

# Commercial Motor Vehicle Air Brake Failure Analysis



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**Highway Collision Research & Reconstruction**



*Stopper & Associate's Federal Motor Carrier Safety  
Administration (FMCSA) Approved  
Portable Performance Based Brake Tester (PBBT)  
-Widely used in Europe to test truck brakes-*



# PBBT testing of motor coach brakes involved in fatal rollover crash





# Abstract

- Air brake equipped heavy trucks, trailers and buses manufactured since late 1994 were originally equipped with self adjusting brakes.
- Many commercial motor vehicle (CMV) drivers believe there is little need to thoroughly inspect self adjusting air brakes
- Still others are in the habit of manually adjusting these brakes, which in some cases can actually damage the mechanisms and can lead to loss in brake efficiency or brake failure.



# FMVSS - 121

- Air braked vehicles subject to Federal Motor Vehicle Safety Standard (FMVSS) 49 CFR §571.121 and Commercial Motor Vehicles (CMV) subject to Federal Motor Carrier Safety Regulation (FMCSR) 49 CFR §393.53(b),(c), manufactured after October 20, 1994 are required to be equipped automatic brake adjusters

# Code of Federal Regulations

- FMVSS:

- 49 CFR 571.121  
S5.1.8 applies to trucks, buses and truck tractors

- 49 CFR 571.121  
S5.2.2 while identical, applies to trailers

- FMCSR

- 49 CFR 393.53  
Automatic brake adjusters and brake adjustment indicators.

- 49 CFR 393.55  
Antilock brake systems



# Effective Dates

- 49 CFR 393.53 - Automatic Brake Adjusters for CMVs manufactured on or after 10/20/94.
- 49 CFR 393.55 – Antilock Brakes for truck tractors manufactured on or after 3/1/97
- 49 CFR 393.55 – Antilock Brakes for CMV trucks, buses & trailers manufactured on or after 3/1/98
- ABA (term used in the FMVSS) also commonly called ASA – Automatic Slack Adjuster

# TRACTOR TRAILER vs SCHOOL BUS MULTIPLE FATALITY INVOLVING MULTIPLE BRAKE FAILURES

## Case Study

National Transportation Safety Board,  
*Collision Between Truck-Tractor Semitrailer  
and School Bus Near Mountainburg, AR on  
May 31, 2001*, NTSB/HAR-02/03; PB2002-  
916203; Adopted September 4, 2002.

