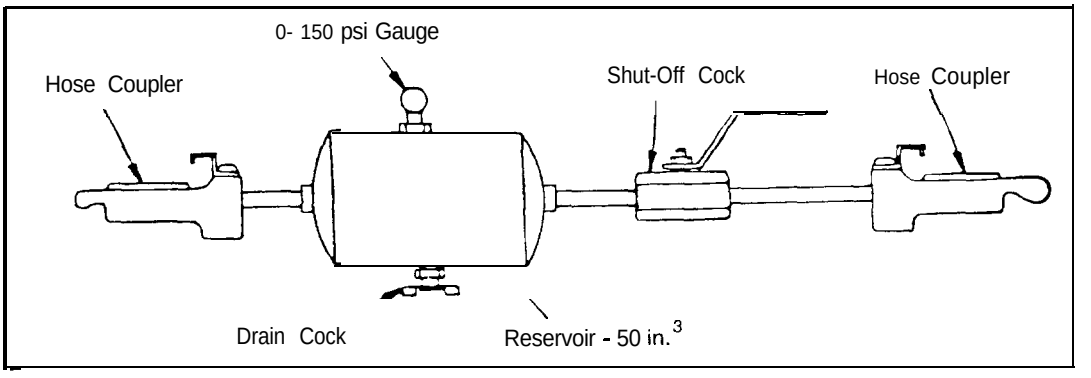

Fig. 1: 50 Cubic Inch Reservoir Test Unit

vehicle remains in neutral throughout the test and all brake controls 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.

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.

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: Lack of air in any protected reservoir indicates a probable malfunctioning checkvalve 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. Stan 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 ten percent of each other.

12. Stop engine.

13. Check the unapplied air loss at the wet tank test gauge for one minute. Loss should not exceed 2 psi for single vehicles and 3 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. 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% with a FMVSS-121 towing vehicle or 20% with a pre-121 towing vehicle, and for non-towing vehicles shall not exceed 12% for a 121 vehicle or 15% for a pre-121 vehicle.

16. Continue full application of the foot valve and record the air pressure drop at the wet tank test gaugeovera period of one full minute. The drop shalt not exceed 3 psi for single vehicles and 4 psi for combination vehicles.

17. 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 3 psi over a period of one full minute.

18 While making this check with the hand valve, also check for audible leaks and chafed or kinked brake hoses and/or lines. Afler test gauges stabilize, compare the readings of control (service) and emergency line gauges. The service line must be at least 50 % 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 isvisible 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 80 psi. 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 60 psi.

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

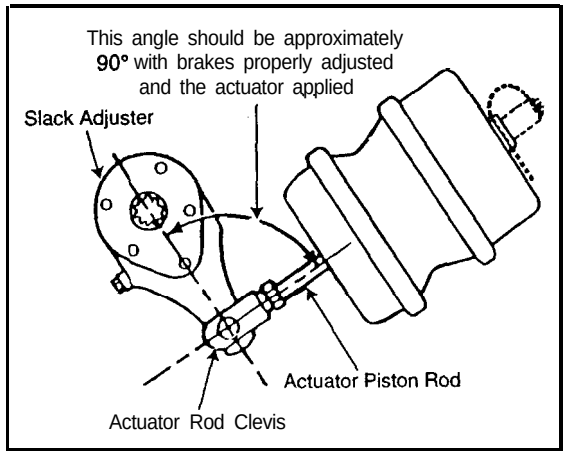

Fig. 2

the tractor protection valve closes off air lines to the trailer. Repair or replace the tractor protection valve or trailer emergency 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 aircontinues 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 trailersequipped 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. Onvehicles with S-cam brakes, mark the air chamber push rod at the chamber, with the brakes in unapplied position.

23. Depress the service brake treadle and hold. Service brakes on all axles of all vehicles must apply. Check to ensure that the angle of the push rod to slack adjuster is approximately 90 degrees. See **Fig. 2.**

24. Measure the amount of push rod travel. 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, adjust the brakes to the vehicle manufacturer's recommendations. Start engine and recharge system, markairchamberpush rods (if necessary), apply and hold foot valve, and remeasure stroke. If the stroke still exceeds maximum or if the push rods fail to retract, identify the problem and correct.

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

29. On FMVSS-121 semitrailers, charge thesystem 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 tractorprotection control knob (trailer air supply or trailer emergency valve) in the emergency position 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 running position and check to ensure that the trailer parking brakes release. 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.

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.

Depress service brake treadle and hold, service brakes on all vehicles must apply. Check to assure that the angle of the push rod to slack adjuster is approximately 90". (See **Fig. 2)**

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"
(Note: Proposed for adoption in 1995)	24"	7-7/32"	2-1/2"
	30	8-3/32"	2-1/2"
Rotochambers	9	4-9/32"	1-1/2"
	12	4-1 3/16"	1-1/2"
	16	5-1 3/32"	2"
	20	5-15/16"	2"
	24	6-1 3/32"	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 disc or wedge brakes.
* For 3" max. stroke type 24 chambers

For ordering information, see page 97

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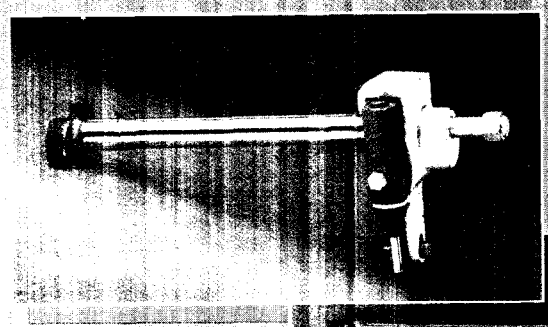
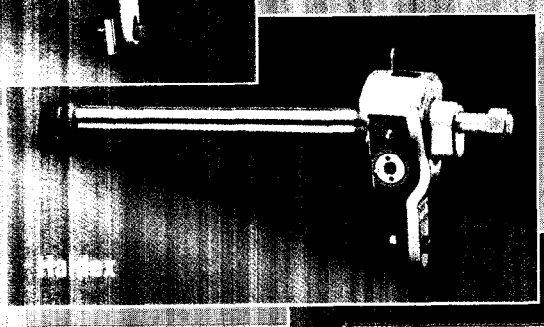
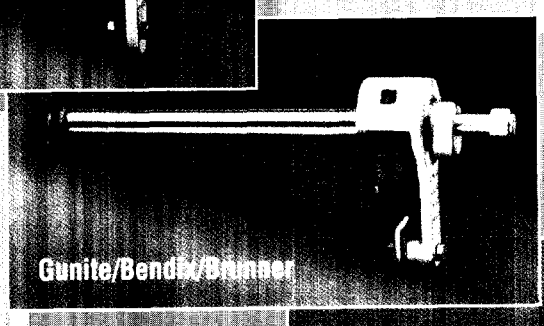
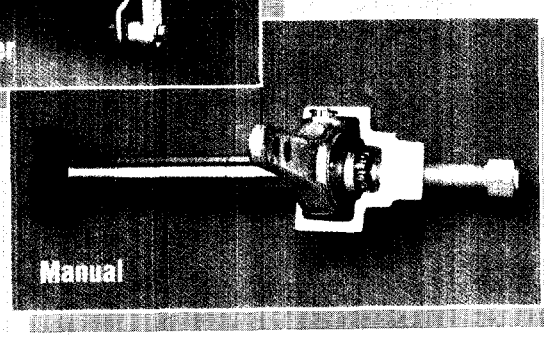
[illegible] hammers, bars or cutting torches. [illegible] INC., a company dedicated to the [illegible] and the Brake Clevis Pin [illegible] of the finest, [illegible]



THE Tiger SLACK ADJUSTER PULLERS







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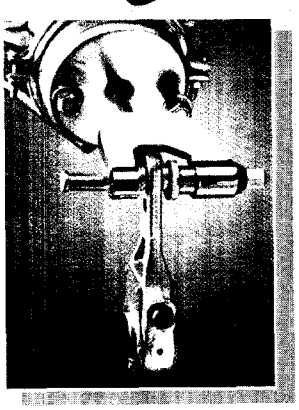

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TMC Recommended Practice

RP 609A VMRS **13-001-030, 13-002-28**

MANUAL AND AUTOMATIC SLACK ADJUSTER REMOVAL, INSTALLATION AND MAINTENANCE

PREFACE
The following Recommended Practice is subject to the Disclaimer at the front of this manual. Users are urged to read the disclaimer before adopting any portion of this Recommended Practice.

PURPOSE AND SCOPE
The purpose of this Recommended Practice is to provide information regarding the removal, installation, operation, maintenance, and selectionof heavy-duty vehicle manual and automatic slack adjusters.

INTRODUCTION
In an S-cam type foundation brake, the final link between the pneumatic system and the foundation brake is the slack adjuster. The arm of the slack 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 slack 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 slack adjusters are in use: manual type slack adjusters, which periodically require a manual adjustment, and automatic slack adjusters which will automatically adjust during normal service braking applications. All slack adjusters utilize the worm and gear principle and fundamentally differ only in their torque limit specification.

