

# Heavy Truck Brake Adjustment—Problems And Solutions

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## ABSTRACT

The National Transportation Safety Board recently inspected 1,520 combination vehicles and found 56 percent had brake violations serious enough to put the vehicles out of service. The National Highway Traffic Safety Administration has said that brake performance could contribute to as many as one-third of all truck crashes, although most sources found 2% or fewer truck crashes to be brake related.

## BACKGROUND

In its April, 1992, *Heavy Vehicle Airbrake Performance* study [1], the National Transportation Safety Board (NTSB) examined the brakes of 1,520 five-axle combination trucks and found 56 percent had violations serious enough to be placed out of service. Forty-six percent of all vehicles inspected were placed out of service for out-of-adjustment brakes alone.



Figure 1. State Police Inspector Measures Brake Adjustment

The NTSB study found that many motor carriers and drivers of commercial vehicles fail to understand the need for well-maintained brake systems. This lack of understanding is easy to comprehend - poorly-adjusted air-brake systems give little driver "feedback" and in routine operations may perform adequately - but in emergency situations, with high brake temperatures and hard applications, adequate braking may not be available.

While the number of brake violations found in roadside inspections is high, there is no agreement on the contribution of those violations to truck accidents.

Congress requested a study of the problem, suggesting brake mechanic training practices as the primary concern. However, the Trucking Research Institute (TRI) and the Federal Highway Administration (FHWA) agreed that mechanic training is likely to be only a part of the problem, and broadened the study to a comprehensive effort to identify cause(s) of brake violations and achieve solutions, assuming that the problem's solution was likely to be some combination of improved:

- Education and Information
- Equipment Technology
- Mechanic and Driver Training
- Enforcement
- Management Commitment

The study concentrates on "solutions" to the brake violation problem which are likely to be practical and acceptable to the motor carrier industry. The assumption is made that effective solutions to the brake violation problem must, at least in the short term, accept the enforcement method and brake system which are presently in use.

The principal sources of information for the study were a comprehensive literature search, interviews with a total of 51 motor carriers (almost equally divided between those with low and high brake-violation rates in roadside inspections), interviews with truck manufacturers, brake suppliers, user groups and enforcement organizations, and a review of FHWA's 1992 Motor Carrier Management Information System (MCMIS) data.

The following findings, conclusions and recommendations represent the views of the author, who is responsible for the accuracy of the data presented herein. They do not necessarily reflect the official policy of the Federal Highway Administration.

## STUDY FINDINGS

### CONTRIBUTION OF BRAKE VIOLATIONS TO TRUCK ACCIDENTS

There are no good data and therefore no real agreement on the contribution of brake violations to truck accidents. Estimates range from zero (assuming "risk homeostasis" [drivers adjust to improved brakes by increasing speed/decreasing following distance so that risk level is unchanged]) to 1% (OMC accident reports) to one-third [2] of truck accidents being attributable, at least in part, to brakes.

### EFFECT OF ADJUSTMENT ON BRAKE EFFECTIVENESS

The vast majority of truck braking is done at low decelerations, using low air pressures, with cool brakes. With all brakes at the manufacturer's stroke adjustment limit, a vehicle would provide acceptable stopping performance in normal (low deceleration, cool brakes) operation. Because air brakes do not provide the pedal "feel" of a hydraulic brake system, drivers may not be aware of brake problems until the vehicle fails to perform properly in an emergency (high deceleration, hot brakes) situation.

### VEHICLES WITH OUT-OF-SERVICE BRAKE VIOLATIONS

The National Transportation Safety Board placed 56% of a "representative sample" of 1,520 combination vehicles inspected on the highway out of service for brake violations. Commercial Vehicle Safety Alliance (CVSA) inspections put a total of 21.7% of over 56,000 vehicles checked (31.8% using the tougher level 1 inspections only) out of service during Roadcheck 93.[3] MCSAP (Motor Carrier Safety Assistance Program) inspections in 1990 put 18% of the vehicles out-of-service for brakes.[4] There are a number of reasons why these data are not directly comparable, but the same conclusion can be drawn from all of them: there are too many trucks with brake violations operating on the nation's highways.