&

*Stopper & Associates Investigation*



NTSB/HAR-02003  
PR2002-010303

Highway Accident Report

**Collision Between Truck-Tractor  
Semitrailer and School Bus  
Near Mountainburg, Arkansas  
on May 31, 2001**

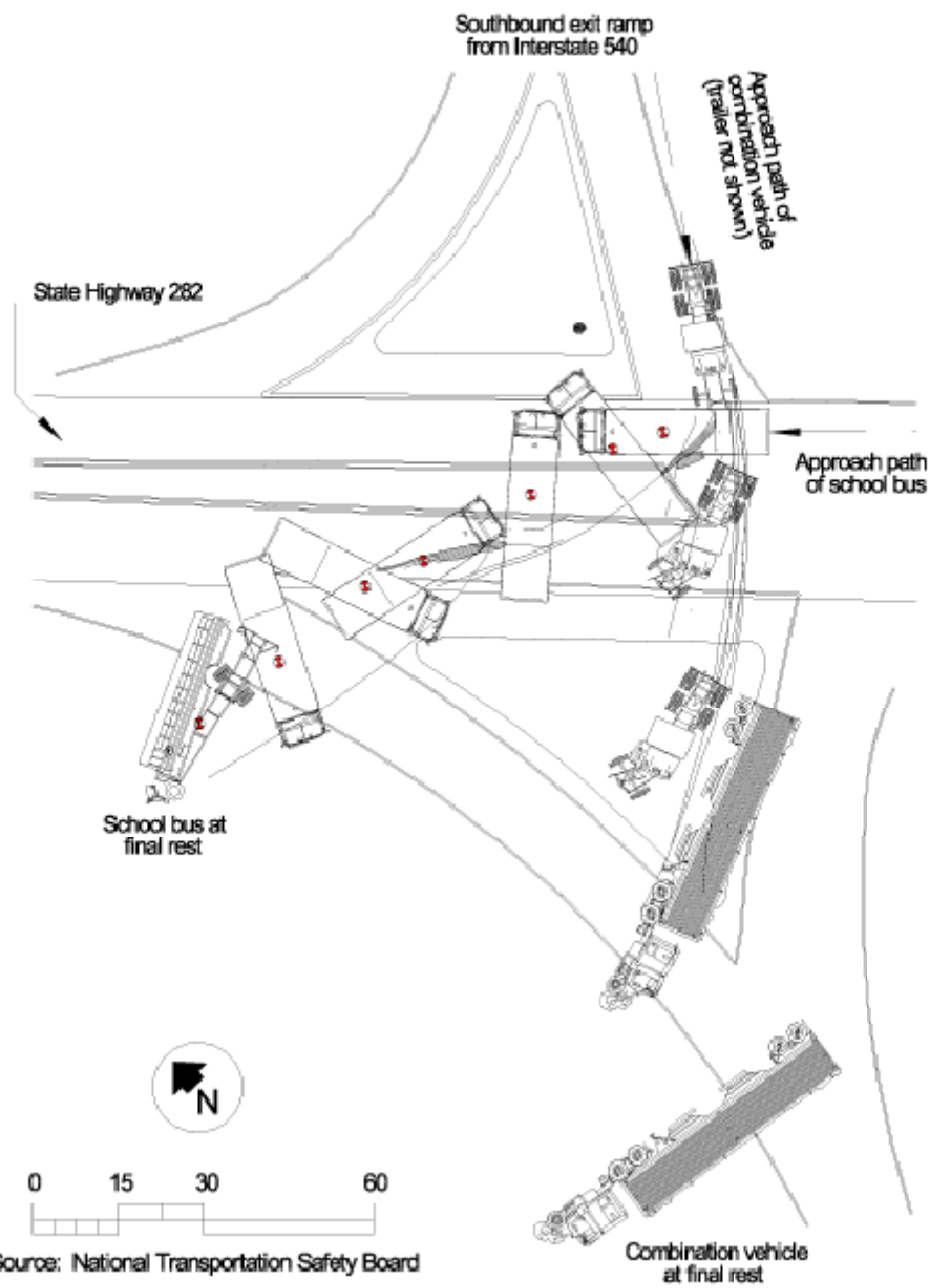


**National  
Transportation  
Safety Board**  
Washington, D.C.

## Executive Summary

On May 31, 2001, about 3:28 p.m. central daylight time, a southbound Gayle Stuart Trucking, Inc., truck-tractor semitrailer exited Interstate 540 at State Highway 282 near Mountainburg, Arkansas. The driver was unable to stop at the stop sign at the bottom of the ramp. The 79,040-pound combination unit was traveling approximately 48 mph when it entered the intersection and collided with the right side of a westbound, 65-passenger, 1990 Blue Bird Corporation school bus operated by the Mountainburg, Arkansas, Public Schools. The school bus rotated approximately 300 degrees clockwise and overturned; the body, which partially separated from the chassis, came to rest on its right side on the eastbound shoulder of State Highway 282. The tractor semitrailer continued across the roadway, rotated about 60 degrees clockwise, overturned, and came to rest on its left side.





Source: National Transportation Safety Board



**Figure 3.** Tractor semitrailer, postaccident.



**Figure 4.** School bus, postaccident.

ICAO INJURY LEGEND		
N	=	None
M	=	Minor
S	=	Serious
F	=	Fatal
F	=	FEMALE
M	=	MALE
#	=	AGE
International Civil Aviation Organization		
SAMPLE		
INJURY LEVEL	AGE	GENDER
		F - 14: Minor
Source: NTSB		

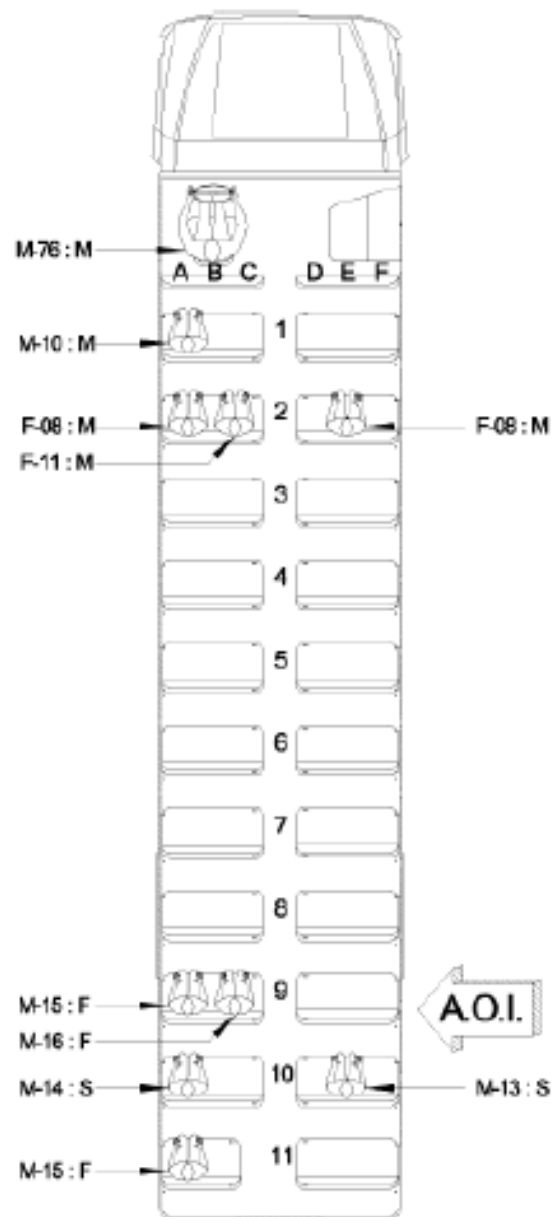


Figure 5. Mountainburg school bus seating chart.





# 8 of 10 brakes found defective

Table 4. Brake adjustment.

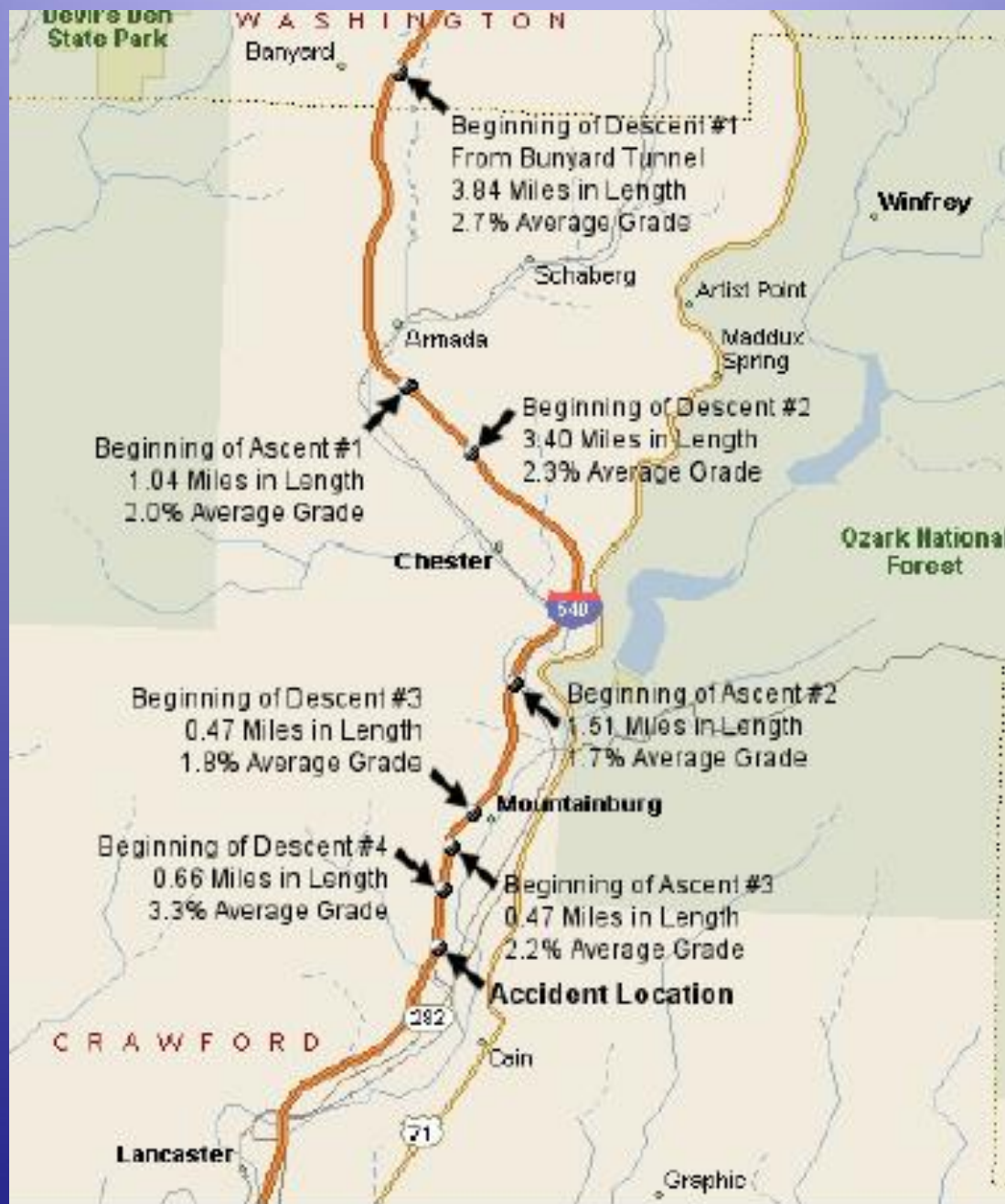
AXLE	MAXIMUM STROKE ALLOWED*	MEASURED STROKE	NOTES
1 Left (tractor)	1 3/4 inches	2 1/8 inches**	
1 Right (tractor)	1 3/4 inches	2 3/8 inches**	
2 Left (tractor)	2 inches	2 3/8 inches**	
2 Right (tractor)	2 inches	2 1/4 inches**	
3 Left (tractor)	2 inches	1 7/8 inches**	Parking/emergency brake spring broken, restricting pushrod travel; no dust cover
3 Right (tractor)	2 inches	2 1/2 inches**	No dust cover
4 Left (trailer)	2 inches	1 1/2 inches	Parking/emergency brake spring broken; no dust cover
4 Right (trailer)	2 inches	1 3/4 inches**	Incorrectly installed brake chamber
5 Left (trailer)	2 inches	1 inch**	Parking/emergency brake spring broken, restricting pushrod travel; no dust cover
5 Right (trailer)	2 inches	1 1/2 inches	