NOTE: Manual and automatic slack adjusters are for brake adjustment and will not compensate for faulty foundation brakes.

MANUAL SLACK ADJUSTERS
Manual slack adjusters contain four basic components: the body, worm gear, worm shaft, and locking screw or collar. **See Figure 1.**

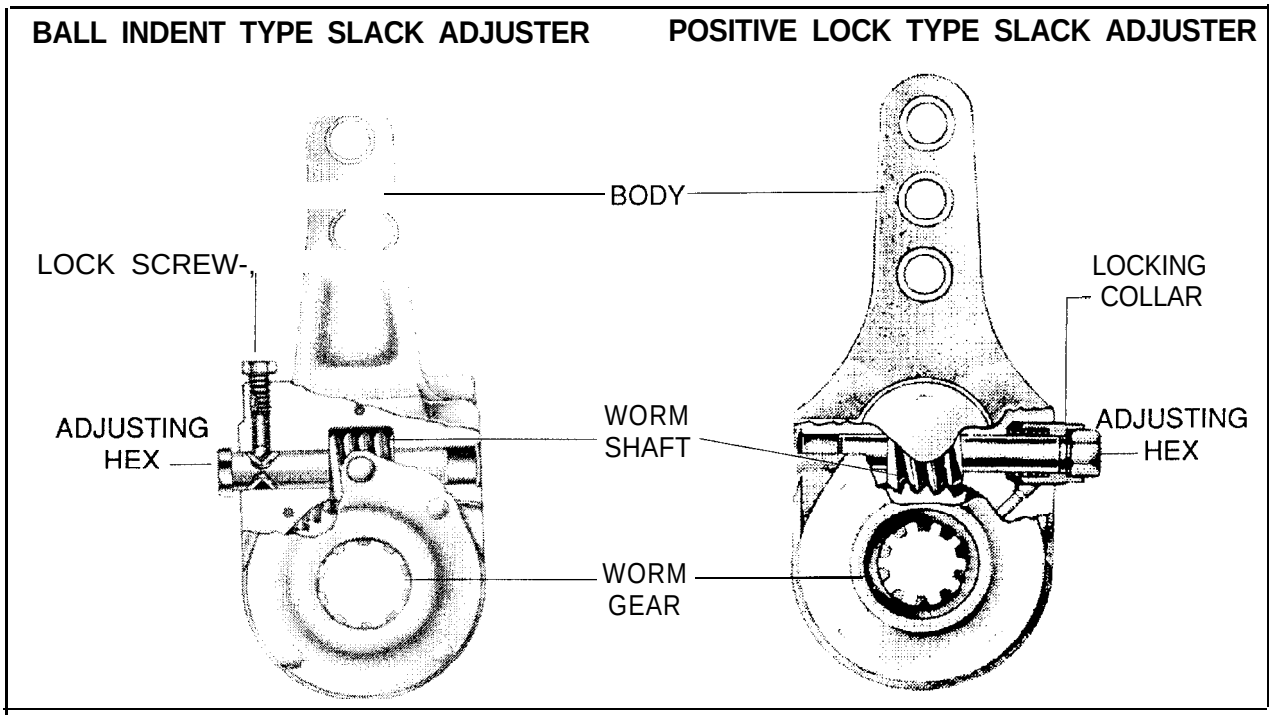

FIGURE 1: MANUAL SLACK ADJUSTERS

The worm shaft of a slack 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.

Highertorque rated slack 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.

AUTOMATIC SLACK ADJUSTERS

While automatic slack adjuster designs vary in the manner in which they are installed and operate, all are designed to automatically maintain a predetermined shoe-to-drum clearance or brake chamber stroke. Some automatic slack adjusters adjust upon the brake application stroke, others adjust upon release. Automatic slack adjusters can greatly reduce manual adjustments. Automaticslack adjusters do not reduce the need for periodic maintenance.

SLACK ADJUSTER REPLACEMENT

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

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

SLACK 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 slack 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 Slack Adjuster Removal-

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

B. Manual Slack Adiuster Installation—

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

C. Automatic Slack 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 retaining ring quick connect yoke.
   c. Style C-Remove the pawl, clevis, and link pins.
   d. Style D-Remove the clevis pin and anchor bracket nuts.
2. Remove the retaining mechanism from the end of the brake cam shaft.
3. Rotate the adjusting mechanism to back the automatic slack adjuster out of the clevis, if necessary.
4. Remove the automatic slack adjuster from the spline end of the brake cam shaft.
   NOTE: If a manual slack adjuster is being removed to be replaced with an automatic slack adjuster, the manual or threaded clevis

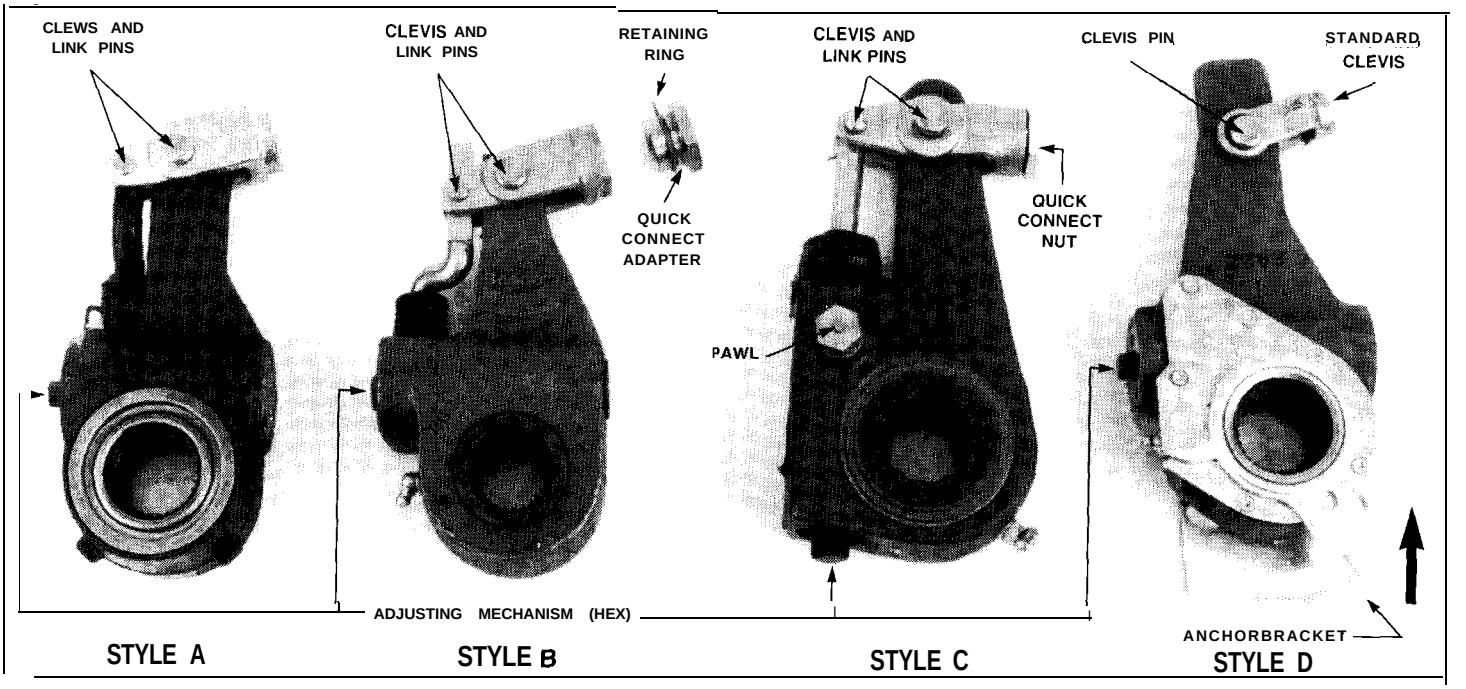

FIGURE 2: AUTOMATIC SLACK ADJUSTER TYPES

must be removed from the brake chamber push rod (with Style D automatic slack adjuster, the existing clevis is utilized and additional anchor bracket hardware is required). Leave the jam nut on the push rod.

D. Automatic Slack Adjuster Installation—

1. Insure that the brake chamber is installed in the bracket holes appropriate for the automatic slack adjuster arm length.

2. Clean the camshaft splines.

3. Coat the camshaft splines and the end of the brake chamber push rod with an anti-seize type product.

4. Install either a quick connect nut or threaded clevis on the brake chamber push rod per the manufacturer's recommendations. Some manufacturers offer both quick connect and threaded clevises.

5. Install the automatic slack adjuster on the camshaft.

6. Install the automatic slack adjuster retaining mechanism on the end of the brake cam shaft, being sure to shim it to less than 0.060 inch of end play.

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

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

8A. Using the correct gauge or template, (see Figure 2, Styles A, B, and C) check for the proper mounting angle. Adjust the clevis for the correct angle, if necessary. **NOTE:** The brake chamber push rod may require shortening or replacement to obtain the proper installation length.