### STANDARDIZED ADJUSTMENT PROCEDURE

Standardized adjustment procedures (called for in the NTSB report) for manual and automatic slack adjusters can be found in The Maintenance Council's (TMC) Recommended Practice RP 609A, included in *The Air Brake Book*. [5] These procedures are also found in recent video training materials from TMC and the Owner-Operator Independent Drivers Association. The procedures are simple and direct. However they were not normally strictly followed by the maintenance personnel visited during this study.

### AUTOMATIC SLACK ADJUSTERS

Various studies show the out-of-adjustment rate of automatic slack adjuster (ASA) equipped brakes to be about half that of brakes with manual slack adjusters (MSAs). NTSB found that a fully-effective automatic brake adjusting system would be the single most effective equipment

solution to the out-of-adjustment problem. Today's generation of ASAs are substantially improved over past ASAs, but carriers report they are far from maintenance and failure free. They can be installed incorrectly, require frequent maintenance, and may fail in "dirty" carrier operations. Many carriers visited during this study have seen a major decrease in out-of-adjustment complaints and maintenance requirements with ASAs. Others have tried them and gone back to manual slack adjusters. Still others have heard "through the grapevine" that ASAs are unacceptable in their type of operation. Often carriers are unaware of the effectiveness of ASAs since they routinely adjust (rather than check) both ASAs and MSAs at frequent maintenance intervals.

### NEW BRAKE TECHNOLOGY

In the not-too-distant past, wedge and disc brakes challenged the old, established S-cam drum brake for supremacy on heavy trucks. Neither design was widely accepted. S-cam designs have been simplified over the years, and have the advantages of availability and interchangeability of parts, mechanic understanding of the system, and low cost. More importantly, they work well and are reasonably accepting of mistreatment. In the near term we do not see S-cams being displaced by other technology. In the longer term today's air application system may be replaced by an electro-pneumatic hybrid (Electronic Braking System [EBS] or brake-by-wire) and disc brakes may again be considered by the industry.

### EXPERIENCE IN OTHER COUNTRIES

Other advanced countries have brake violation problems similar to those found in the U.S. PMVI (periodic motor vehicle inspection) requirements are more stringent in Europe (and some Canadian provinces) than in the U.S., but it is not clear that there are differences in violation rates attributable to these requirements. In U.K. "heavy goods vehicle" PMVI inspections, the failure rate averages around 30%, with the leading cause normally being brakes. The British Vehicle Inspectorate's roadside inspections, which include only a cursory visual inspection of brakes, put 7.2% out of service (1992/93) and gave 7.6% a "delayed prohibition," finding brake system components topping the list of the most frequent defects. A trucking association official in Europe summed up the general feeling of those contacted for this study, saying "[t]ruck brakes top the failure list [in annual inspections], but no one recognizes it as a serious problem."

### MOTOR CARRIER MANAGEMENT INFORMATION SYSTEM (MCMIS) DATA

FHWA collects data on motor carrier operations, inspections and maintenance. The 1992 data files used in the study list 307,805 motor carriers and 1,129,672 vehicle inspections. MCMIS data show a wide variation among states in brake violations per vehicle inspection, ranging from 1.9 in Maine to 0.12 in Illinois. Only part of this variation is explained by different "levels" of inspections run in different states. Nationwide, the most frequent

