Brake Safety on the Road

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Committee on Truck and Bus Safety
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What I'll talk about …

- Brake Sensors Mini-FOT
- Other Field Studies:
  - PBBTs at roadside
  - In-service assessment of CMV braking capability
  - Smart Infrared Inspection System
- Bench Testing of SABAs
- Brake Adjuster Education/Outreach

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Purpose and Objectives

- How do systems perform? How reliable, durable, maintainable?
- Do systems influence maintenance practices?
- What are costs and benefits?
  - Maintenance costs
  - Component life
  - Vehicle performance and safety

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Fleet Characteristics

- Washington Metro Area Transit Authority
  - Four Mile Run facility
- Orion VII urban transit buses, MY 2005
  - 12 test and 12 control vehicles
- 300 sq mi service area in Arlington, VA
- Average travel 129 mi/day
- Average travel speed 16 mph
- Over 800,000 vehicle miles traveled during 12 months of data collection

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Brake Sensors

- Commercially-available stroke monitors using Hall-effect sensors (2 makes)
- Strain gauged anchor pins (1 make)
- All are retrofittable to in-service vehicles
- All provide an in-cab display
- Data collected, devices checked weekly
- Buses tested monthly on a PBBT

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Results: Brake Deficiencies

- 69 “unsafe brake conditions” identified
  - 50 were confirmed faults
  - 19 were false-positives (no visual validation)
- Only 1 complete sensor failure
  - But other sensor faults due to wiring harness connections and loose sensors

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Results: Brake Troubleshooting

- Both types of Hall-effect sensors identified a "dragging brake" condition on all buses
- Misalignment found between pushrod and slack adjuster
- Bus OEM resolved the situation
- *Without this data, situation could have gone undetected for months!*

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Results: Technician Feedback

- Prognostics helped technicians quantify and reduce driver brake performance complaints
- WMATA and study team worked with suppliers to minimize system false positives and improve reliability
- *Improved details on brake performance allowed WMATA to drop a "hand-on" 3,000-mile brake PM inspection.*

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Role of PBBTs

- What a PBBT can do: Provide a rapid, objective and consistent measure of vehicle braking performance, irrespective of brake type, energy supply, or actuation method.

- What a PBBT cannot do: Replace inspector's skill in finding brake defects unrelated to immediate brake performance, such as air leaks, chafed hoses, or thin brake pads.

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Use of PBBTs: Roadside Inspection

- Out-of-Service Criteria: Failing to develop a total brake force as a percentage of gross vehicle or combination weight of 43.5 or more on an approved PBBT.
- In the United States, an approved PBBT must meet the FMCSA functional specifications (65 FR 48799, August 9, 2000)

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CMV Field Based Brake Wear and Performance Test

- Test site: Greene County, TN CMV inspection facility
- Vehicles selected from traffic stream
  - Inspector-selected subset of vehicles directed to cross the permanent scale
  - Level I brake-related inspection results and companion PBBT inspections
- February – November 2008: 647 trucks (5,642 wheel ends) tested

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Comparison: PBBT Results and Brake System Violations

	Pass PBBT	Fail PBBT
Pass NAS Level I	**57.3 %**	**10.4 %**
Fail NAS Level I	**20.9 %**	**11.4 %**

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Status

- Field data collection continues
- Long-term fleet vehicle data collection underway
- PBBT informational brochure and training video updated

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In-service Assessment of CMV Braking Capability

- Q: Do CMVs still meet the 20 mph stopping distance test that 49 CFR 393.52 requires?
- A: We need to do some testing … the last field tests were done in 1983.