\* Manufacturers' recommended maximum adjustment length.

\*\* Out of adjustment or not functioning properly.

# Why brakes failed at this location?

- Air brakes, when heated due to repeated applications, can also cause bottoming out, resulting in loss of braking capability
- Heated brake drums expand, thereby increasing the distance that the brake shoes must move so that the lining contacts the drum
- S-cam must be rotated farther, requiring an extra, or reserve, pushrod stroke



# Brake failure

- Driver was familiar with area
- Brakes had sufficient brake force so long as not subjected to long, multiple brake applications
- Last 12 miles before crash; long steep grades
- Brake drum temperature estimated at 900+ degrees



# Type 30/30 brake chamber with Meritor ABA

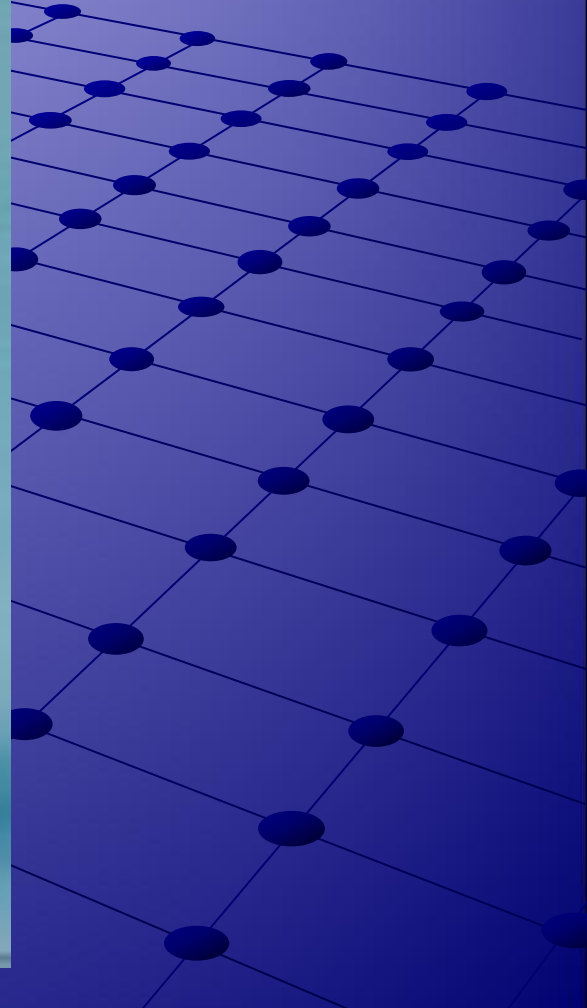
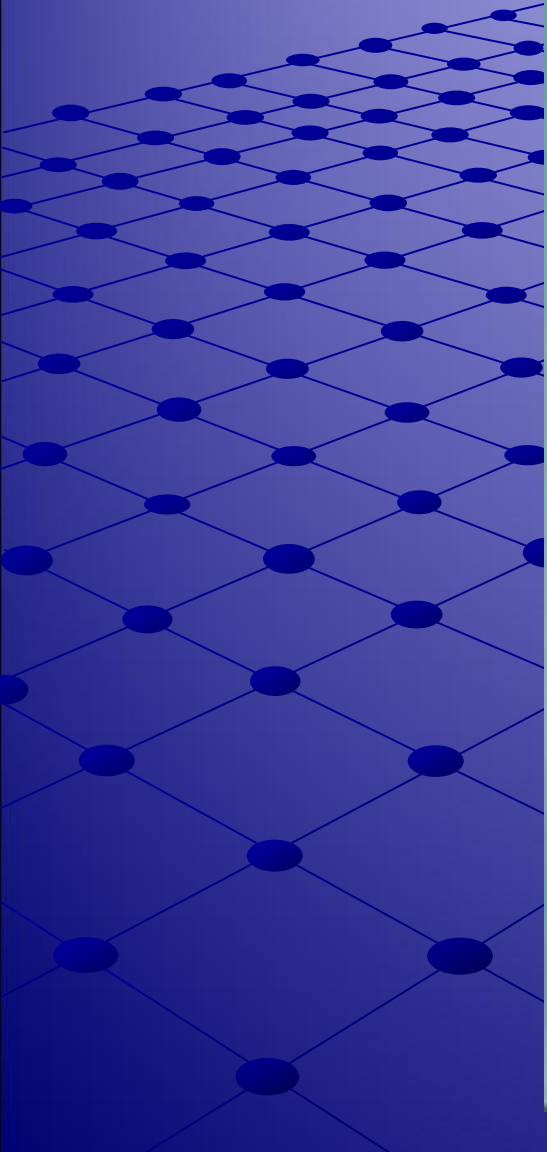
(Note: Central Tools™ “Wheels On” brake drum gauge)