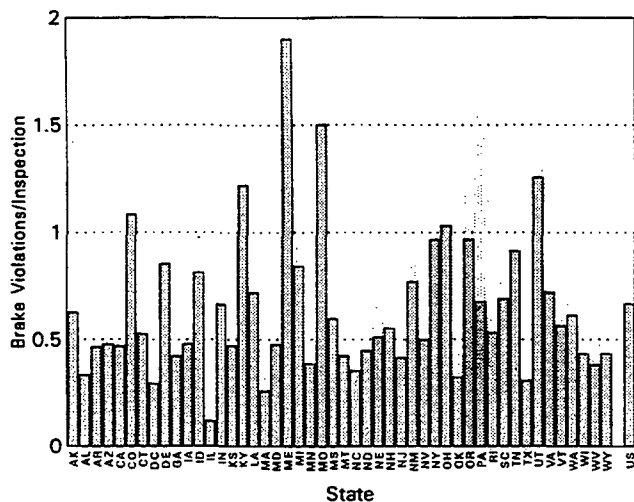


Figure 2. Brake Violation Rate by State

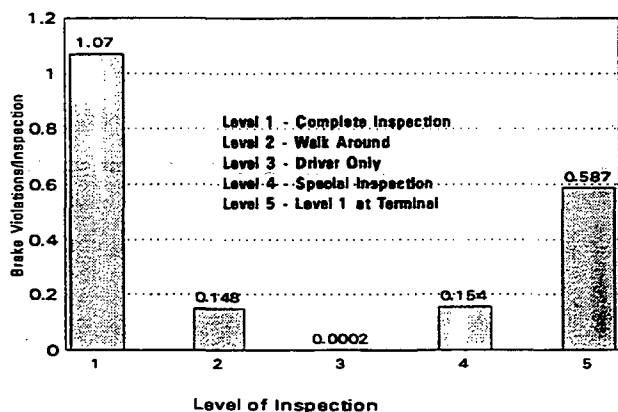


Figure 3. Brake Violation Rate by Inspection Level

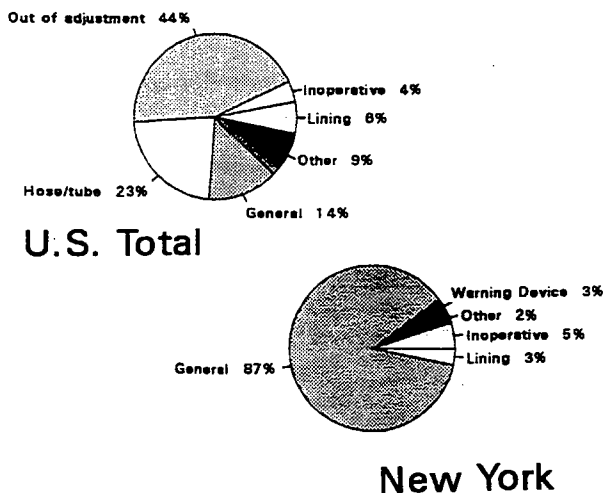


Figure 4. Brake Violation Types - U.S. Total and New York

single brake violation (44%) is "out of adjustment." Yet California, Michigan, New Jersey and New York record less than 0.1% brake violations as "out of adjustment." Those states apparently lump these violations in the "general" or "inoperative brakes" categories. In general, larger fleets do have better vehicle and brake-violation ratios than smaller fleets and newer vehicles are better than older ones. See Figures 2 - 6, taken from 1992 MCMIS data.