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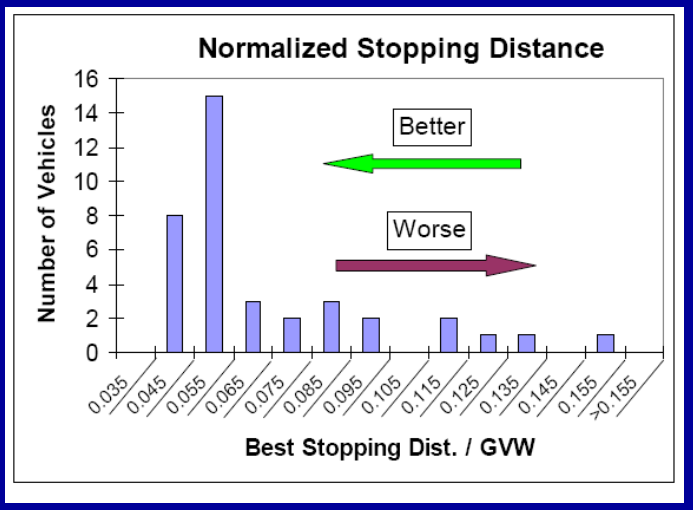
Results from first 38 vehicles …



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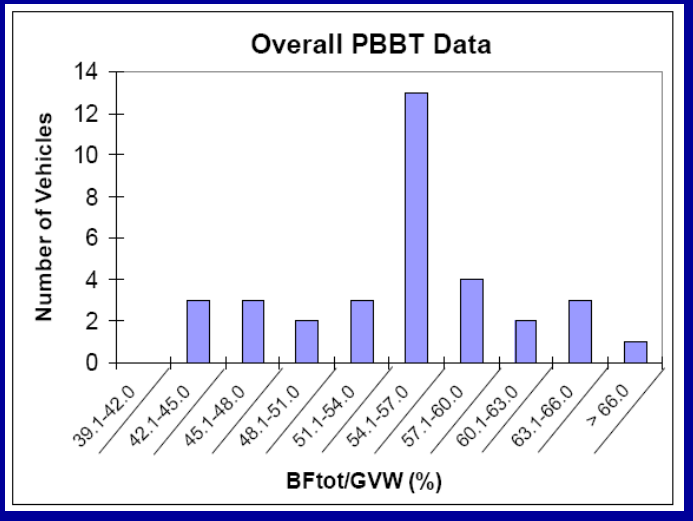
More results from first 38 vehicles …



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Smart Infrared Inspection System

- Sponsored by FMCSA
- Period of performance: September 2006 - October 2009
- Current activity:
  - Ongoing update and testing of algorithms for automatic isolation of regions of interest
  - Preliminary definition of possible "rules" to include in SIRIS software
  - Hardware modifications (faster setup, improved detectors, higher-res color camera, etc.)
  - Deployed 3 systems in field
  - Defined statistical parameters for analysis

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Some "rules" being considered

- Non/low functioning brakes
  - Every wheel should have brake heat
- Grabbing or dragging brakes
  - Brakes should not be "super hot"
- Overloaded, broken suspension, underinflated tire
  - Tire sidewall should be "cool"
- Tire rubbing
  - Tire tread should be "cool"
- Tire tread separation
  - Tire tread temperature should be uniform
- Ungreased axle bearing or missing bearing cap
  - Axle bearing cap should not be "super hot"

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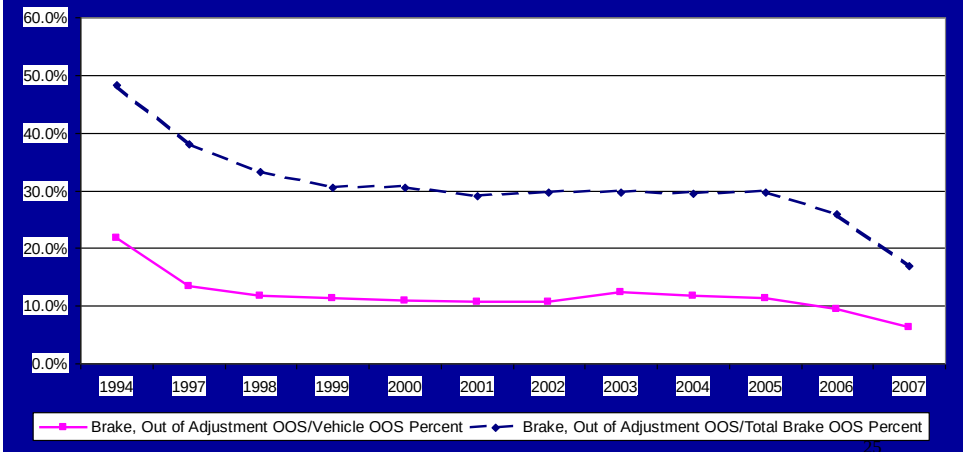
Roadside Inspections: Brake Adjustment OOS Violations