# AVAILABLE TECHNOLOGY TO ALERT DRIVER OF BAD BRAKE ADJUSTMENT:

## Crewson-Brunner ASA

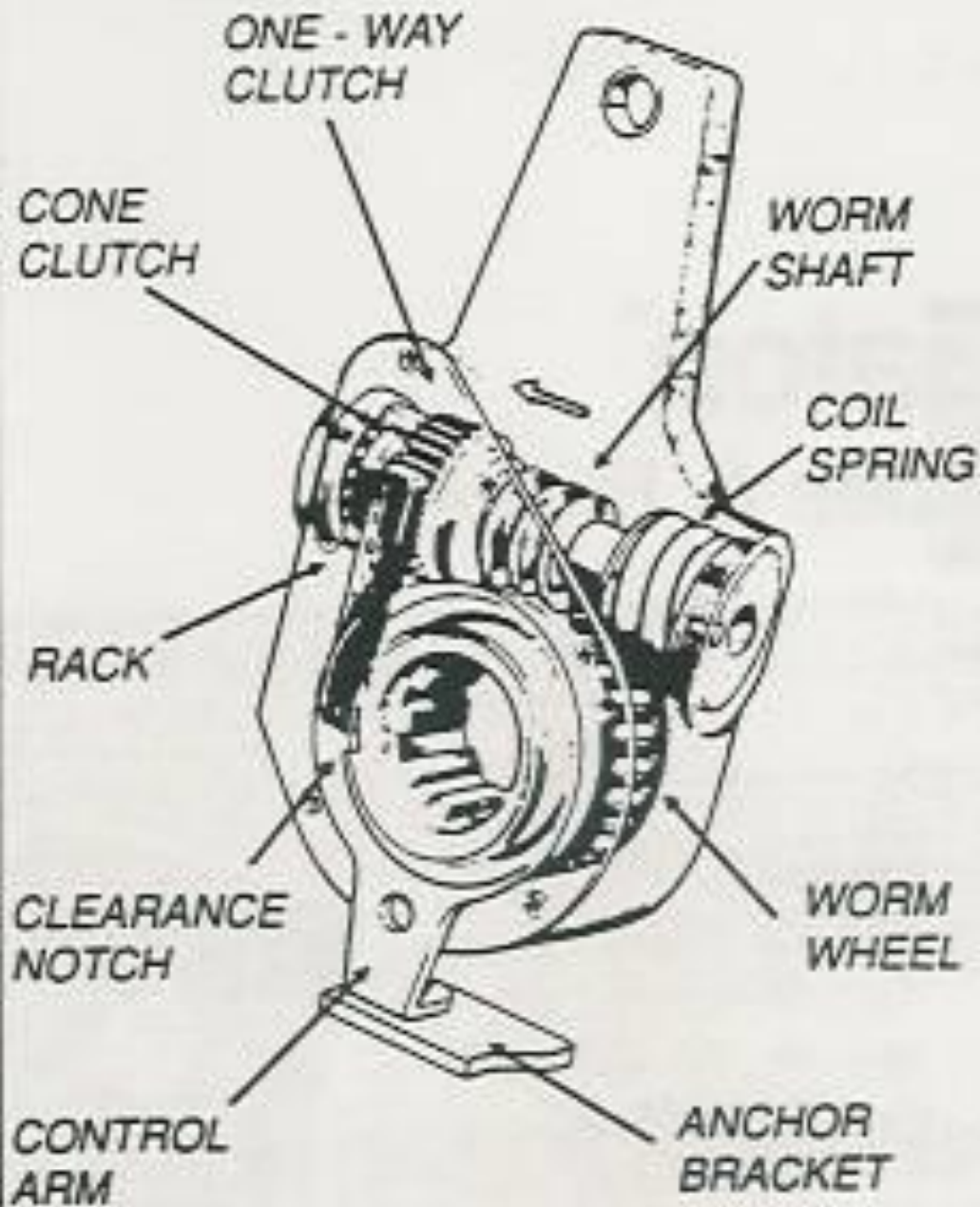
- The Crewson-Brunner ABA has incorporated a unique permanently mounted template which easily allows a driver to evaluate brake adjustment.



# Haldex S-ABA

- The second ASA design unique to the Haldex S-ABA™ (Self Setting Automatic Brake Adjuster) utilizes an anchor bracket.
- The anchor arm is then attached to a fixed point by a bracket typically attached to the axle, brake spider or to a mounting bolt of the air brake chamber





# Example of defective Haldex ABA

- Adjusting link (Anchor bracket) has worn through
- Clevis pin bushing worn out – Excessive play
- NTSB has reported finding Haldex ABA backing off adjustment when anchor bracket is loose.
- Result of poor maintenance

- WORN ADJUSTING LINK:





# Adjusting Link Geometry

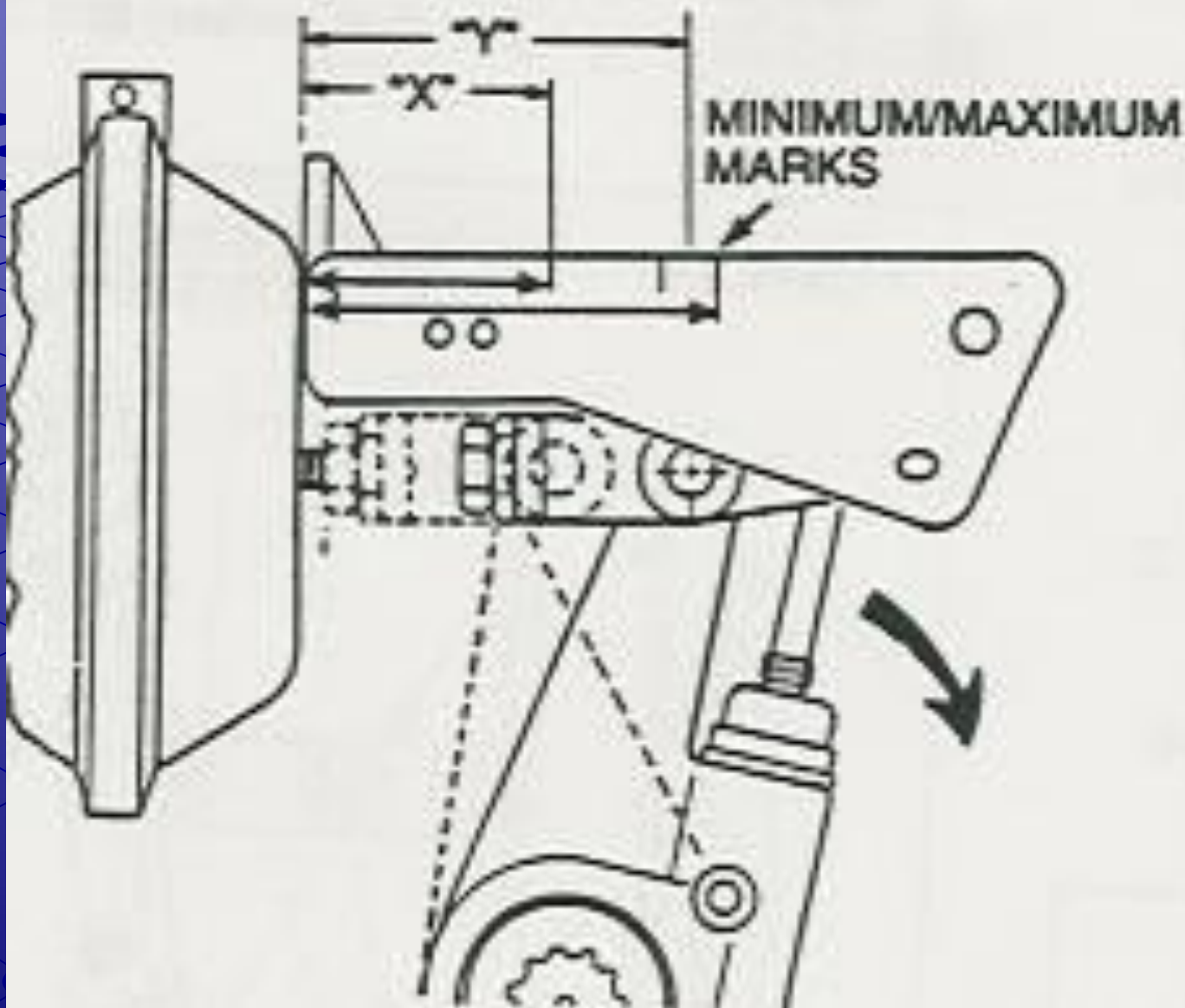
- The geometry, more commonly referred to as installation angle, is critical to proper function of ASAs equipped with a pushrod clevis actuated adjusting link.
- The angle created by the three center points between the cam shaft, clevis pin and adjusting link clevis pin are critical
- The ASA must be checked with a template supplied by the manufacturer.



**INSTALL BOTH  
CLEVIS PINS**



# MEASURE "FREE STROKE" WITH TEMPLATE



# Proper ASA for the Air Chamber?

- Meritor (formerly Rockwell) uses a color coding system
- The nylon strap tie that secures the rubber boot is a different color for various air chamber “Type” sizes.
- color coded nylon strap has been eliminated however the “color” is still referenced