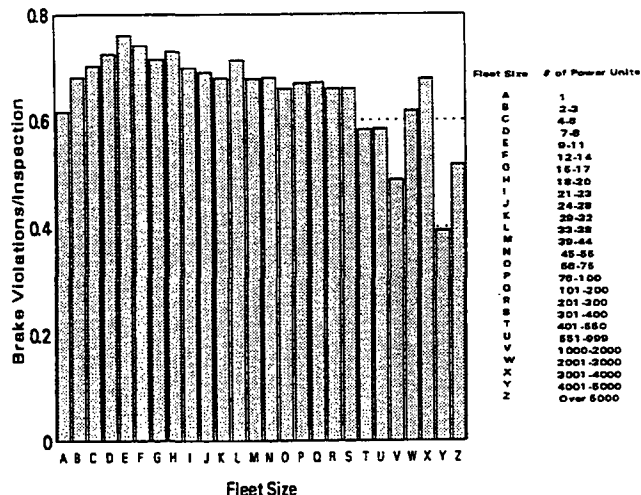


Figure 5. Brake Violation Rate by Fleet Size

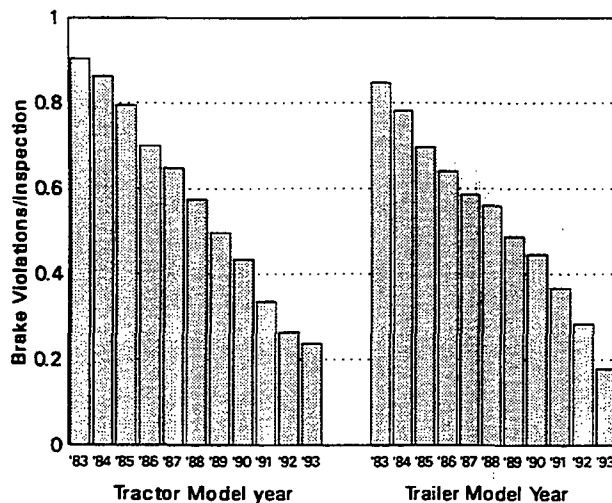


Figure 6. Brake Violation Rate by Vehicle Model Year

CARRIER SURVEY AND ANALYSIS

Fifty-one carriers, almost equally divided between those with very low and very high brake-violation ratios, were visited. Although differences in such things as mechanic training and hiring, shop cleanliness, and brake inspection and adjustment practices were found, these seemed to be subsidiary to two major differences: "type of fleet cargo and operation," and "management commitment to excellence" of the carriers. It is much harder for fleets engaged in "dirty" (e.g. gravel, aggregate or mine opera-

tions, [wood] chip hauling, container hauling) operations to keep up good brake maintenance practices than for fleets in "clean" (e.g. wholesale grocery distribution, gasoline, general freight) operations. Management dedication to good maintenance practices, can, but often does not, overcome other fleet disadvantages.

#### MEETINGS WITH EXPERTS

Discussions with brake suppliers, tractor and trailer manufacturers, motor carrier user groups, an enforcement organization and brake repair facilities focused primarily on the technical side of brakes and brake maintenance. Since the 1973 oil embargo, efforts to improve vehicle fuel economy have led to greatly improved vehicle aerodynamics, lower rolling resistance, and smaller engines with less internal friction. While doubling fuel economy, this has also doubled the amount of work brakes must do, by decreasing a vehicle's natural retardation. During the same period the maximum national gross vehicle weight increased nine percent. All this with no increase in brake lining area or brake drum size. The job of an automatic slack adjuster is difficult because much of the available brake pushrod travel is used for system deflection and drum thermal expansion during hard brake applications, leaving the ASA little tolerance to do its job. Brake system components have been redesigned and lightened over the years to save cost and weight. While lighter components are not necessarily weaker, they are generally less "stiff," allowing greater deflection in hard brake applications.

#### CONCLUSIONS

##### THERE IS NO "SILVER BULLET"

The literature review, technical discussions, MCMIS data study and meetings with low and high brake violation-ratio motor carriers make it clear there is no one simple way to guarantee a quick and substantial improvement in brake violation rate. Solutions such as educating and informing carrier management and technical personnel or better mechanic training will not stand by themselves. Their success depends on each carrier's dedication to vehicle maintenance excellence. Carrier dedication to maintenance excellence often, but not always, follows from an overall dedication to business excellence in all fields, normally led by top management.

Although carriers are responsible for the safety of their vehicles, not all companies will ever boast true management excellence, and therefore not all carriers will fully meet their responsibility. In our visits to 51 low and high brake violation-rate carriers, it was clear that the type of business in which a carrier is involved may make it relatively easy or difficult to conduct an effective brake maintenance program. Carriers in "dirty" operations have a much more difficult time supporting good brake maintenance. Carriers under strong time constraints at specific seasons (e.g. serving road construction in the summer) have a difficult time. And carriers in fiercely competitive fields (e.g. hauling container chassis) may not feel they can afford the time, or money or have the "clout" with shippers to assure

good maintenance. On the other hand, carriers hauling "clean" commodities with trucks that return home at regular intervals to company maintenance facilities, have an easier time.

In even the worst case, there are management teams that make vehicle maintenance a priority and succeed in having low brake-violation rates. And in even the best cases, some companies have poor maintenance practices and a high brake-violation rate.

Only providing more information and education about brake problems will have little long-term effect on maintenance practices. Mechanic training can only be effective, over the long term, in companies which strive for maintenance excellence. More/stronger enforcement is not likely to prove cost-beneficial, however better **targeted** enforcement should be useful.

