THE EFFECTS OF AIR PRESSURE ON PUSH ROD STROKE MEASUREMENTS

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Since the inception of the Motor Carrier Safety Assistance Program (MCSAP) through the Surface Transportation Assistance Act of 1982 (reference 49 CFR Part 350)[1], many hundreds of public safety officials have been trained in the enforcement of the Federal Motor Carrier Safety Regulations[2], which include inspection and enforcement of brake related regulations and standards (reference 49 CFR §393.40-§393.52). Data collected as a result of these inspections have been routed to and recorded by the U.S. DOT Office of Motor Carrier Safety's Safetynet Program (reference 49 CFR Part 385). This program records and tracks motor carriers' compliance through on-site audits, random roadside inspections and accident reports. These data are filed pursuant to a motor carrier's U.S. DOT number (reference 49 CFR §390.21) or ICC Motor Carrier number for the entire fleet.

This information is utilized by U.S. DOT Office of Motor Carrier Safety to assist in the assignment of Motor Carrier Safety Ratings. It is also used as a database by State and Federal officials, as well as the commercial vehicle industry to establish the industry's compliance with the Federal Motor Carrier Safety Regulations. Information from this database may also be helpful in the investigation of a motor carrier.

NTSB Brake Study

In 1990, the National Transportation Safety Board began a safety study of "Heavy Vehicle Airbrake Performance"[3]. The initial phase of this study was presented to the National Transportation Safety Board (NTSB) headquarters in Washington, D.C. in March of 1992 and adopted April 29, 1992. Initial review of Safetynet data in this study revealed a wide variance in the percentage of commercial motor vehicles declared out of service for brake related defects from state to state. The NTSB study was the result of carefully monitored random inspections of 1,520 truck tractors and semi-trailers in 5 states throughout the United States, both on and off

[1] *Code of Federal Regulations, Transportation 49, Parts 200 to 399, U.S. Government Printing Office, 1994*

[2] *Federal Motor Carrier Safety Regulations Pocketbook, J.J. Keller & Associates, Inc., Neeenah, Wisconsin, Library of Congress Catalog Card Number—75-32244; ISBN 0-934674-28-0, 7/95. Available from publisher or Stopper & Associates.*

[3] *"Heavy Vehicle Airbrake Performance," Safety Study, National Transportation Safety Board, P892-917003, Washington, DC, Adopted April 29, 1992.*

interstate highways. A specially trained team of NTSB investigators and brake experts conducted the inspections. This study found even higher numbers of brake defects than the MCSAP data.

As a result of the NTSB study, a variation in motor carrier inspection methods was found, explaining some of the differences in reported results through the Safetynet Program. Although some regional differences were noted, and compliance was found to meet higher levels in areas of strict enforcement, the study results revealed a national average in excess of 60 percent of air-braked vehicles being operated with brake defects sufficient to have the vehicle declared "Out-of-Service." The majority of these defects were brakes beyond the adjustment limits (excessive push rod travel).

Participants in the study agreed that the most common explanation for the wide disparity between the safety study investigation and random roadside inspections reported through the Safetynet Program was failure of inspectors to monitor proper air brake pressure (85 to 90 psi) being delivered to the service brakes during brake inspections. This was through no fault of the inspectors themselves, but was due to inadequate emphasis on the importance of utilizing adequate brake pressure, as well as lack of air pressure monitoring equipment made available to motor carrier inspectors. All trucks, truck tractors and buses are required to have air pressure gauges to monitor the air reservoir system (reference 49 CFR δ393.51(c)(2)). A small number of these vehicles are also equipped with an "application pressure" gauge, which allows the operator to monitor the amount of delivered service brake pressure. This gauge is not a required component in an air brake system.