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

9. Tighten the jam nut.

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

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

BRAKE ADJUSTMENT PROCEDURE

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

WARNING: To avoid possible injury, proper precautions must be taken to prevent automatic actuation of the brake chambers while adjusting slack 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 Slack Adjuster Brake Adjustment Procedure-

1. **Slackadjusters 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 slack adjuster to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting hex must be turned in the opposite direction until it will go no further. After establishing solid shoe-to-drum contact, back off the adjusting hex 1/4 turn for worn linings and 1/2 turn when relining brakes. The actuator stroke should be as short as possible without the brakes dragging. Measure the chamber power stroke at 80 - 90 psi as described in section "B," "Automatic Slack Adjuster Brake Adjustment Procedure," below. Take a free stroke measurement as outlined in the section entitled "FAILURE ANALYSIS." Make sure you have at least 3/8" of free stroke. Free strokes 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.

   CAUTION: When the manual slack 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 slack adjuster can back itself off.

2. **Slack 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, directly above. Following brake adjustment, make certain that the lock ball or plunger engages the worm shaft indent. Without such engagement, the slack adjuster can back itself off.

B. Automatic Slack Adjuster Brake Adjustment Procedure-

An automatic slack adjuster should not have to be manually adjusted except for initial installation and at brake reline. Instead of manually adjusting the slack, the following procedure should be followed during inspection:

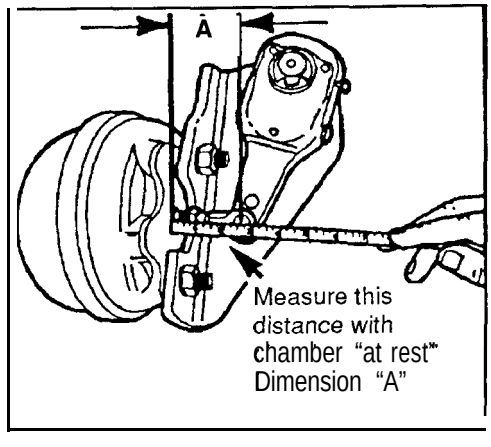

Figure 3

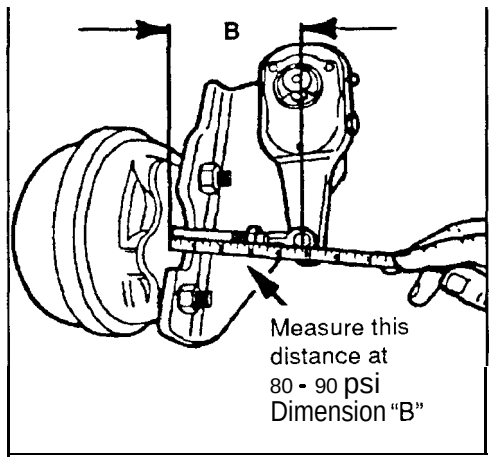

Figure 4

Chamber Type	Maximum Legal Stroke
12	Less than 1-3/8"
16	Less than 1-3/4"
20	Less than 1-3/4"
24	Less than 1-3/4"
24 Long stroke	Less than 2.0"
30	Less than 2.0"
36	Less than 2-1/4"

Table 1: Chamber Type vs. Maximum Legal Stroke at 80 psi Brake Application Pressure

Chamber Power Stroke: A power stroke at 80 - 90 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 Figure 3).**

2. Make brake applications until the air reservoir gage reads 90-l 00 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 Figure 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," below.

AUTOMATIC SLACK ADJUSTER ADJUSTMENT PROCEDURE AT RELINE AND INSTALLATION

An automatic slack adjuster should be manually adjusted after a brake reline and/or installation using the following procedure:

1. Position a wrench or socket over the adjusting mechanism. **NOTE:** If the automatic slack adjuster is equipped with a pawl, remove the pawl forthe brake adjustment and then properly reinstall the pawl (see Figure 2, Style C). Tighten the pawl to 15 - 20 ft.-lbs.

2. Rotate the adjusting mechanism until the brake shoes contact the drum. Pull on the slack adjuster by hand to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting hex must be turned in the opposite direction until it will go no further.

3. Reverse the rotation, backing the slack adjuster off one-half (1/2) turn.

4. Measure the chamber power stroke at 80 - 90 psi brake application pressure as described in the previous section.

5. Take a free stroke measurement as outlined in the section entitled "FAILURE ANALYSIS." Make sure you have at least 3/8" free stroke. Free strokes of less than 3/8" can cause brake drag. If youcannot maintain the maximum legal stroke and the free stroke is less than 3/8", contact the brake manufacturer for foundation or brake geometry problems.

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

1. Block the wheels or mechanically secure the vehicle. On the brakes to be adjusted, spring brakes must be mechanically caged or release with air.

2. Rotate the adjusting mechanism until the brake shoes contact the drum. Using a pry bar, pull on the slack adjuster by hand to make sure it will not move. If there is movement, adjustment was made in the wrong direction and the adjusting mechanism must be turned in the opposite direction. Tap the brake drum with a wrench; you should hear a dull clunk indicating the brake linings are tight against the drum.

3. Back off the slack adjuster a small amount at a time, while tapping on the brake drum with a wrench in between adjustments. Stop backing off the adjuster when you hear a clear ringing sound from the brake drum when tapped with a wrench.

4. Using a pry bar, pull on the slack adjuster by hand. If movement is more than 5/8", adjustment was not done properlyorthere 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

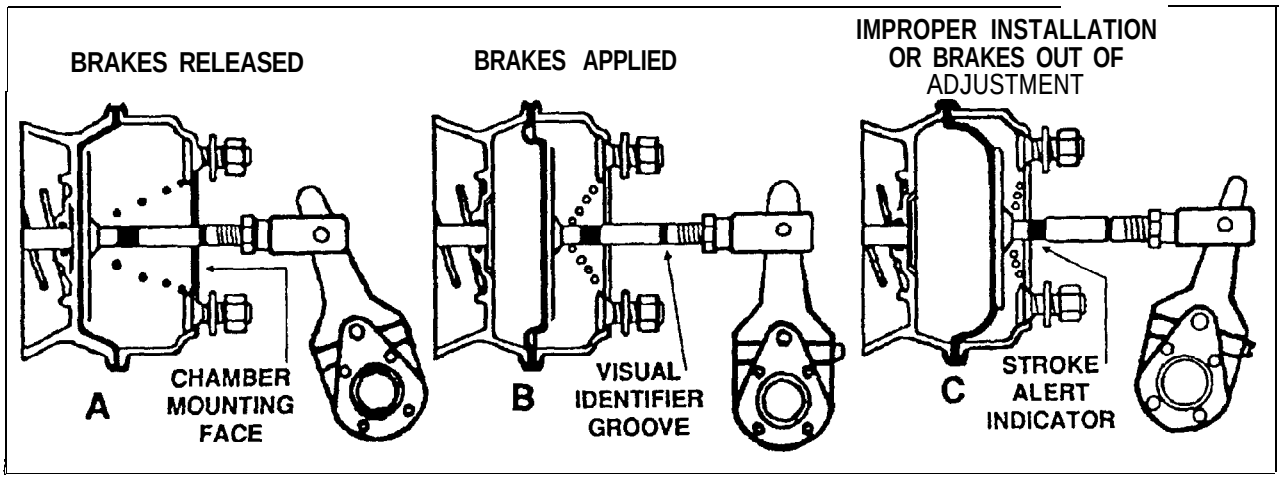

FIGURE 5

indicator **(see Figure** 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 **Figure** 5, diagram C).

FAILURE ANALYSIS

Manual Slack 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 slackshould be replaced. Repeat this procedure every 1/4 turn of the adjusting nut to check the whole gear set.

Automatic Slack Adjuster Failure Analysis-If the power stroke is at or more than the maximum stroke, measure free stroke to determine if the slack adjuster is operational.

FREE STROKE MEASUREMENT

Free stroke is the amount of slack 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 slack adjuster arm until the brake shoescontact the drum and measure the slack adjuster movement (see Figure 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. Checkformissingorworncomponents,cracked brake drums, or improper lining-to-drumcontact. If the free stroke is greater than recommended, an automatic slack adjusterfunction test should be performed.

AUTOMATIC SLACK ADJUSTER FUNCTION TEST

1. Remove the pawl, then rotate the adjusting mechanism at least one complete turn as if backing off the brake adjustment **(see Figure** 2, Style C). The pawl must be installed properly and tightened to 15 - 20 ft.-lbs after backing off the adjuster.

2. Apply the brakes several times and observe whether the adjustment mechanism is rotating in the direction needed to reduce brake chamber push rod stroke. If the adjusting mechanism does not rotate, the slack adjuster should be replaced.

3. Check back-off torque by rotating the adjusting hex as follows (see Figure 2):
   Style A: Minimum 15 ft.-lbs. counter clockwise (CCW)
   Style B: Minimum 15 ft.-lbs. CCW
   Style C: Less than 45 in.-lbs. CCW (pawl removed)
   Style D: Minimum 15 ft.-lbs. CCW

Consult the manufacturer for more information.

PREVENTIVE MAINTENANCE

Every month, 8,000 miles, or 300 operating hours, check brake chamber push rod travel; stroke should be as short as possible without the brakes dragging or the push rod binding. Adjust manual slacks if necessary. Due to different operating conditions, adjustments may be necessary at earlier intervals.