It appears that relatively straightforward technical solutions will provide the best substantial short-term improvement in the brake-violation rate. In the longer term, major technical improvements will be made in truck brake systems and brake inspection technologies.

The following matrix provides a quick overview of potential short-term solutions to the brake violation problem. The information presented in the matrix is based on the literature search and visits with brake system "experts" and 51 motor carriers.

#### IT IS THE MOTOR CARRIERS' RESPONSIBILITY TO PUT WELL-MAINTAINED, SAFE, VEHICLES ON THE HIGHWAY AND OPERATE THEM IN A RESPONSIBLE AND SAFE MANNER

No matter how difficult it may be, because of equipment design, operational or financial pressures, staff motivation or practical knowledge, motor carrier management is ultimately responsible for the safety of its vehicles and drivers.

#### AVAILABLE MCMIS DATA REPRESENT A SOURCE OF INFORMATION FOR MOTOR CARRIER SAFETY IMPROVEMENTS

MCMIS data provide a level of understanding of the motor carrier industry, the enforcement community, and motor carrier safety, which is not available elsewhere. The MCMIS data in this report, concerned primarily with brake violations, represent only a small percentage of what appears to be available. The use of these data could be expanded to help understand the industry and to achieve maximum results from the federal and state enforcement programs. In-depth study and time-series evaluations can track the effectiveness of regulatory changes (e.g. introduction of the CDL, ASAs or ABS), and the relationship among company variables (e.g. size, type of operation, location, age of equipment, hours of service, accident type and severity). The already-available data can provide higher levels of motor carrier safety without necessarily increasing regulatory burdens or enforcement costs. To be most effective, vehicle identification number (VIN) should be recorded for each vehicle inspected.

Suggested Solution                  Upside                          Downside                          Likelihood of Implementation

Weekly brake adjustment	Almost perfect solution	Costly, time consuming	Few carriers can be expected to do this religiously
Mechanic training	Better quality maintenance	Costly, time consuming	Effectiveness depends on management commitment to excellence
Management information	Greater quality and quantity of maintenance	Costly, time consuming	Could be implemented on reasonable level by FHWA, ATA, TMC. Targeted program most cost/effective.
More enforcement	More carrier management concern for brake maintenance	Costly, time consuming	Significant resources required
More targeted enforcement	Aimed at carriers with known problems	Slight additional cost	Demonstration could be run under Phase II of this program
Annual or semi-annual state or federal inspection (European style)	Vehicles will be completely checked out at least once or twice a year	Costly, time consuming	Significant resources required. Carrier opposition likely.
Present ASAs	> 50% improvement in adjustment	Less frequent brake inspection, increased cost and complexity compared w MSAs	Required on all new air brake vehicles 10/94. FHWA NPRM considering requiring continued use and retrofiting.
Improved ASAs	Best short-term technical solution	Less frequent brake inspection. Designs not presently in place.	Only a matter of time and demand
Long-stroke chambers	Less frequent and less sensitive adjustment. Improved fade resistance and high temperature performance.	May slightly increase air consumption and cost. Need changes in FMVSS 121 brake reservoir requirements.	Very likely
Retarders	Decrease load on brake system and frequency of adjustment	Substantial cost penalty, increased weight and maintenance	Continued slow increase in use rate
Air discs	Less temperature sensitivity, less system deflection	Major changeover in industry. Possible incompatibilities. Higher cost. Systems not presently in place. Need to agree on inspection requirements.	Long term good bet, but not until systems proven acceptable, perhaps in Europe
Stiffer components	Less system deflection	Increased cost, weight	Possible if ASAs and long-stroke chambers not adequate
Pushrod marking	Spotting out-of-adjustment brakes somewhat easier	Checking brake adjustment still awkward	Required on all new air-braked vehicles 10/94
Good brake out-of-adjustment/failure sensor	Driver feedback of brake system problem	Cost, complexity of present systems	Likely only as benefit of future EBS unless simple, low-cost, low-maintenance new design developed
Purchased maintenance	Potential for better quality maintenance	No assurance of universal good quality. Lack of carrier control.	Will likely increase in use over time as found cost/beneficial to carriers and equipment and regulations become more complex
CVSA, TMC program to work w fleets on inspection requirements	Better quality maintenance	Cost, likelihood that problem carriers will show no interest	Demonstration could be run under Phase II of project