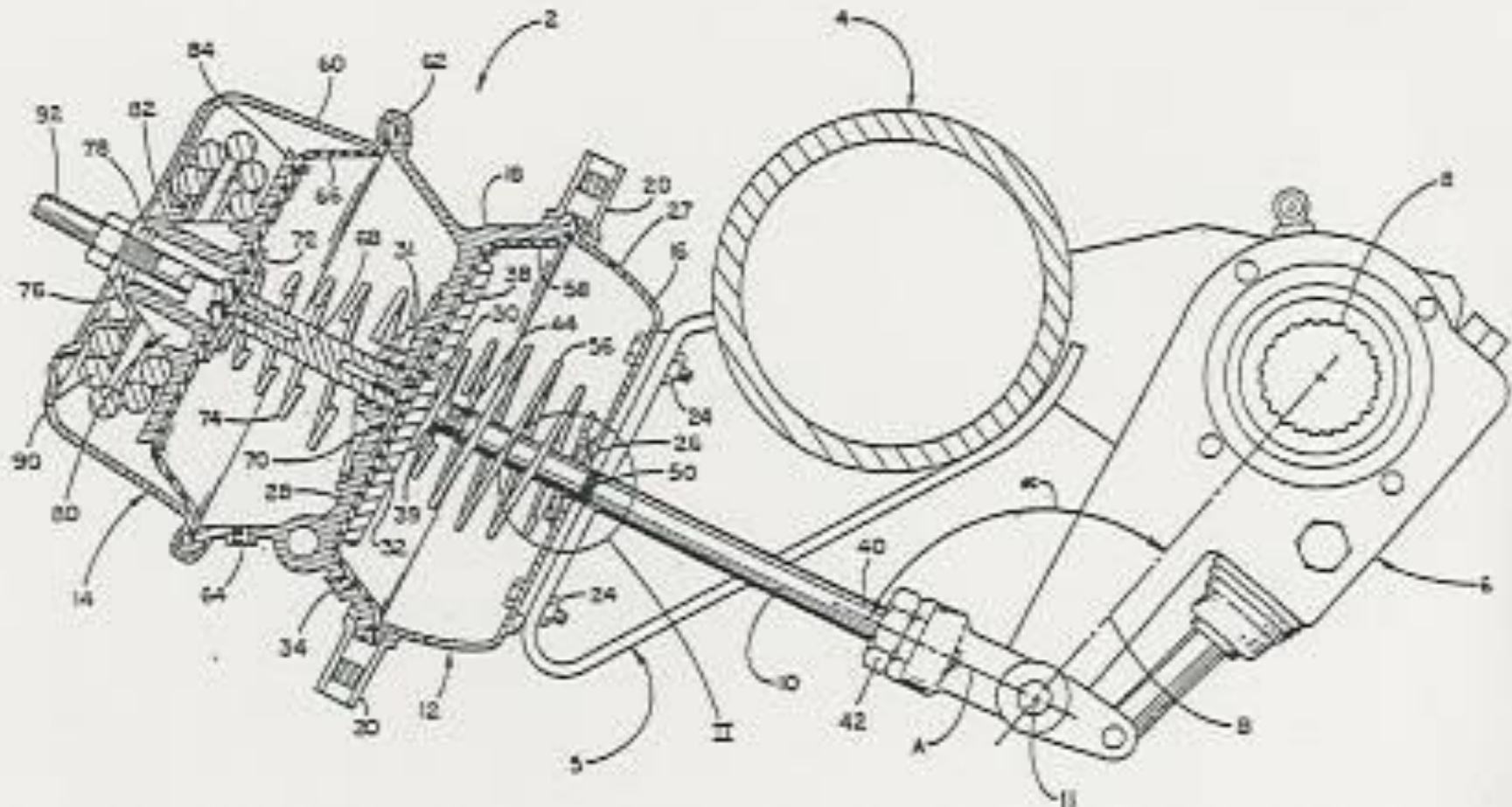
- Meritor ABA Identification



# Push Rod Length

- New air brake chambers generally are provided with a 12 inch push rod which must be cut to proper length
- If cut too short, when the slack adjuster it may contact axle components
- This prevents the ASA from completing a full apply to release cycle and will not allow proper automatic adjustment.



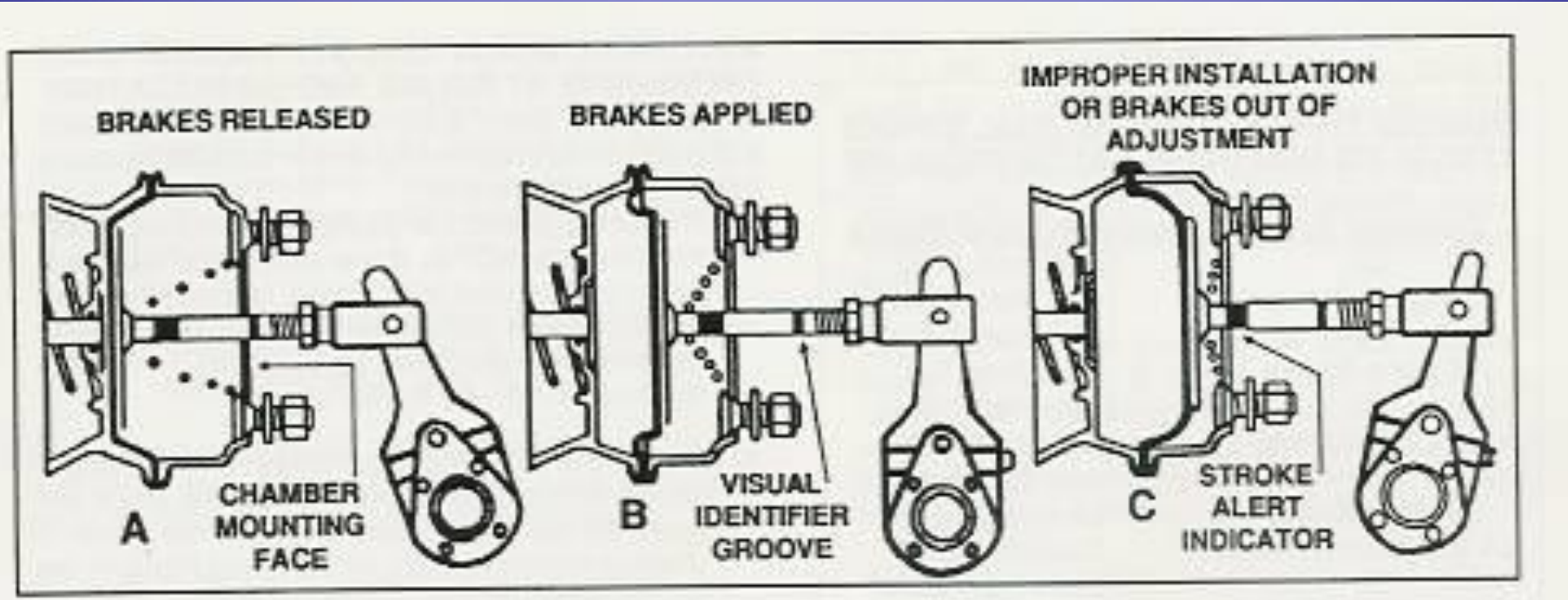


# Mountainburg, AR fatality case

## NTSB wrote:

- *“During the post accident inspection, investigators discovered that the angle between the pushrod and the slack arm on brake 4R (semitrailer left leading axle) was greater than the 90 degrees that specifications allowed. When measured against a slack adjuster template, the pushrod was about 1 inch shorter than the pushrod on the left side of the trailer, causing the greater angle. According to the manufacturer, the automatic slack adjuster was bottoming out, thus preventing full release of the pushrod and preventing the brakes from automatically adjusting. The 4R brake drum was rusty and the brake did not appear to be functioning.”*

# Brake adjustment indicator







# Defective Air Brake Chambers

- Often overlooked and difficult to diagnose are worn out air brake chambers.
- Most inspections of air brake chambers only involve a check for leaking air diaphragms and connecting air hoses
- Air Chambers should also be checked for defective power springs (spring brake)



# Mountainburg, Arkansas in 2001 NTSB “Factual Information” report

- *“The parking/emergency brake spring was found to be in three pieces when brake disassembled. After a manual caging bolt was installed, the chamber retracted an additional 5/8 inch, indicating that the broken spring was preventing full pushrod release. The spring was fractured in such a way that it prevented full return of the pushrod; thus, the automatic slack adjuster did not have the minimum 1½ inches of stroke necessary to activate the adjusting mechanism.”*

# Disassembly of Type spring brake chamber – **WARNING!**

- Inspection of a service-spring brake chamber suspected of a fractured power spring requires great care
- Disassembly should NEVER be attempted except by a professional equipped with a proper compression press
- Failure to do so could result in SERIOUS INJURY OR DEATH