Every 6 months, 50,000 miles, or 1,800 operating hours, lubricate all slack adjusters and clevis pins with manufacturer's recommended lubricant. Check

for worn clevises, clevis pins, clevis pin bushings, and control arm/bracket wear. Failure to replace worn components will increase chamber stroke. Lubrication and inspection may be necessary at earlier intervals due to difference operating conditons.

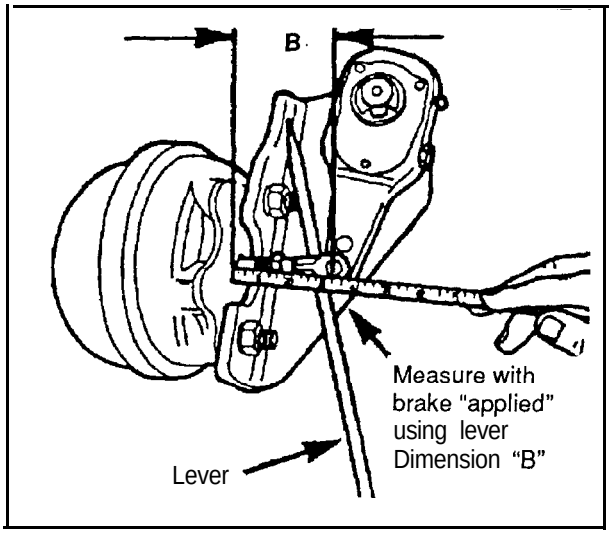

FIGURE 6

BRAKE-ADJUSTMENT TRAINING VIDEO
A 17-minute videotape that teaches drivers and mechanics how to adjust manual and automatic brake adjusters (aka "slacks"), with wheels raised or on the road, is available from Customer Service Department, The Maintenance Council, American Trucking Associations, 2200 Mill Rd., Alexandria, Va. 22314. Including shipping, the price of the *TMC* Brake *Adjustment Video* is $59.00 for TMC members and $69.00 for non-members. Virginia residents must add 4.5% sales tax. To order by phone, using Visa or Master Card, call 1-800-ATA-LINE. Prices are subject to change.

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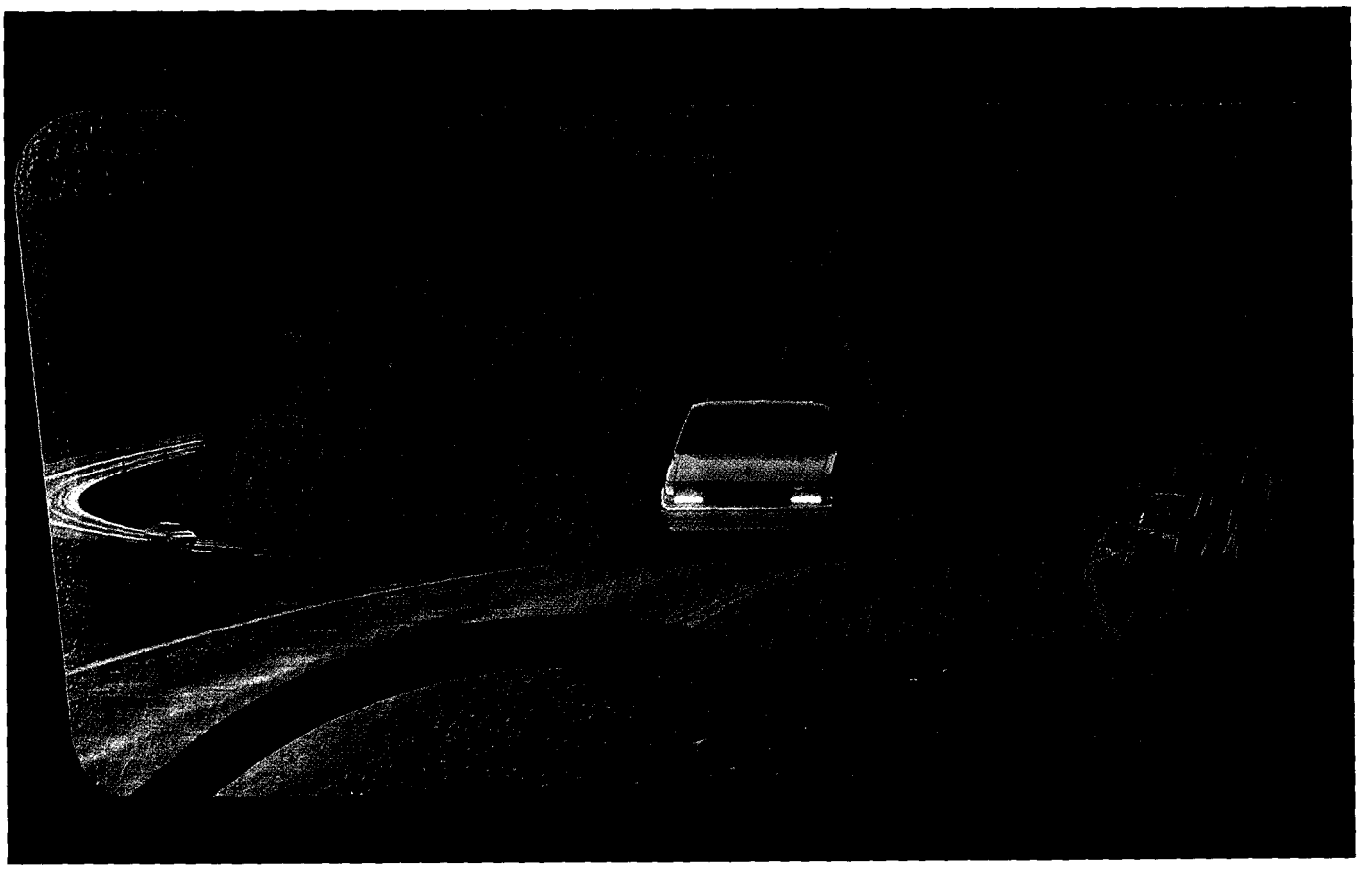

AIR BRAKE GLOSSARY

ABA: The abbreviation for automatic brake adjuster. Also called an automatic slack 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 brake adjusters require manual adjustment.

ABS: The abbreviation for "anti-lock brake system." ABS electronically monitors wheel speed and prevents wheel lock-up 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.

Air build-up: 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 two 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. Most trailers also have primary and secondary tanks. 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 freeze-up. 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 (ex. Type 30 chamber has effective area of 30 sq.in.). "L" equals the effective length, in inches, of the slack adjuster. For example, 30 x 6 in. = 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.

Anti-lock: Currently optional, 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 12 1, the point at which all service chambers reach 60 psi).

GLOSSARY

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

Automatic slack 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 slack adjusters require manual adjustment.

Automatic traction control (ATC): 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.

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 Slack adjuster).

Brake balance: Basically, balance is achieved when all brakes on all axles do their fair share of the work.

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 and/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 push rod travel is insufficient to fully actuate the brakes. This is one example of mechanical fade, which also may result from various mechanical defects (ex. 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, 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 individual-wheel-control system refers to the number of individual brakes its electronic control unit (ECU) is capable of independently controlling.

2-Channel ABS: A system design that uses two wheel-speed sensors and one control valve. 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. This system is the most economical but provides the least control of all ABS systems.

4-Channel ABS: A system design that uses four wheel-speed sensors and four ABS control valves 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 offers an optimum blend of performance and economy.

6-Channel ABS: A system design that features six wheel-speed sensors and six ABS control valves to individually monitor and control all six wheel of a three-axle truck or tractor. This type of system provides the highest available level of ABS control.

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

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

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

Control algorithm: The computer commands programmed into the electronic control unit ECU to control brake actuation under impending wheel lock-up.

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

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

Diagnostics/ABS: 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 wet tank. 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 dual 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).

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

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 (ex. EE, FF, GG, FG) printed on the edge of a brake block to designate its range of aggressiveness. Currently, this coding system is being revised.

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 Parking Brake.)

Engine brake: Optional device that converts a diesel engine into a power-absorbing air compressor to slow a vehicle on downgrades.(See Jake Brake.)

Exhaust brake: Optional device that uses engine exhaust back pressure to slow a vehicle on downgrades.

Fail-safe/ABS: If anti-lock brake system should fail during vehicle operation, a dash light warns driver that ABS is disengaged. Meanwhile, the tractors 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 is now or 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.)

GCW: Gross combination weight is the total weight-carrying capacity of a combination vehicle as determined by axle ratings.

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.

GVW: Gross vehicle weight is the total weight-carrying capacity of one vehicle, (such as a straight truck, bus, tractor or trailer) as determined by axle ratings.

Hand valve: (See Trailer control valve.)

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

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

Hold-off spring: A spring within a relay valve or quick release valve that's 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: Normally open, an air control valve often used in inter-locking applications where components must operate in a specific sequence.

Jackknife: Uncontrollable articulation of a tractor-trailer typically resulting from lock-up of tractor drive axle(s). The risk of jackknife is greatest on a slippery road with an empty or lightly-laden trailer in tow.