Figure 7. Brake Violation Solution Matrix

### IN THE SHORT TERM, OVERALL TRUCK BRAKE SYSTEM DESIGN WILL CHANGE VERY LITTLE

The basic design of today's air-actuated, cam-operated, drum brake system has changed little in the past 70 or so years. It has survived challenges from wedge and air disc brakes in the past 30 years, and will likely be challenged (and may be overcome) by an electronically operated and controlled, air-actuated, disc brake system in the future, but not the near future.

clearly necessary to achieve the type of reliability found in other truck components.

The environment in which an ASA operates makes its job extremely difficult. Much of the available pushrod movement is taken up by system deflection in the extremely high-pressure brake application used to check brakes in roadside inspections (or in a high-deceleration stop). Hard or continuous brake application raises temperatures causing drums to expand, using more pushrod travel. This leaves

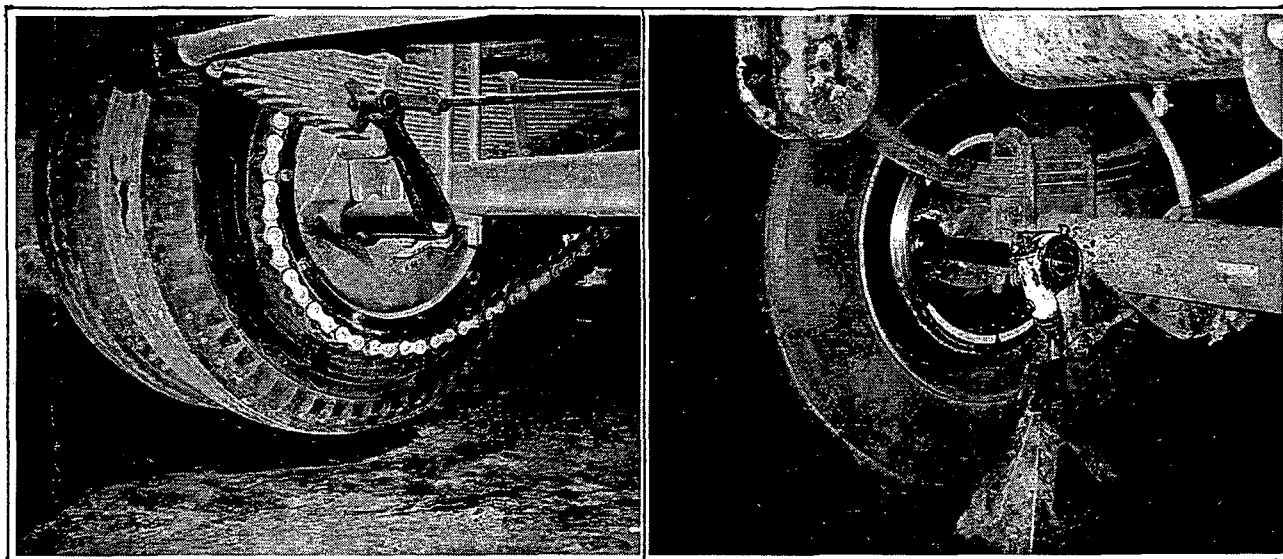


Figure 8. 1921 Mack chain drive brake actuation system was similar in principle to today's cam-activated drum brakes (although it used mechanical, not pneumatic, power)

Truck manufacturers and operators look for a number of things in designing and specifying a brake system and brake components:

- Effectiveness
- Low initial cost
- Simplicity
- Parts availability
- Regulatory compliance
- Durability
- Low maintenance cost
- Standardization
- Balance and compatibility
- Light weight

Today's S-cam air brake systems meet all these requirements, to one degree or another, and mechanics are experienced in maintaining them. The principal reasons for considering a major brake system redesign would be to achieve higher effectiveness (e.g. greater energy absorption), better durability and/or better balance and compatibility. Today's systems enjoy the benefits of low initial cost, simplicity, standardization and widespread parts availability.