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Current Practices related to SABAs

- E-mail survey to CVSA Associate Members and TMC members
  - Current practice on air brake maintenance
  - Awareness of proper procedures/warnings
- Key results:
  - Many respondents are routinely adjusting SABAs (as if they are manual brake adjusters)
  - More than half did not believe adjusting SABAs was a dangerous practice
  - More than 60 percent were not aware of <u>any</u> warnings against manually re-adjusting SABAs

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CVSA-sponsored study: What happens when SABAs are manually adjusted?

- Typical SABA adjustment procedure:
  - Rotate adjusting nut clockwise until brake pads come in contact with drums
  - Back adjusting nut off, counter-clockwise (CCW) ½ turn

When rotating the adjusting nut CCW, internal mechanisms are subject to high forces

  - Wear and potential damage can occur
  - One type can be irreparably damaged with a single adjustment, if the manufacturer's warning and adjustment procedures are not followed

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What happens to SABAs when manually adjusted?

Method: 5 popular OEM SABAs were purchased off-the-shelf

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Experiment

- SABAs were randomly selected and designated "A" through "E". *
  - Purpose was not to say Brand "X" is better than Brand "Y"
  - Purpose was to quantify what happens to an ABA when manually adjusted, and
  - How much adjustment can a typical SABA tolerate before it ceases to function properly?

* - Please don't ask, because I don't know which is which

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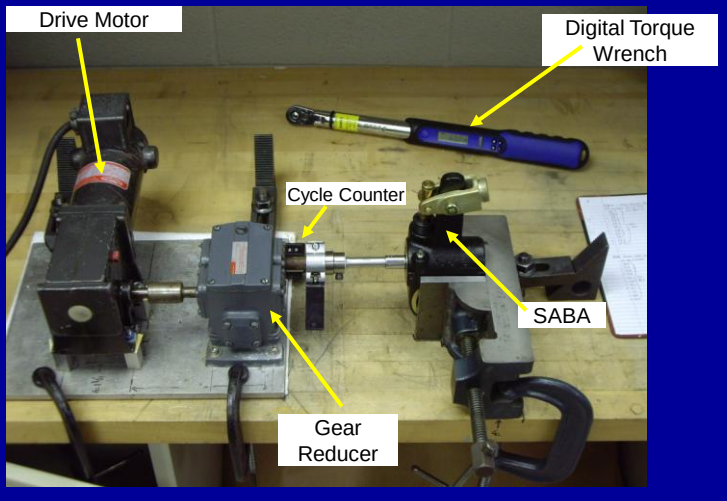
Bench-Top Setup



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Procedure

- Rotate adjustment nut CCW, periodically measure torque
- Compare measured torque to manufacturer's recommended minimum for proper operation
- Test duration: Assume "lifetime" of a vehicle is 10 years
  - Vehicle is driven 300 days per year
  - Adjustment made every time it is driven (150 CCW cycles per year)
  - Total of 1500 CCW revolutions in vehicle lifetime