Jake Brake: Trade mark 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/min. air loss noted on the dash-mounted pressure gauge for straight trucks; 4 psi/min. 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 push rod travel without exceeding its readjustment limit. For example, a regular, clamp-type, Type 30 chamber has a readjustment limit of 2 in. A long-stroke version of that chamber has a readjustment limit of 2 1/2 in.

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).

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.

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 time frame 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 eighty grit emery cloth.

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

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

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

Push rod: 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: Used to speed the application of brakes, especially in multiple-trailer applications.

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

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.

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.

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).

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

Split-coefficient surface: Also called split-U (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 4- or 6-channel ABS system (anti-lock 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. SO ONLY TRAINED MECHANICS SHOULD ATTEMPT THE PROCEDURE. The spring portion often is referred to as the piggyback. Some spring brake actuators do not incorporate a service air chamber and are solely parking and emergency brakes. For example. some parking brakes are applied by air pressure and subsequently held mechanically by a pin which drop into a notch on the brake chamber push rod.

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

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

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

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

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

Tire 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 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 hand valve.

Trailer push: Caused by the tractor braking prior to the trailer and/or with greater torque.

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

The Air Brake Book

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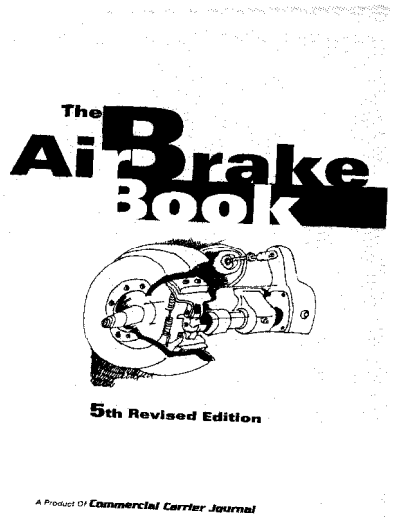

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AIR BRAKE

TROUBLESHOOTING GUIDE

By **DARWIN BURKHOLDER** and RAY **TINNEL**

This guide lists common air brake system problems, and provides step-by-step procedures for finding the cause of each. Brake component performance tests are also provided. The guide is designed to augment the knowledge and experience of professional brake technicians, and to decrease brake system troubleshooting time. Although CCJ and the authors believe the information in this guide is correct, no warranty is made, and neither CCJ nor the authors assume liability for errors, omissions or harm resulting from the guides use.

PROBLEM #1

Air Leak at Brake (Foot) Valve Exhaust Port with Service and Parking Brakes Released

NOTE: For air to leak at the Exhaust Port of any valve:
- *The valve is bad, or;*
- *Tank pressure is getting to the Delivery Port from other components.*

POSSIBLE CAUSES:
1. Tractor Protection Valve
2. Trailer Components
3. Tractor Parking System Components
   A. Anti-Compound Valve (if equipped, and depending on plumbing)
   B. Spring Brake Control (if equipped)
   C. Spring Brake Chambers
4. Brake (Foot) Valve

TRACTOR PROTECTION VALVE TESTS

STEP #1

1. Pull Trailer Supply (red knob on dash).
   A. If leak continues, go to STEP #6.
   B. If leak stops, go to STEP #2.

STEP #2

1. Disconnect Glad Hands and connect to holder on tractor.
2. Push Trailer Supply.
   A. If Exhaust Port of Foot Valve leaks, replace Tractor Protection Valve.
   B. If Exhaust Port of Foot Valve does not leak, problem is in Trailer. Go to STEP #3.

TRAILER COMPONENT TESTS

STEP #3

1. Connect Glad Hands.
2. Release Trailer Brakes.
3. Disconnect Control Line from Service Port of Relay.
   A. If leak continues, go to STEP #4.
   B. If leak stops, go to STEP #5.

STEP #4

1. Disconnect Anti-Compound Line (if equipped).
2. Leak at Exhaust Port of Foot Valve should stop.
   A. Replace Trailer Spring Brake Valve.

STEP #5

1. Disconnect Delivery Lines to Service Side of Spring Brake Chamber, one at a time.
   A. If there is a leak out of the Service Side of Chamber, replace Spring Brake hamber. (Remember, there may be more than one bad Chamber)
   B. With all Delivery Lines disconnected and leak continues, replace Relay Valve.

TRACTOR PARKING SYSTEM COMPONENT TESTS

STEP #6

1. Pull Park Control.
   A. If leak continues, go to STEP #9
   B. If leak stops, go to STEP #7.

ANTI-COMPOUND VALVE TEST

STEP #7

1. Release Park Brakes.
2. Disconnect Anti-Compound Line.
   A. If leak stops, replace Anti-Compound Valve.
   B. If leak continues, go to STEP #8.
   C. If not equipped with Spring Brake Control Valve, go to STEP #9.

SPRING BRAKE CONTROL VALVE TEST

STEP #8

1. Disconnect Delivery Line from Secondary Signal Line.
   A. If leak stops, replace Spring Brake Control Valve.
   B. If leak continues, go to STEP #9.

SPRING BRAKE CHAMBER TEST

STEP #9

1. Disconnect Delivery Line to Service Side of Spring Brake Chambers, one at a time.
   A. If there is a leak out of the Service side of the Spring Brake Chamber, replace Spring Brake Chamber (Remember, there may be more than one bad chamber).

BRAKE (FOOT) VALVE TEST

STEP #10

1. After completing STEPS # 1 thru 9, and leak continues, disconnect all Delivery Lines.
   A. If leak continues, replace Brake (Foot) Valve
   B. If leak stops, recheck STEPS # 1 thru 9.

PROBLEM #2

Air Leak at Exhaust Port of Rear Axle Tractor Relay with Service and Parking Brakes Released

POSSIBLE CAUSES:

1. Spring Brake Chamber
2. Relay
3. Anti-Compound Valve (depending on plumbing)

SPRING BRAKE CHAMBER & RELAY TEST

STEP #1

1. Pull Park Control Valve (Yellow or Blue Knob on dash).
   A. If leak continues, go to STEP #2.
   B. If leaks stops, go to STEP #3.

STEP #2

1. Replace Relay.
   A. Bad or dirty Inlet

STEP #3

1. Release Parking Brakes.
2. Disconnect Delivery Lines to Service Side of Spring Brake Chamber, one at a time.
   A. If there is a leak out of the Service Side of the Spring Brake Chamber, replace Chamber (Remember, there may be more than one bad Chamber)
   B. If Chambers do not leak, go to STEP #4.

ANTI-COMPOUND VALVE TEST

STEP #4

1. Disconnect service side of Anti-Compound Valve.
2. Release Parking Brakes.
3. If air leaks out of Anti-Compound Valve, replace valve.

PROBLEM #3

Air leak at Exhaust Port of Relay In Front Axle System with Service Brakes Released

POSSIBLE CAUSES:

1. Relay
   A. Bad or dirty Inlet

PROBLEM #4

Air Leak In Parking System Relay

POSSIBLE CAUSES:

1. Relay
   A. Bad or dirty Inlet

PROBLEM #5

Air Leak at Exhaust Port of Quick Release Valve in Rear Axle Tractor Service System with Service and Parking Brakes Released

POSSIBLE CAUSES:

1. Spring Brake Chamber *(Remember, there may be more than one bad Chamber).*

STEP #1

1. Release Parking Brakes.
2. Disconnect Delivery Lines to Service Side of Spring Brake Chamber, one at a time.
   A. If there is a leak out of the Service Side of the Spring Brake Chamber, replace Chamber

PROBLEM #6

Air Leak at the Exhaust Port of the Trailer Hand Control with Tractor and Trailer Brakes Released

POSSIBLE CAUSES:

1. Tractor Protection Valve
2. Trailer Components
3. Trailer Hand Control

STEP #1

1. Pull Trailer Supply.
   A. If leak continues, go to STEP #2.
   B. If leak stops, go to STEP #3.

STEP #2

1. Replace Trailer Hand Control
   A. Bad or dirty inlet

STEP #3

1. Disconnect Glad Hands and connect to holder on tractor.
2. Push Trailer Supply.
   A. If Exhaust Port of Trailer Hand Control leaks, replace Hand Control
   B. If Exhaust Port does not leak, go to STEPS # 3 thru 5 of PROBLEM # 1

PROBLEM #7

Air Leak at Exhaust Port of Tractor Protection Valve with Tractor and Trailer Brakes Released

POSSIBLE CAUSES..