### IN THE SHORT TERM, NEAR UNIVERSAL USE OF IMPROVED ASAs AND LONG-STROKE CHAMBERS OFFERS THE SINGLE BEST SOLUTION

Past automatic slack adjuster equipped vehicles have had about half the brake out-of-adjustment violations of vehicles with manual slacks. Each succeeding generation of ASA design is found to be more reliable. But users say today's ASAs still may be installed incorrectly and require continuing maintenance (primarily greasing) and checking to be sure they operate properly. Further improvements are

a small operating envelope for ASAs to keep the system within legal limits, and this envelope gets smaller as system components wear.

Some ASA suppliers and vehicle OEMs feel ASAs alone can virtually eliminate out-of-adjustment violations. Others feel that ASAs, in combination with long-stroke chambers, are needed. They are ready to provide long-stroke chambers as standard equipment if FMVSS 121's brake reservoir capacity requirements are changed to accommodate them.

Long-stroke chambers should make the job of any ASA easier. NTSB concluded that "...combining a properly installed and maintained automatic slack adjuster with a long stroke chamber could reduce the percentage of brakes at or past the limit of adjustment from...26-percent...for...manual slack adjusters...to...4-percent..." [1]

### THE TRUCKING INDUSTRY SHOULD STRIVE FOR A BRAKE SYSTEM AS MAINTENANCE AND FAILURE-FREE AS OTHER MAJOR TRUCK SYSTEMS

Excellent self-adjustment systems have been in place on light-duty vehicles since the early '60s. Certainly trucks are asked to operate under more difficult circumstances than most passenger cars, but less maintenance-intensive brake systems are a reachable goal. Truck engines, transmissions, drive trains and body hardware require far less maintenance than equivalent passenger-car systems, while

operating in a more difficult environment - why not brake systems?

Automatic slack adjusters are a good start. Today they provide a major decrease in brake adjustment violations. Still, today's ASAs are not as maintenance and failure-free as users have come to expect of most truck components. The best of today's technology can provide far more maintenance and adjustment-free brake systems.

#### A SIMPLE, LOW COST, LOW MAINTENANCE, SYSTEM PROVIDING DRIVER FEEDBACK OF BRAKE CONDITION WOULD DECREASE THE FREQUENCY OF BRAKE VIOLATIONS

While measuring adjustment (and adjusting) air brakes is not difficult, it is time consuming and messy, since it requires getting under the vehicle. This is contrasted with the simplicity of monitoring brake adjustment in a hydraulically-operated brake system, where the driver feels the pedal go down further if brakes are not properly adjusted.

Various methods have been developed to ease the task of checking brake adjustment, from the simple pushrod marking now required by FMVSS 121, to sophisticated electronic brake-adjustment sensing and reporting systems. None of these systems fully meets industry needs to provide a simple, low-cost, low-maintenance, driver feedback system.

The benefits of a simple, low-cost, low-maintenance system to provide driver feedback or a brake failure warning could be substantial and should not necessarily await major brake system redesigns.

#### MECHANIC AND DRIVER TRAINING ARE NOT STAND-ALONE SOLUTIONS TO THE BRAKE VIOLATION PROBLEM

Any lack of mechanic and/or driver training in brake maintenance is a symptom of the problem, not the problem itself. While it is true that there is no standardization among carriers and carrier mechanics on methods of checking and adjusting brakes, there appears to be adequate material and tutelage available from brake suppliers, vehicle manufacturers, and carrier organizations such as The Maintenance Council. However, many carriers are not aware of the availability of this information or do not take advantage of it.

The real issue is management interest in and commitment to proper maintenance practices. Some carriers in so-called "dirty" operations exhibit excellent maintenance practices and some in so-called "clean" operations have poor brake maintenance. Improved mechanic and/or driver maintenance performance follow from a management commitment to maintenance excellence, not simply from the creation and distribution of more or better training materials.

Brake adjustment is a relatively simple procedure. Some companies require or encourage drivers to adjust brakes. Some forbid drivers to adjust brakes. It is likely some good could come from more people - drivers, mechanics and management - understanding brake systems and their needs, and making repairs and adjustments as necessary. A low-cost government/industry program could target carriers with brake-maintenance problems to receive

specific guidance (e.g. TMC's brake video and recommended practices) and widely distribute leaflets on proper brake adjustment and maintenance. But the significant resources involved in an across-the-board mechanic training activity would likely not be cost/effective.