# FRACTURED PARKING BRAKE POWER SPRING

**Reference: Mountainburg, AR 31MAY2001 NTSB/HAR-02/03 PB2002-916203**

WORN OR DEFECTIVE SLACK ADJUSTERS MAY NOT FULLY RETRACT

- **FRACTURED SPRING BRAKES CAN PREVENT FULL RETRACTION**
- **AUTO BRAKE ADJUSTERS (ABAs) WON'T SELF ADJUST IF PUSH ROD IS NOT FULLY RETRACTING**



# NTSB reported:

- *“A broken spring, which is difficult to detect, can reduce emergency-parking brake forces or render the emergency-parking brake inoperable, and the broken spring pieces can be displaced, thus shortening the pushrod stroke or preventing the automatic slack adjuster from functioning. The extent of the broken spring problem is undetermined.*”

# Undetected brake defects

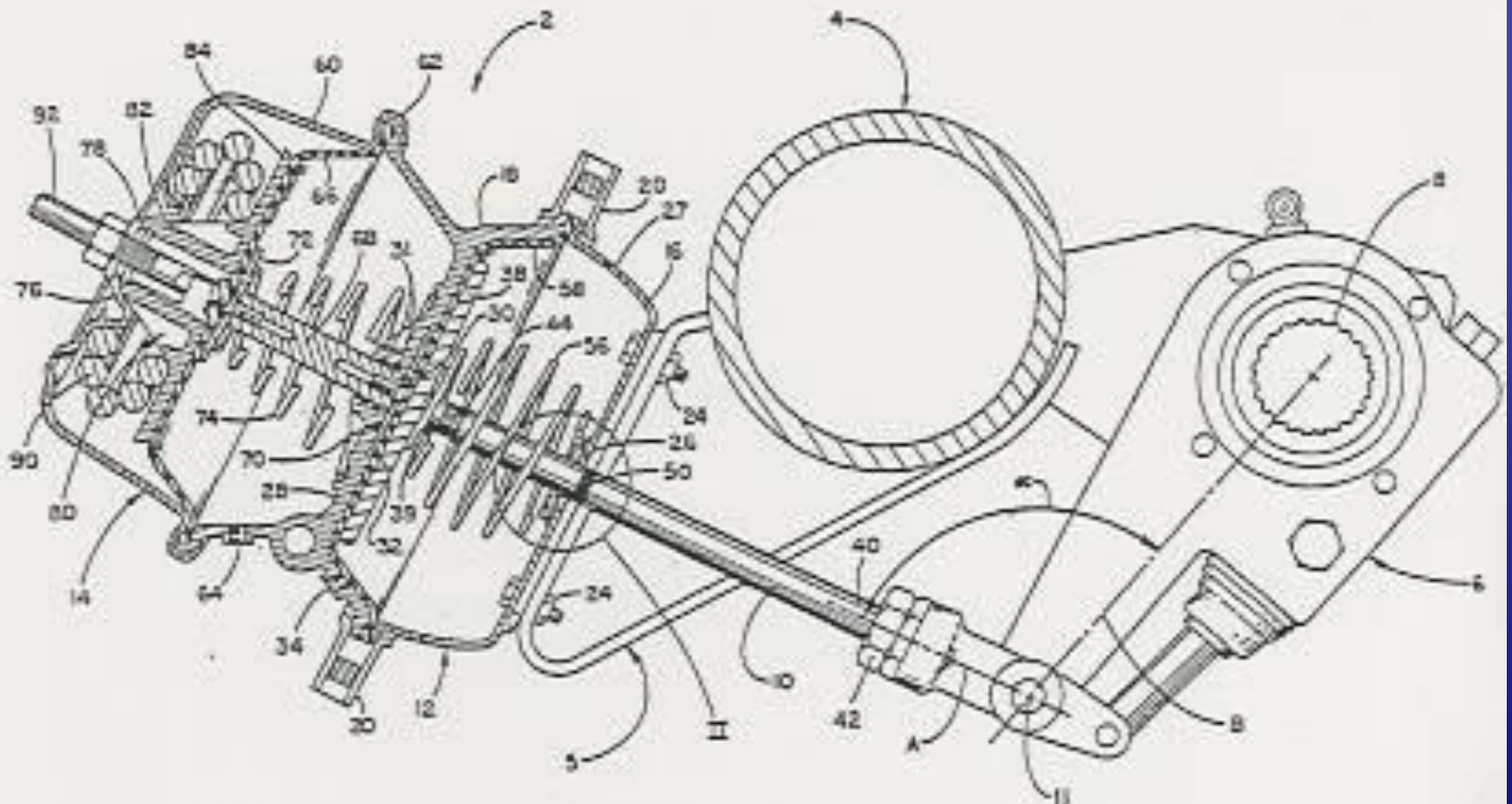
- *“Radlinski and Associates, a brake consulting firm, reported to investigators that in an inspection of 11 five-axle combination trucks at a large firm with an excellent maintenance program, an inspector found an average of two broken spring brakes on each tractor semitrailer.”*
- This defect could allow an air brake vehicle to operate with seriously compromised brakes that appear to be correctly adjusted