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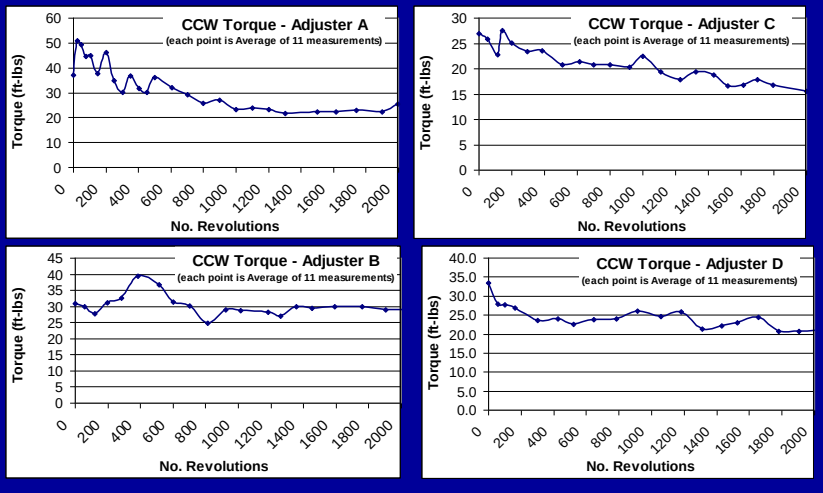
Nearly all SABAs lose torque after some amount of manual adjustment



Note: "E" was not tested because single rotation without releasing pawl causes immediate destruction. Releasing pawl causes no decrease in torque.

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What does this mean?

- *Tests are preliminary*
- Planning similar testing on aftermarket and "knockoff" SABAs
- Also planning to test using a complete wheel end assembly to more accurately assess interplay of all components (pending availability of resources).

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DRIVERS: Do Your Brakes Measure Up? How to Check Adjustment of S-cam Air Brakes with Clamp-Type Chambers

⚠ WARNING: SELF-ADJUSTING BRAKE ADJUSTERS SHOULD NOT REQUIRE IN-SERVICE READJUSTMENT. SEE BACK OF CARD FOR ADDITIONAL INFORMATION.

⚠ WARNING: ONLY USE THIS CHECKLIST IF YOU ARE TRAINED AND AUTHORIZED TO CHECK BRAKE ADJUSTMENT!

SET-UP PROCEDURES

1. Park vehicle on level ground. Put wheel chocks in place. Wait until brakes are cool to the touch. Determine the chamber types.

2. Start engine to build air reservoir pressure.

3. Release spring-type parking brakes and all service brakes.

4. Turn off engine when both air reservoir pressure gauges reach 90-100 psi (620-690 kPa). Place transmission in low gear.

5. Push against the pushrod with your hand to ensure that it is fully retracted into the brake chamber. Repeat at each wheel end.

6. If your brakes have moveable stroke indicators, set them (some slide, others need a special tool). If not, mark the pushrod with chalk or other marking device where it exits the brake chamber. If the chamber is not accessible, mark the pushrod where it aligns with the chamber mounting bracket (reference surface). Repeat at each wheel end.

You can check brake adjustment of S-cam brakes using the applied stroke method or free stroke method. The applied stroke method is more reliable.

APPLIED STROKE METHOD

7A. Make a full brake application with air reservoir pressure gauges at 90-100 psi (620-690 kPa).
(a) Ask an assistant to completely depress the brake pedal, or
(b) Use a prop to hold the brake pedal fully applied, or
(c) Activate a dash-mounted brake valve actuator.

8A. With the brake fully applied, tap the side of the brake drum with a small hammer. You should hear a dull "clunking" sound. *If you hear a "ringing" sound, the brake lining is not against the drum. Have the brake inspected immediately by a certified brake technician.* Repeat at each wheel end.

9A. Use a ruler to measure the applied stroke, which is the distance from the chalk mark on the pushrod to where it exits the brake chamber (or the reference surface used in Step 6). Repeat at each wheel end.

10A. Is the measured pushrod stroke at or greater than the maximum adjustment limit for the chamber type (see side 2 of card)? OR, do you see a red or orange colored band on the pushrod (excessive stroke indicator) when the brake is fully applied? If yes, write it down. Have the brake inspected immediately by a certified brake technician to determine if repairs are needed.

FREE STROKE METHOD

Drivers: If you must check your brakes without assistance, you can use the free stroke method with a pry bar.

7B. Attach a pry bar and pull hard on the brake adjuster arm. Repeat at each wheel end.