Inspection Without Application Gauge

Absent the optional "application pressure" gauge, the motor carrier inspector has no other simple method to establish proper "application pressure" while conducting air brake tests. A reasonably reliable method absent an "application pressure" gauge is to bring the air brake system to full pressure (approximately 120 psi) and turn off the engine, which shuts off the air compressor. Air brake pressure should then be reduced by progressive applications to approximately 100-105 psi. Once the pressure is reduced to this level, a maximum effort, full-treadle brake application should be made. Testing has revealed this will generally deliver the desired 90 psi "application pressure" to the service brake chambers. There is difficulty with this methodology when multiple brake applications are required to conduct measurements on separate axles or axle groups. Air pressure will progressively decrease, resulting in underestimating the effective push rod stroke. This requires restarting the truck and repeating the process.

Inspection With Application Gauge

During the NTSB study, all inspections were conducted while inserting an application pressure gauge between the truck tractor and semi-trailer at the service brake "gladhand" (generally the blue hose between truck tractor and semi-trailer). A simple device was constructed by inserting an air pressure gauge with a brass T-fitting between 2 standard gladhands. This is an excellent

location to monitor application pressure as the service brake hose is directly connected to the application treadle valve through the tractor protection valve. This air pressure measuring device can easily be constructed for less than $30 if purchasing the items at retail costs, and can often be partially constructed from used truck components for significantly less money.

When conducting inspection of a straight truck or bus that is not equipped with an "application pressure" gauge, an air pressure gauge may typically be inserted into the service brake inlet port (generally a 3/8 inch NPT). Most service brake chambers are equipped with two inlet ports that allow service brake delivery hose installation variations due to size or space restrictions. The second inlet port is typically plugged with a 3/8 inch NPT nut. Removal of this plug allows installation of an air pressure application gauge immediately at the steer axle air chamber for accurate monitoring. The steer axle, like the service brake connecting hose on truck tractors, is typically connected directly to the air brake treadle valve.

Steer Axle Limiting Valves

The inspector should also be aware of any manual or automatic limiting valves attached to the steer axle brake lines. Manual limiting valves are a typical option on pre-1975 U.S. manufactured vehicles and are still found on many current Canadian vehicles. When the manual valve is set in the "wet" or "slippery" position, the front axle brake pressure will be delivered at one-half the delivery pressure to other brakes in the system. It must be set in the "dry" or "normal" position during brake testing. It is illegal to operate a truck or truck tractor equipped with such a valve set "wet" on dry surfaces (49CFR δ393.48(b)(1)). Automatic limiting valves (ALV's) deliver half brake pressure at applications of 0 to 40 psi. Application pressure increases between 40 and 60 psi. Application pressures above 60 psi result in steer axle application pressure which should match all other brakes in the system. At the recommended 85 to 90 psi brake application, a properly functioning automatic limiting valve will not affect the test.

Full Release of Spring Brakes

Proper air brake system pressure is a further concern when inspecting brakes on axles equipped with spring actuated emergency/parking brakes. The parking brake release valve can be activated at pressures as low as 60 psi. At this pressure, although the parking brake begins to release, the inspector cannot be assured it has fully released. If the spring emergency/parking brake has not fully retracted, the measured push rod stroke on the service brake chamber will be incorrect as the service brake is incapable of full release. This results in an underestimation of the push rod stroke. At 85-90 psi, the spring emergency/parking brake that is in proper condition should fully retract.

The majority of spring emergency/parking brake air chambers are equipped with an open port on the rear of the chamber to allow insertion of a "caging bolt." This allows manual release of the emergency/parking brake in the absence of sufficient available air pressure. This port also allows visual inspection to ensure complete retraction of the spring brake. **NEVER INSERT A**

FINGER OR ANY OTHER BODY PART INTO THIS PORT AS TRAUMATIC AMPUTATION MAY RESULT.

Any measurement or inspection into this port must be conducted visually or with a disposable probe. Occasionally, an inspector will find a broken or misaligned spring brake. Typically the plate where the caging bolt is inserted is found tilted and significantly out of alignment with the hole on the back of the chamber. If this is found, the spring emergency/parking brake may not be fully retracted even when adequate air pressure is applied. With a defective spring brake it is possible to measure a push rod stroke that is within the prescribed "adjustment limits" and yet the brake be partially or totally ineffective.