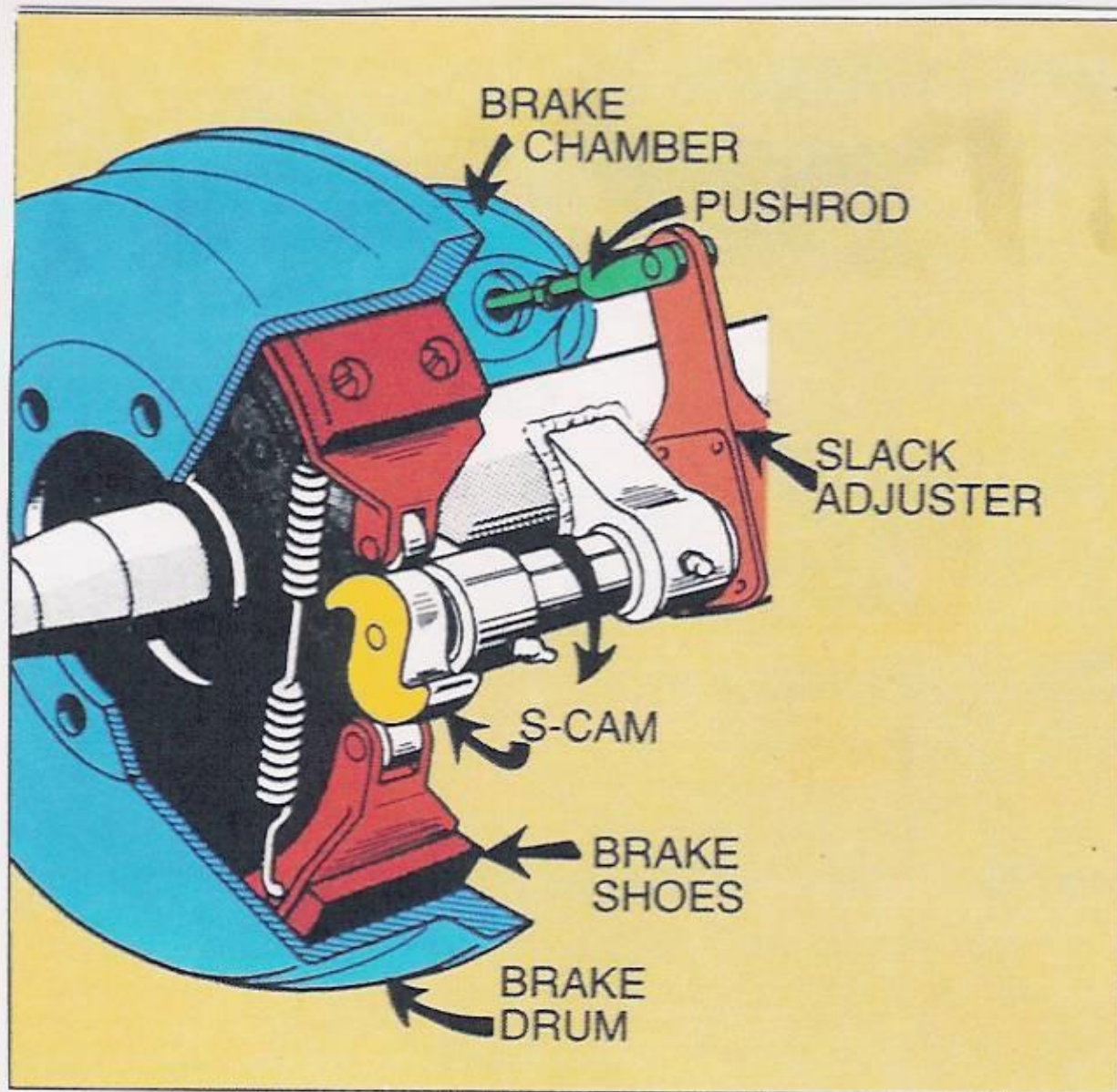


# Weak Return Springs

- Both service and service/spring air brake chambers are equipped with return springs to retract the push rod and slack adjuster to its fully released position.
- ASAs must return to the fully retracted position to adjust
- return spring needs a minimum of 32 pounds of spring force







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





Internal adjusting mechanisms are sensitive to excessive dirt /moisture

- Worn rubber boots, protecting internal parts must be inspected





# Manual Adjustment of an ABA

- Drivers and mechanics often insist on manually adjusting ABAs
- Meritor ABA adjusting pawl, can be damaged by manual adjustment.
- Meritor (formerly Rockwell) ABA “Pawl” must be disengaged during manual adjustment

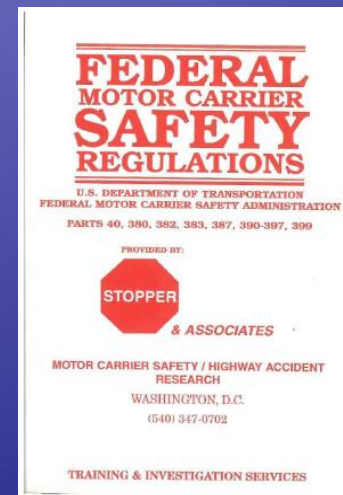
# Damaged Pawl



# Other manufacturers of ABAs use a variety of clutch spring assemblies

- Excessive manual adjustment can cause clutch springs to weaken and fail to maintain adjustment
- To test the clutch spring, a torque wrench must be used to test the hold position of the manual adjustment nut.
- These vary between manufacturers (consult service manuals)

# South Carolina I-20 Darlington, I-26 Scales, Summerville CMV Brake Research Project September 13-18, 2010





COMMERCIAL MOTOR VEHICLE (CMV)  
COLLISION INVESTIGATION DATA  
COLLECTION

**AIR BRAKE RESEARCH PROJECT**

STUDY TO COMPARE 1989-1991  
NTSB DATA TO CURRENT CMV  
BRAKES - 20 YEARS LATER

National Transportation Safety  
Board, *Heavy Air brake*

*Performance- Safety Study,*  
*(NTSB/SS - 92/01)*

**STOPPER & ASSOCIATES**

**PARTICIPATED IN 1989-1991 NTSB  
DATA COLLECTION & STUDY**



# SPECIALLY TRAINED TEAM FROM SOUTH CAROLINA LAW ENFORCEMENT OFFICERS, SC Transport Police with STOPPER & ASSOC.



# CHECKED BRAKE DRUMS & BRAKE SHOES









# CHECKED ABS LIGHTS & "CHUB TEST"



# PRELIMINARY RESULTS

● 303 - FIVE  
AXLE  
TRACTOR  
TRAILERS  
INSPECTED  
IN 4 DAYS



# 19% DECLARED “OUT OF SERVICE” FOR ALL TYPES OF BRAKE DEFECTS





# 16% of the 19% “OUT OF SERVICE” FOR POOR BRAKE ADJUSTMENT





# 94% EQUIPPED WITH AUTOMATIC BRAKE ADJUSTERS



1.3% TRUCK TRACTORS WITH AIR DISC BRAKES  
(0% SEMI TRAILERS)

NEW AIR BRAKE TRUCKS – MFG. AFTER  
August 1, 2011 - 30% SHORTER STOP DISTANCE  
REQUIREMENT (FMVSS 121)





# ANTI LOCK AIR BRAKE SYSTEMS WELL ESTABLISHED (REQUIRED SINCE 97'-98 MODELS)

Few drivers knew how to check proper abs function

Disconnected ABS cable to relay valve – DEFECT:



# Conclusions

- It has become apparent there is a general lack of knowledge and training as to the critical nature of proper installation, lubrication as well as daily and periodic inspection of air brakes, a critical safety device.



# Conclusion

- It is very important that collision investigators and CMV maintenance personnel be well trained and become familiar with the operation and critical factors that can render air brakes weak or inoperative leading to diminished brake force and/or brake failure.

# For more information on investigations or training:

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