8B. With the pry bar pulling on the brake adjuster, tap the side of the brake drum with a small hammer. You should hear a dull "clunking" sound. *If you hear a "ringing" sound, the brake lining is not against the drum. Have the brake inspected immediately by a certified brake technician.* Repeat at each wheel end.

9B. Use a ruler to measure the free stroke, which is the distance from the chalk mark on the pushrod to where it exits the brake chamber (or the reference surface used in Step 6). Repeat at each wheel end.

10B. Is the free stroke more than 5/8 inch* (16mm*) for a self-adjusting brake adjuster or more than 1/2 inch* (13mm*) for a manual brake adjuster? If yes, write it down. Have the brake inspected immediately by a certified brake technician to determine if repairs are needed. (*Refer to your vehicle owner's manual for specific limits.)

MAXIMUM ADJUSTMENT LIMITS FOR S-CAM AIR BRAKES WITH CLAMP-TYPE CHAMBERS

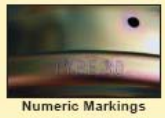
Using the applied stroke method, 90-100 psi (620-690 kPa) reservoir pressure

CHAMBER TYPE (Size)

You can determine the type (or size) of brake chamber 3 ways:
1. Use a special tool,
2. Look for the word "TYPE" followed by a number (e.g., 9, 12, 18, 20, 24, 30, 36) on the clamp or body of the brake chamber, or
3. Ask a certified brake technician.

NOTE: Although clamp-type is the most common brake chamber, there are others. Check with a certified brake technician if you are uncertain about the style, type and maximum applied stroke of brake chambers installed on your vehicle.

Special Tool



Numeric Markings

STANDARD Stroke Brake Chambers

Standard stroke brake chambers generally have:
- ROUND ports,
- NO SPECIAL TAG or service instructions embossed on flange case.

TYPE	*Brake Adjustment Limit @ 90-100 psi*
9	1-3/8 inches (35 mm)
12	1-3/8 inches (35 mm)
16	1-3/4 inches (45 mm)
20	1-3/4 inches (45 mm)
24	1-3/4 inches (45 mm)
30	2.0 inches (51 mm)
36	2-1/4 inches (57 mm)

LONG Stroke Brake Chambers

Look for one of the following three features. They generally distinguish a long stroke brake chamber from a standard stroke brake chamber (SAE J1817):

1. Raised SQUARE port on spring brake chamber (NOTE: used on Type 24" and Type 30L chambers ONLY) or Raised SQUARE embossment (service brake chamber)
2. TRAPEZOID-shaped tag
3. INSTRUCTIONS EMBOSSED on flange case (Example: "Use only 3 inch long stroke diaphragm")

TYPE	*Brake Adjustment Limit @ 90-100 psi*
12L	1-3/4 inches (45 mm)
16L	2.0 inches (51 mm)
20L	2.0 inches (51 mm)
24L	2.0 inches (51 mm)
24" For 3" maximum stroke Type 24 chambers	2-1/2 inches (64 mm)
30L	2-1/2 inches (64 mm)

⚠ WARNING: ONLY USE THIS CHECKLIST IF YOU ARE TRAINED AND AUTHORIZED TO CHECK BRAKE ADJUSTMENT!

⚠ WARNING: Self-adjusting brake adjusters should only need manual readjustments when they are first installed and when brakes are relined. Only perform a "temporary" roadside manual re-adjustment to safely drive the vehicle directly to a certified shop for troubleshooting and repair.

⚠ REMEMBER: Brake adjustment problems could be caused by the adjuster; the chamber; the foundation brake; or other parts of the brake system.

⚠ REMEMBER: Manually re-adjusting a self-adjusting brake adjuster does not fix the problem; will not keep the brake in adjustment; can contribute to abnormal wear of the internal adjusting mechanism; and could cause the brake to fail.

U.S. Department of Transportation

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Thank you very much!

- For further information, contact
  - Luke Loy, luke.loy@dot.gov
  - Debbie Freund, deborah.freund@dot.gov

- Thanks for the photos:
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  - Oak Ridge National Labs

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