If a defective spring brake is suspected, visual inspection is necessary through the opposite side (service brake chamber section) where the push rod extends to the slack adjuster. A narrow ruler may be utilized by inserting it against the push rod and measuring the distance from base of the service chamber to the diaphragm push plate. If the brake chamber is at maximum travel (bottomed out), the push plate will be approximately one-half inch from the exterior face of the service side of the air brake chamber. Under this scenario, push rod stroke may also be measured by carefully taking measurements from both the released and applied position by inserting the ruler into the service side of the chamber to establish effective push rod stroke. As with the spring brake side of the chamber **NEVER INSERT A FINGER OR ANY OTHER PART INTO THIS PORT AS TRAUMATIC AMPUTATION MAY RESULT.**

Full Release

Another subtle defect which can lead to an erroneous push rod stroke measurement results from defective or improperly installed automatic slack adjusters. The actuating mechanism and adjusting linkage for automatic slack adjusters, when defective or improperly installed, can restrict full retraction of the service brake push rod. This, again, can result in a push rod stroke measurement which is within the prescribed adjustment limits, when, in fact, the air chamber is near or at full stroke. Failure of an air chamber to fully retract in the released position can also result from weak return springs or inadequately lubricated foundation brake components, such as the slack adjuster and cam shafts. The inspector should manually push against the slack adjuster with the heel of his/her hand or foot when the brakes are fully released to ensure full retraction of the push rod in the service brake chamber. When conducting this portion of the examination, **KEEP FINGERS AND EXTREMITIES CLEAR OF MOVING PARTS. USE OF THE HEEL OF THE PALM OF THE HAND OR A PUSH BY THE INSPECTOR'S FOOT AGAINST THE SLACK ADJUSTER WITH PROPER SAFETY SHOES WILL ALLOW THIS EXAMINATION.**

Summary

Proper methodologies and ensuring adequate air pressure during the inspection of heavy commercial vehicle air brake systems by both motor carrier inspectors and mechanics will ensure a higher degree of accuracy when conducting these inspections and subsequent required maintenance procedures. Further simple methodologies which ensure full retraction of an air chamber push rod prior to measuring push rod strokes also will lend to more accurate measurements, as well as identification of needed lubrication and maintenance to these components. Since my participation in the 1990-1992 "Heavy Vehicle Airbrake Performance" Safety Study a standard part of motor carrier inspection and accident reconstruction training at Texas A & M University, Texas Engineering Extension Service, has included student exercises where commercial vehicle air brake systems are tested by students at monitored air pressures of 30, 60, and 90 psi. A random sampling of recorded test results from previous classes is attached to allow the reader an appreciation for the significance of utilizing proper inspection methodology.

PUSH ROD STROKES AT 30, 60, 90 PSI

10-79 Freightliner Conventional Cab
4-76 Custom Trailers, Inc. Tanker Semi-Trailer
Test Date 2/23/95

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
16	1	24/32	1 5/32	1 12/32	29/32	1 8/32	1 16/32
30/30	2	1 2/32	1 4/32	1 16/32	1 2/32	1 4/32	1 9/32
30/30	3	30/32	1 4/32	1 8/32	1 1/32	1 2/32	1 9/32
30/30	4	1 2/32	1 24/32	2”	1”	1 4/32	1 8/32
30/30	5	28/32	1 10/32	1 16/32	31/32	1 12/32	1 18/32

1994 Freightliner Cabover
1979 Strick Van Semi-trailer
Test Date 2/23/95

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
20	1	1 8/32	1 18/32	1 22/32	1 4/32	1 12/32	1 16/32
30/30	2	29/32	1 4/32	1 6/32	20/32	1 7/32	1 8/32
30	3	23/32	30/32	1 1/32	22/32	30/32	1 1/32
30/30	4	2 16/32	2 16/32	2 16/32	2 24/32	2 24/32	1 8/32
30/30	5	2”	2 8/32	2 10/32	2 7/32	2 13/32	2 14/32