1. Tractor Protection Valve

PROBLEM #8

Air Leak at Exhaust Port of Park Control and Trailer Supply with Tractor and Trailer Brakes Released

POSSIBLE CAUSES;

1. If leak is out of Park Control, Park Control is bad.
2. If leak is out of Trailer Supply, Trailer Supply is bad

PROBLEM #9

Air Leak at Exhaust Port of the following valves with Service Brakes Applied

POSSIBLE CAUSES:

1. Brake (Foot) Valve
   A. Bad or dirty Exhaust Seat
2. Relay
   A. Bad or dirty Exhaust Seat
3. Quick Release Valve
   A. Bad or dirty Exhaust Seat
4. Ratio Valves
   A. Bad or dirty Exhaust Seat
5. Trailer Hand Control Valve
   A. Bad or dirty Exhaust Seat

PROBLEM #10

High Pressure in Air System

POSSIBLE CAUSES:

1. Stuck Unloader Plunger (valves)
2. Bad Governor
3. Plugged or broken Governor Signal Line

STEP #1

1. Build pressure to 140 psi.
2. Loosen mounting bolts of Governor.
   A. Disconnect Unloader Line if Governor is remotely mounted.
3. If air leaks, go to STEP #2.
4. If air does not leak, go to STEP #3.

STEP #2

1. Remove and inspect Unloader Plungers (valves).
2. Replace if necessary.

STEP #3

1. Remove and inspect Governor.
2. Replace if necessary.

PROBLEM #11

No Air Pressure Build-Up

POSSIBLE CAUSES:

1. Plugged Air Filter
2. Broken Drive Belt (if equipped)
3. Air Leaks
4. Restricted Discharge Line
5. Restricted One-way Check Valve or Valves
6. Governor
7. Unloader Plungers (valves)
8. Air Compressor

STEP #1

1. Visually inspect belts, lines and connections.
   A. If broken, frayed, worn or loose, repair as necessary.
   B. If belts, lines and connections are okay, go to STEP #2.

STEP #2

1. Disconnect Discharge Line at Supply Tank and Compressor.
   A. If plugged, clean or replace as necessary.
   B. If not plugged, go to STEP #3.

STEP #3

1. Remove and inspect One-way Check Valves.
   A. If bad, replace the valve.
   B. If good, go to STEP #4.

STEP #4

1. Remove Governor.
   A. Check for stuck piston.
   B. Check for restricted exhaust.
   C. Check for a restricted unloader line (if equipped).
2. If bad, repair or replace as necessary.
3. If good, go to STEP #5

STEP #5

Inspect unloader plunger movement:

1. Remove intake connection. (Filter or Elbow)
2. Start engine.
   A. If air is pushed out of intake, remove and inspect Unloader Plungers. Replace if necessary.
   B. If air pressure starts to build, check for a restricted intake.
   C. If there is no air movement, go to STEP #6.

STEP #6

Replace or rebuild Air Compressor.

About the authors: [illegible] are technical instructors at Northwestern College, Lima, Oh. They are ASE certified Master Truck Technicians with [illegible] years combined experience. [illegible]

PROBLEM #12

Excessive Oil in Air System

POSSIBLE CAUSES:

1. Restricted Intake
   A. Hose between Air Compressor Intake and Engine Intake Manifold.
   B. Plugged Air Strainer (filter)
2. Flooding
   A. Plugged drain to Engine from Air Compressor
3. Bad Piston and/or Rings in Air Compressor

STEP #1

1. Check hose or filter to Air Compressor.
   A. If plugged, repair or replace as necessary.
   B. If good, go to STEP #2.

STEP #2

If Air Compressor is:

1. Belt-driven with oil drain to engine, check for a plugged drain
2. Gear driven, remove Air Compressor.and check drain ports
3. If drain is plugged, replace or repair as necessary
4. If drain is not plugged, replace Air Compressor.

PROBLEM #13

Slow or No Release of Brakes

POSSIBLE CAUSES:

1. Hinge Pin on Brake Pedal
2. Air Delivery Lines restricted
3. Control Line restricted(Delivery of Brake(Foot) Valve to Service Port of Relay restricted
4. Relay Valve not exhausting
5. Quick Release Valve not exhausting
6. Brake (Foot) Valve not exhausting
7. Binding parts in the Foundation Brake

STEP #1

1. Check Hinge Pin in Brake Pedal. If free, go to STEP #2.

STEP #2

1. Have an assistant make a brake application and release.
2. Listen for exhaust noise from the exhaust parts of:
   . Relay Valve
   . Quick Release Valve
   . Brake (Foot) Valve.
   A. If no exhaust noises, go to STEP #3.
   B. If exhaust is normal, go to STEP #4.

STEP #3

1. Check for restrictions in all Delivery Lines from the Valve that is not exhausting.
   A. If a kink or dent is not found, remove and check internally.

NOTES:

- *Line could be plugged or may have* been *crimped with vice grips or pliers.*
- *If line is free of restrictions, replace or repair valve.*

STEP #4

1. Check S-Cam. It should rotate freely (Cam Brakes).
2. Check Anchor-Pins (Cam Brakes).
3. Check Wedge Assembly and Actuation Housing (Wedge Brakes)
4. Check Clevis Pin in Slack Adjuster. It should rotate freely (Cam Brakes).

COMPONENT PERFORMANCE TESTS

SINGLE (ONE-WAY) CHECK VALVE TEST

STEP #1

1. Build system to cut out pressure.
2. Drain Wet (supply) Reservoir.
3. Watch Primary and Secondary Air Gauge
   A. If 3-Reservoir system, and if Primary or Secondary Reservoir loses pressure, replace Single Check Valve to that Reservoir.
   B. If Reservoir(s) have more than one compartment, and if either Reservoir loses pressure, there is a hole between Reservoir compartments.
4. If no leakage, Single Check Valves are good. Go to STEP #2.

TWO-WAY CHECK VALVE AND SPRING BRAKE CONTROL TESTS

STEP #2

1. Drain Primary Reservoir.
2. Watch Secondary Gauge.
   A. If Secondary Gauge loses pressure, replace Two-way Check Valve.
   B If Secondary Gauge holds pressure, Two-way Check Valve is working. Go to STEP #3.

STEP #3

If equipped with a Spring Brake Control, with Parking Brakes released:
1. Make a Brake application.
2. Watch Rear Spring Brake Chamber.
   A.. If Rear Spring Brake Applies, go to STEP #5.
   B. If Rear Brakes do not apply, go to STEP #4.

STEP #4

1. Check Secondary Delivery Line to see if it's kinked or plugged.
   A. If line is restricted, replace or repair line.
   B. If line is not restricted, replace Spring Brake Control.

STEP #5

1. Build system to Governor cut out pressure.
2. Drain Secondary Tank.
3. Watch Primary Gauge.
   A. If Primary Gauge loses pressure, replace Two-way Check Valve.
   B. If Primary Gauge holds pressure, Two-way Check Valve is working. Go to STEP #6.

STEP #6

1. Apply Service Brakes.
2. Secondary Brakes should apply.
   A. If not, check delivery lines and Secondary Delivery Port of Brake (Foot) Valve.

NOTE: Stop lights should light in STEPS #3 and #6.

TWO-WAY CHECK VALVE WITH TRAILER HAND CONTROL TEST

STEP #1

1. Apply brakes with Hand Control Valve
2. If there is air exhausting from Brake (Foot) Valve Exhaust Port, check to see if Primary or Secondary Tractor Brakes are applying.
   A. If yes, go to STEP #2.
   B. If no, go to STEP #3.
3. If only Trailer Brakes apply and there aren't any Exhaust Port leaks, Two-way Check Valves are working.

STEP #2

1. If Primary Brakes are applying, Two-way Check Valve to which Primary Delivery Line is connected is bad.
2. If Secondary Brakes are applying,Two-way Check Valve in Secondary Delivery Line is bad.

STEP #3

1. Disconnect Primary Delivery Line from Two-way Check Valve.
   A. If air leaks out of Two-way Check, the Two-way Check Valve is bad.
   B. If air does not leak, the Two-way CheckValve is good.
2. Disconnect Secondary Delivery Line from other Two-way Check Valve.
   A. If air leaks out of Two-way Check Valve, the valve is bad.
   B. If air does not leak, the Two-way Check Valve is good.

AIR BRAKE TRAINING GUIDE

Abex Friction Products
(lining)
Heavy Duty Director
2410 Papermill Rd.
Winchester, Va. 22601-2450
Phone: 800-4ABEXHD/703-662-3871
Fax: 703-665-0617

Field Training: On-site evaluation of brake systems and balance. Free training by engineers in proper repair and replacement of friction materials.

AlliedSignal
Truck Brake Systems Company
Communications Dept. S31
901 Cleveland St.
Elyria, Oh. 44036
(components/compressors/lining)
Phone: 216-329-9000
Fax: 216-329-9557

Factory Training: Free seminars on Bendix products are held between October and May. Each seminar is 3-1/2 days and covers the entire air brake system. Topics include operation, maintenance and troubleshooting of all major air brake systems components.

Field Training: On-site training for Bendix products customers may be available. Contact regional sales offices:

Northeast/Canada: 5 19-652- 1369
Northcentral: 8 1 o-827-6460
Central (Mid-West): 309-676-2371
Southeast: 704-391-5574
Western: 503-53 l-2020

Training Aids: Videos also available. Contact regional sales office.