#### EFFORTS TO IMPROVE MANAGEMENT COMMITMENT TO BRAKE MAINTENANCE EXCELLENCE CAN BE MOST COST/EFFECTIVE USING A TARGETED APPROACH, RATHER THAN MAJOR ACROSS-THE-BOARD PROGRAMS

With or without improvements in brake system technology, management commitment to maintenance excellence can substantially lower the level of motor carrier brake violations.

In most cases, a company's vehicle maintenance policies flow from the attitudes of top management. Top management (like the rest of us) can be influenced and encouraged to act in a conscientious way by peer pressure, law and regulation, morality, education, (bad or good) press, profits, and enforcement (coercion).

The number of vehicle inspections has increased from perhaps thirty to thirty-five thousand a year in the early '60s to two million a year today without eliminating the brake-violation problem. Most carriers visited during the study understand the nature and importance of the problem, believe they are doing a good job on brake maintenance and feel it is someone else who has the bad record. Based on these visits, it appears that one solution may be a targeted education program, aimed at a relatively small number of carriers with known high brake-violation rates.

The use of MCMIS data allows the identification of carriers with high brake-violation rates. A targeted education program could send personal letters to those carriers, reminding them of the brake violation problem, citing figures showing that they are a major cause of the problem, and offering help from industry sources, trade associations or state or regional motor carrier safety personnel. Limiting the program only to the 10% of carriers with over 25 inspections in the past year, with the highest-violation rate, would include less than 800 carriers, a workable number, but with potential for substantial results.

#### A SIMPLE, STANDARDIZED, MORE ACCURATE TOOL WOULD BE USEFUL FOR INSPECTORS IN MEASURING BRAKE PUSHROD TRAVEL

During this study a number of carriers and others expressed concern with the accuracy of brake adjustment measurements taken by some inspectors.

The width of the chalk lines often used by inspectors to mark the pushrod may introduce error. Inspectors commonly measure to the nearest eighth inch, rather than being more exact. Inspectors may have trouble subtracting fractions of an inch (e.g. 5 5/8" minus 3 15/16") in their heads while lying on their backs under wet trucks in semi-darkness.

To assure more accurate and repeatable measurements, a simple tool should be developed for use in checking brake adjustment. It might, for example, use a magnet to stick against the brake chamber face and have a sliding scale with a hook to snap onto the clevis end of the pushrod. The



Figure 9. Some carriers use a "stock box" system to provide all necessary parts for replacement during brake relining

sliding scale would be set at "0" with brakes released. The inspector would install the measuring devices at each wheel, come out from under the truck to (or have a co-worker) monitor a proper brake application by the driver, and then get under again to read the total travel on each tool. A more sophisticated version could even provide a digital readout for increased accuracy and ease of use.

## RECOMMENDATIONS

1. Motor Carriers must accept the ultimate responsibility for appropriate maintenance to ensure the safety of their vehicles.
2. A vehicle demonstration program, incorporating the best current technology (e.g. ASAs, long-stroke chambers and low-deflection components) to provide a nearly "no adjust, no maintenance" brake system, should be undertaken to encourage the industry to produce and accept this technology.
3. Brake suppliers and/or vehicle OEMs should strive to develop and market a simple, low cost, low maintenance, system to provide driver feedback of brake failure (particularly out-of-adjustment brakes).
4. Mechanic and driver training should not be seen as a stand-alone solution to the brake violation problem.
5. Government and industry efforts to improve motor carrier management commitment to brake maintenance should take a targeted, rather than a general approach,

starting with a program of contacting high violation-rate carriers, informing them of their problems, and offering them both help from industry and government sources (carrot) and selective enforcement (stick) as necessary.

6. The use of MCMIS data should be expanded to help understand the industry, and achieve maximum results from federal and state enforcement programs.

7. Vehicle Identification Number (VIN) should be recorded and reported for every vehicle inspection.

8. A simple, standardized, more accurate tool should be developed for use by inspectors in measuring brake pushrod travel.

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