1989 White GMC Conventional
1978 Strick Box Van - Semi Trailer
Test Date 5/25/95

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
20	1	1 12/32	1 20/32	1 27/32	1 18/32	1 28/32	2 2/32
30/30	2	24/32	1 4/32	1 11/32	30/32	1 4/32	1 9/32
30	3	21/32	1”	1 5/32	21/32	1 1/32	1 8/32
30/30	4	26/32	1 26/32	2 2/32	31/32	1 10/32	1 2/32
30/30	5	1 4/32	1 12/32	1 22/32	1”	1 16/32	1 24/32

PUSH ROD STROKES AT 30, 60, 90 PSI

8100 6 x 4 International Conventional Cab
11/89 Lufkin Van Semi-Trailer
Test Date 8/24/95

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
20	1	24/32	1”	1 12/32	24/32	1	1 12/32
30/30	2	1	1 8/32	1 12/32	1	1 8/32	1 24/32
30	3	20/32	28/32	1 4/32	1”	1 12/32	1 16/32
30	4	1 2/32	1 8/32	1 24/32	1 2/32	1 8/32	1 24/32
30/30	5	1 4/32	1 8/32	1 16/32	1 4/32	1 8/32	1 16/32

90 Ford F800 Dump
Test Date 11/10/94

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
20	1	23/32	29/32	1 1/32	22/32	29/32	1 2/32
30/30	2	26/32	1 2/32	1 8/32	26/32	1 2/32	1 8/32

90 Volvo-GM Conventional
Load Craft Bush Hog Drop Deck Semi-Trailer
Test Date 11/10/04

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
T-12	1	1 1/32	1 6/32	1 10/32	25/32	1 3/32	1 16/32
30/30	2	1 3/32	1 16/32	1 21/32	1 5/32	1 9/32	1 16/32
30	3	1 8/32	1 4/32	1 22/32	1 16/32	1 14/32	1 20/32
30/30	4	1 21/32	2 2/32	2 4/32	1 24/32	2 3/32	2 8/32
30/30	5	1 25/32	2 6/32	2 10/32	1 24/32	2 3/32	2 8/32

DATA FROM
SCARS CONFERENCE JULY 23, 2007
CHARLESTON, SC

03/07 Freightliner Columbia w/ABS brakes
08/97 HEIL Fuel Tanker Semi Trailer
Test Date 07/23/07

CHAMBER TYPE	AXLE	L 30 PSI	L 60PSI	L 90PSI	R 30PSI	R 60PSI	R 90PSI
T-20 5.5" ABA	1	7/8"	1 1/8"	1 ¼"	7/8"	1 1/8"	1 ¼"
30/30 5.5" ABA	2	1 1/8"	1 ½"	1 9/16"	1"	1 3/8"	1 ½"
30 5.5" ABA	3	1 1/8"	1 3/8"	1 ½"	1 1/8"	1 ¼'	1 3/8""
30/30 5.5" ABA	4	1 1/4"'	1 3/8"	1 7/8"	1"	1 ¼"	1 5/8"
30/30 5.5" ABA	5	1 5/8"	1 ¾"	2 1/8"	1 1/8"	1 ¼"	1 ½"

October 22, 2014
Ontario Provincial Police
CMV Forensics Course
Baire, Ontario Canada

2012 Freightliner (manufactured 05/2011) Model 15X15485
Odometer 595575.8 km
GVRW 63500

S Cam brakes

(in inches)	Slack Adjustors	Brake Type	30PSI	60PSI	90PSI
FL	Auto	24L	1 1/4	1 3/8	1 ½
FR	Auto	24L	1 7/8	2 1/4	2 3/8
2nd axle left	Auto	30L	1 1/2	1 3/4	2
2nd axle right	Auto	30L	1 3/8	1 5/8	1 7/8
3rd axle left	Auto	30L	1 1/4	1 3/8	1 7/8
3rd axle right	Auto	30L	1	1 1/4	1 1/2