American Isuzu Motors Inc.
13 18 1 Crossroads Parkway North
4th Floor
City of Industry, Calif. 9 1746
(imported brake systems)
Phone: 3 10-699-0500/800-726-2700
Fax: 310-692-7135

Factory Training: Air brake training is available as part of comprehensive F-Series training to dealers and larger fleet customers. A fee is involved.
For information call:

Grand Prairie, Tex.: 214-647-298 1
Roswell, Ga.: 404-475-9195
Irvine, Calif.: 714-770-2626
Northvale, N.J.: 201-784-1414
Redmond, Wash.: 206-88 l-0203
Glen Burnie, Md.: 410-761-2121
Elk Grove Village, Ill.: 708-952-8111

Carlisle Corp.
(lining)
Motion Control Industries, Inc.
103 1 E. Hillside Dr.
Bloomington, Ind. 47401
Cust. Service: 800-374-3492
Cust. Service Fax: 814-776-5479
Product Info.: 812-334-8707
Product Info. Fax: 812-336-3985

Field Training: Free systems analysis, brake troubleshooting, and maintenance training conducted on-sight by Carlisle technical expert. Training also available at distributor locations and at Carlisle's headquarters in Bloomington, Ind.

Training Aids: Technical literature and brake maintenance troubleshooting pamphlets are available free through local distributors or Carlisle headquarters.

Caterpillar Inc.
(engine brakes)
Supervisor, Tech. Training
Engine Div. Tech. Training
Bldg. JJ
600 W. Washington St.
East Peoria, 111. 61630
Phone: 309-675-1000 (main number)
309-675-3698
Fax: 309-675-0525

Field Training: Engine brake training available, for a fee, from local dealers. Some dealers have on-site training available.

Training Aids: Instructions for engine brake adjustment and troubleshooting are included in an appropriate engine manual. Fee charged.

Cummins Engine Co.
(engine brakes)
Service Training Dept. MC 9 1300
PO Box 3005
U.S. 31 Bypass
Columbus, Ind. 47202-3005
Phone: 812-377-5604/800-343-7357
Fax: 812-377-3082

Field Training: Engine retarder "C" Brake instruction is included in basic engine and overhaul courses taught by local Cummins distributors. Fee charged.

Training Aids: For a fee, slide program covering engine brakes is available from Cummins training department.

Dana Corp.
(axles)
Spicer Heavy Axle Div.
PO Box 2229
Fort Wayne, Ind. 46801
Phone: 219-481-3362
Fax: 219-481-3115

Factory Training: Program available. Call headquarters for scheduling.

Field Training: Available. Contact local dealer or headquarters.

Training Aids: Manuals available free. Contact dealer or headquarters.

Dayton Parts Inc.
(brake drums/rotors/hubs/disc pads/attaching components)
PO Box 5795
3500 Industrial Rd.
Harrisburg, Pa. 171 lo-0795
Phone: 7 17-255-8500/800-233-0899
Fax: 7 17-255-8568

Field Training: Free clinics covering maintenance, operation and troubleshooting of air braking systems are conducted at distributor locations.

Training Aids: Product catalogs and technical publications available.

Dayton-Walther Corp.
(discs/rotors and other parts)
2800 E. River Rd.
Dayton, Oh. 45439
Phone: 5 13-296-3 113
Fax: 5 13-296-3 128

Field Training: Free on-site training. Contact disc brake engineer at 5 13-296-3096 or other engineer at 513-296-3057.

Training Aids: Free manuals and wall charts are available.

Eaton Corp.
(components/foundation brakes/lining/automatic brake adjusters and other components)
PO Box 4013
Kalamazoo, Mich. 49003
Phone: 616-342-3000/800-826-4357

Field Training: On-site mobile training clinics and regional seminars are available. Call 800-826-4357 for details.

Training Aids: Video programs illustrate proper brake maintenance (fee charged). Service manuals, parts books, and other literature are available for a price. Contact Eaton Corp., Marketing Communications Dept., PO Box 4013, Kalamazoo, Mich. 49003.

Euclid Industries, Inc.
(brake shoes, friction material, camshafts, automatic and manual slacks, spring brakes, air hose and brake hardware)
6660 Beta Dr.
Cleveland, Oh. 44143-232 1
Phone: 216-461-4300/800-488-6608
Fax: 800-776-4307

Field Training: Free technical service clinics are held by Euclid distributors for their customers.

Training Aids: Free service bulletins are available from local distributors.

Ferodo America Inc.
(components, foundation brakes, lining)
Heavy Duty Products Div.
1375 Heil Quaker Blvd.
Box 7010
La Vergne, Tenn. 37086
Phone: 615-793-5177
Fax: 615-793-5141

Field Training: Contact local distributor for on-site training.

Factory Training: Brake School: The three day course includes brake system design and application methods, air brake systems, hydraulic brake systems, friction material, brake parts and spring brakes. For information contact: Vickie Diener at X00-25 l-3390.

Training Aids: Brake Balance Video & Handbook covers pneumatic, torque and mechanical balance. It shows how to avoid maintenance errors leading to dangerous braking or block/drum damage. Handbook includes system diagrams and torque calculations. Available from marketing department for $25.

Freudenberg - NOK
(oil bath seals)
Seals Div. - Attn: C. Reagan
47690 East Anchor Ct.
Plymouth, Mich 48 170
Phone: 313-451-0020 Ext. 270
Fax: 313-451-1539

Training Aids: A 13 minute video on proper oil bath seal installation; wall chart on proper oil bath seal installation; brochure explaining features and benefits of Outrunner seal.

Gunite Corp.
(automatic brake adjusters/brake drums/hubs, rotors, cast-spoke wheels)
Technical Service Manager
302 Peoples Ave.
Rockford, Ill. 61104
Phone: 815-964-3301/800-677-3786
Fax: 815-965-9197/815-964-0775

Field Training: Free on-site training is available to fleets.

Training Aids: Free manuals are available from headquarters or local reps. VHS videotape covering installation and maintenance of automatic brake adjusters is available.

Haldex Corp.
(automatic brake adjusters, air dryers)
Service Manager
PO Box 4080
Blue Springs, MO. 640 14
Phone: 8 16-229-7582/800-821-8469
Fax: 8 16-224-7090

Field Training: Free on-site training by area reps.

Training Aids: Free manuals and videotapes are available on request. Contact company headquarters or local representatives.

Hino Diesel Truck (USA) Inc.
(imported brake systems) (full air, air over hydraulic, vacuum hydraulic)
Technical Services Manager
25 Corporate Dr.
Orangeburg, NY 10962
Phone: 9 14-365-1400
Fax: 914-365-1409

Field Training: Centers providing free three-day training sessions on brake and steering systems are located in Orangeburg, N.Y. and Los Angeles, Calif.

International Transquip Industries, Inc.
(parking brakes)
National Sales Manager
613 1 Brookhill Dr.
Houston, Tex. 77087- 113 1
Phone: 713-641-2300/800-753-4484
Fax: 713-641-2727

Field Training: Free on-site seminar (one to three days) cover the technical aspects of brake systems.

Training Aids: Free service manuals and literature are available on request. Contact headquarters.

Jacobs Vehicle Equipment Co.
(engine brakes)
22 East Dudleytown Rd.
Bloomfield, Conn. 06602
Phone: 203-243-1441
Fax: 203-243-7705

Field Training: Jacobs distributors conduct free, on-site training sessions covering engine brake maintenance and troubleshooting.

Training Aids: Installation and parts manuals free at local distributors or headquarters. Troubleshooting manual and videotapes also available without charge.

MGM Brakes
(spring parking brakes)
8530 Cliff Cameron Dr.
Charlotte, N.C. 28269
Phone: 704-547-74 11/800-527- 1534
Fax: 704-547-9367

Field Training: Free on-site brake safety and maintenance clinics are offered. Contact local distributors, dealer or call MGM headquarters.

Training Aids: Installation and parts manuals available at no charge. Also troubleshooting and maintenance manuals. Cut-away brakes for a fee.

Mack Trucks Inc.
(air brake systems)
Service Training
Box M
2100 Mack Blvd.
Allentown, Pa. 18105
Phone: 610-439-2695
Fax: 6 1 o-439-3800

Factor-y Training: Mack offers a two day course covering foundation brakes, air systems and anti-skid. The course is available through Mack dealers at a minimal fee.

Field Training: Contact the Mack Service Training Department at 610-*439-2695.*

Training Aids: Specific air brake systems publications are available from Mack at a minimal fee.

Midland-Grau Heavy Duty Systems
(compressors/lining/related components)
Training Dept.
10930 N. Pomona Ave.
Kansas City, MO. 64153
Phone: 816-891-2470/800-643-2374
Fax: 816-891-9447

Factory Training: Free instruction covering complete air brake systems, regulations, anti-lock brake systems, friction materials, clutches, foundation brakes and many other Midland product lines. For information, contact headquarters.

Field Truining: Free on-site brake system diagnosis, compatibility tests and brake clinics are conducted by field engineers. Call headquarters.

Training Aids: Free manuals and instructional materials. Contact local distributor or company headquarters.

Mitsubishi Fuso Truck of America Inc.
(imported brake systems)
100 Center Square
Pureland Industrial Park
Bridgeport, N.J. 08014
Phone: 609-467-4500/800-MIT-FUSO
Fax: 609-478-4196

Training: Contact a local dealer for details.

Neway Anchorlok International (NAI)
(combination/piggyback spring brakes)
Anchorlok Service Dept.
1950 Industrial Blvd.
PO Box 425
Muskegon, Mich. 49443
Phone: 616-777-4375/616-773-3271
Fax: 616-766-3893

Factory Training: Available and set up through regional sales managers or directly through corporate service department.

Field Training: Customized training available at customer's facility.

Training Aids: Installation/service manual available upon request.

Parker Hannifin Corp.
(air brake hose and fittings)
Hose Products
30240 Lakeland Blvd.
Wickliffe, Oh. 44092
Phone: 216-943-5700
Fax: 216-943-3129

Factory Training: Parker distributors. User companies by arrangement.

Field Training: Parker distributors. User companies by arrangement.

Training Aids: Hose/Fittings Basics, videos, slides, etc. (not specifically air brake). Air Brake related material could be created on demand.

Parker Hannifin Corp.
(hose and fittings)
Fluid Connectors Group
1528 Old Coach Rd.
Kernersville, N.C. 27284
Phone: 910-996-3422/800-CPARKER
Fax: 910-996-3422

Field Training: Hose and fitting training is available free on-site. Contact your local Parker fleet distributor or call 800-CPARKER.

Training Aids: For a fee, video programs are available which cover air brake applications for hose and fittings. Wall charts and catalogs are also available for a small fee.

Rayloc
(lined shoes)
Heavy Duty Parts
600 Rayloc Dr. S.W.
Atlanta, Ga. 30336
Phone: 404-691-3780/800-LETNAPA
Fax: 404-699-4010

Field Training: Full day to half day complete air system training. Hands on. Contact local NAPA Auto Parts store for scheduling.

Training Aids: Complete tractor and trailer air system simulator. Tech tips.

Rockwell Automotive
(automatic slack adjusters (ASAs)/foundation brakes/Rockwell WABCO air dryers/air brake systems and controls)
Automotive Product Training
2135 W. Maple Rd.
Troy, Mich. 48084
Phone: 810-435-1000 (main number)/
810-435-1737/800-535-5560
Fax: x10-435-1393

Factory Training: Free customized training programs are available on Rockwell S-cam, air disc, wedge and Rockwell WABCO ABS.

Field Training: Training available on-site. Call 800-535-5560.

Training Aids: Service manuals, ASA adjustment templates, parts books and videos are available for a fee.

Rockwell WABCO Vehicle Control Systems
(anti-lock breaking systems/air dryers/automatic traction control (ATC)/suspension and cab leveling valves/electronically-controlled air suspensions (ECAS)/exhaust brakes)
Manager Technical Services
2135 W. Maple Rd.
Troy, Mich. 48084
Phone: 810-435-8001/800-535-5560
Fax: 810-435-8002

Factory Training: Free customized training is available. Call 800-535-5560.

Field Training: On-site training is offered. Call 800-535-5560.

Training Aids: Service manuals and videos are offered for a fee.

Sealco Air Controls Inc.
(control valves)
215 E. Watkins St.
Phoenix, Ariz. 85004
Phone: 602-253-1007
Fax: 800-222-2334

Field Training: Seven regional reps put on classes on-site. Classes range from 45 minutes to three hours, depending on the instruction requested. No charge.

Training Aids: Manuals are provided free at time of instruction.

The Maintenance Council (TMC) American Trucking Associations (ATA)
(brake system)
2200 Mill Rd.
Alexandria, Va. 22314
Phone: 703-838-1763/800-ATA-LINE
Fax: 703-684-4328

Training Aids: Brake adjustment video: 1994-95 Recommended Maintenance Practices manual.

Williams Controls Industries, Inc.
(electronic accelerators, exhaust brakes/valves)
14100 S.W. 72nd Ave.
Portland, Ore. 97224
Phone: 503-684-8600/800-547-1889
Fax: 503-684-8610

Field Training: Troubleshooting only. Contact local dealer or call 800-547-1889 for assistance.

Training Aids: Driver handbook and service bulletins are available from dealers or headquarters.

FINALLY, A WHEEL END SEAL THAT LASTS AS LONG AS YOUR EXTENDED LIFE BRAKES.

Introducing OUTRUNNER™ long distance wheel seals.

Eaton Corporation and Freudenberg-NOK introduce Outrunner, the first wheel end oil bath seal specifically designed to outseal, outsave, and outlast every other wheel end seal on the market.

Outrunner seals have been proven over seven years and 12 million miles of successful road testing to exceed the high performance demands of todays fleets. They last longer to protect bearings and eliminate premature replacement of your extended life brakes caused by seal leakage.

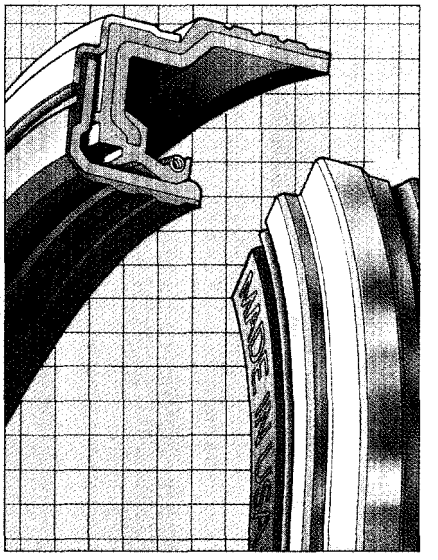
Keeps lube in, dirt out better than any other seal.

Outrunner seals use an advanced lip material to withstand higher temperatures from longer hauls and heavier loads. Its protective labyrinth design gives you excellent protection against dust, while bi-directional helixes pump oil away from the main sealing lip more completely and continuously than any competitive seal. That means extra durability for high-mileage performance.

Lasts up to four times longer between maintenance intervals.

The internal wear ring is lathed, ground and polished for reduced friction, lower torque and more even surface weal: And, the lower heat generated by the Outrunner seal results in less chance of hardening and cracking of the main sealing lip.

Outrunner seals perform so much better than conventional seals that they can help you put an end to premature brake replacement. Scheduled maintenance intervals can be stretched up to four times longer.* Replacing an oil-soaked brake can become a thing of the past.



▲ *Outrunner seal's advanced lip material and labyrinth design keep lube in, dirt out better than any other seal.*

High performance Outrunner seals are compatible with all synthetic and mineral lubes. Combine that with easy installation and you've got a wheel seal that starts paying for itself right out of the box.

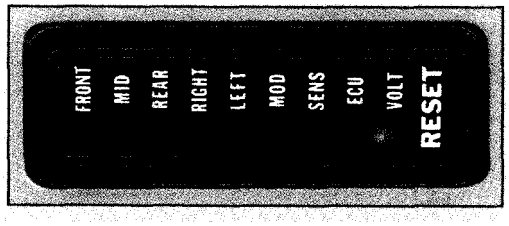
For complete spec'ing and installation assistance, call your nearest Eaton' Roadranger® representative at **1-800-TCM-HELP** (626-4357). He'll tell you how to spec a wheel seal that will fast as long as your extended life brakes. Maybe longer: Outrunner from Eaton.

Technology you can depend on.

EATON

OUTAUNNER is a trademark of Freudenberg-NOK
*Based on documented studies vs. conventional oil bath seals.

HOW DID WE CREATE AN ANTILOCK SYSTEM WITH ADVANCED PERFORMANCE?



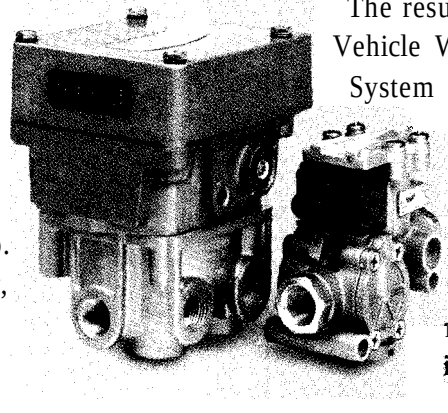
SIMPLY.

Why? So you get anti-lock braking performance easily equal to European systems. Without the complications.

How? We started by using a new generation of digital electronics for the best reliability,

We took advantage of framerail mounting, and located the electronic controller on the easy-to-get-to relay valve for fewer parts and wires. Which makes maintenance a snap.

Most importantly, we built problem detection and fail-safe operation right into the system. With today's **Bendix AntiLock**, a patented self-diagnostic display panel on the controller quickly identifies problems. Without confusing blink codes, how-to manuals or extra test equipment.



The result. Our Full Vehicle Wheel Control System helps vehicles **maintain lateral stability, shortens stopping distances on** most surfaces and **improves** steering control while braking. Especially during panic stops or under hazardous road conditions, And it's just one of several available systems which build off our same simple, high-performance design philosophy. Systems for tractors, buses and other vehicles. Even trailers.

Today's Bendix **AntiLock**. We made it simple to make it right.

For more information on any of our **AntiLock** systems, call or write: Bendix **AntiLock, 901** Cleveland Street, **Elyria**, Ohio **44036**. (216) **329-9000**.

AlliedSignal

Bendix

Brakes