Commercial Vehicle Lifecycle Brake Performance: How It Impacts Roadway Safety

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Agenda

- Key Safety Decision Points
  - Air Disc Brake vs. Drum Brake
  - Aftermarket Safety Impacts
- Vehicle Brake Performance (Lifecycle)

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Vehicle Stopping Power

- 80k GCWR stopping from 60-0 mph

Stopping Power Calculation

- Nearly 75%
  - Normal Deceleration • 5ft/s² or .15g
  - Hard Deceleration • 10ft/s² or .3g
(2) Key Decision Points Impacting Safety

(1) Brake Specification (New Vehicles)

(2) Aftermarket Components (Existing Vehicles)

- Downhill Descents
- Collision Mitigation Systems
- Stop-Go Traffic
- Automated Driving

Warning: Heavy Traffic Ahead!
1) Vehicle Specification Impact on Safety

- **Date of Manufacture:** All Vehicles meet FMVSS-121
  - Meet Reduced Stopping Distance (RSD) – Tractor units since 2013 (Ph-2)
    - 250 feet (at 60mph)

- **Vehicles brake specifications vary**
  - Tractor / Truck
  - Trailer

- **Brake Performance (varies)**

- **Driver Familiarity (varies)**
  (not married to vehicle)

- Again …. All meets current regulation requirements … At Manufacture
Brake System Choices

Front Steer Axle Brakes
- RSD Drum Brakes
- Air Disc Brakes

Rear Drive Axle Brakes
- RSD Drum Brakes
- Air Disc Brakes

Trailer Brakes
- Either Combination
  - Drum Brakes
  - Air Disc Brakes

(A)¹
- RSD Drum Brakes
  - Delete Credit

(B)¹
- Air Disc Brakes

(C)¹,²
- Air Disc Brakes

Either Combination
- (X) Drum Brakes
- (Y) Air Disc Brakes

(1) - Brake Combination(s) meets FMVSS-121 Requirements
(2) - Standard Spec. on (4 of 6) Major Truck OEMs
Air Disc Brakes (Lower Total Cost of Ownership)

- **1.5x Longer Pad Life**
  - Fleet opportunity to eliminate a friction change

- **Lower Maintenance Cost**
  - 1/4th Friction change time of Drum

- **Eliminates Rust Jacking**

- **Improves CSA scores**
  - Out-of-Service as result of Brakes out of Adjustment

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Payback that overcomes Delete Credits!!
Brake Performance Differences (Brake Steer)

- **Brake Steer**
  - Torque imbalance across the axle

- **Torque imbalances produce:**
  - Steer at steer axle
  - Yaw (pull) at the drive axles

- **Air Disc Brakes virtually eliminate brake steer conditions**

- **Providing Smoother / Straighter / Safer Stops**
Brake Performance Differences (Stopping Distance)

- Higher speeds generate longer stopping distances
- Not linear !!!
- Kinetic Energy = \( \frac{1}{2} \cdot \text{mass} \cdot \text{velocity}^2 \)
- Energy dissipated as heat
What combination is behind you ???”

Gross combination weights for all vehicles totaled 80,000 lbs. Both tractor and trailer brakes were applied. Source: 2017 Independent vehicle testing
Brake Performance Differences (Brake Fade)

- Multiple and/or Harder brake stops generate more heat
- Heat dissipates into brake system mass
  - Drum: Friction, Brake Shoes, Drum, etc.
  - ADB: Friction, Pads, Rotor, etc.
- Brake System Designs differ:
  - Drums expand away from friction
    - Produces **Longer** stopping distances
    - Inconsistent brake performance (to driver)
  - ADB rotors expand towards friction
    - (Maintains **Consistent** stopping distances)
Brake Fade Impacts (Drum vs. ADB)

- All Drum Tractor/Trailer (Mint Green)
- All ADB Tractor/Trailer (Silver)
- Equal GCW's (approx. 64,000 lbs.)
ADB vs. Drum Brake Stopping Distance Comparison

Drum Brake Fade Impact on Stopping Distance

Now 70’ Difference
4.5 Car Lengths
1st Drum Stop

Calculated Est. Impact Velocity (mph)
33.6
29.8
25.4
20.1
12.7

Calculated Impact Force Ratio:
7.0
5.5
4.0
2.5
1.0
2) Aftermarket Components Impact on Safety

- **Typical considerations made when replacing friction:**
  - What Geometry / FMSI?
  - Inventory availability
  - 6x4 Pricing
    - Non-RSD ($300)
    - RSD ($400)

- **Brake Performance (increased variation):**
  - Brake performance will vary / Wider scope of friction choices
  - Non-RSD Friction: RSD stopping distance **(Non-Compliant)**
  - RSD Friction: **(Compliant)** additionally more fade resistant

- **Driver Familiarity**
  - Are they married to vehicle?

- **What performance requirements does the AM follow?**
2) Aftermarket Components Impact on Safety

- **AM Perceptions:**
  - Non-RSD AM replacement shoes are acceptable replacements
    - Regardless if they are RSD manufactured tractors
  - RSD ONLY applies to OEM manufactures
  - DO NOT understand FMCSA 393.40(b)(2)

  - **FMCSA 393.40(b)(2)**
    - Air brake systems. Buses, trucks and truck-tractors equipped with air brake systems and manufactured on or after March 1, 1975, and trailers manufactured on or after January 1, 1975, must, at a minimum, have a service brake system that meets the requirements of FMVSS No. 121 in effect on the date of manufacture.
    - Identification? / Enforcement?

- **Pre-Trade-In / Post Trade-In:**
  - 50% Min. Lining Requirement: Fleet replaces w/ low cost friction
  - Traded-As-Is: Dealer may replace with low cost friction
2) Aftermarket Components Impact on Safety

Impacts to non-RSD choices
- Longer Stopping Distances
- Non-Compliance to FMCSA
- Accident Liability

Brake Performance Diminishes:
- As soon as 1st Owner replaces friction
- Continued Cycle for vehicle life
- 2nd, 3rd, etc. Owners unaware

Vehicle Life-Cycle of Degrading Brake Performance:
1. 1st Owner Buys RSD Vehicle
2. 1st Owner Relines w/ non RSD
3. Dealer Buy-Backs (non-RSD)
4. 2nd Owner gets non-RSD
5. 2nd Owner replaces what’s on vehicle (non-RSD)

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OEM RSD vs. Typical AM Non-RSD Performance

- Conducted FMVSS-121 Stopping Distance Test

- Configurations:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Front Axle</th>
<th>Drive Axles</th>
<th>GCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM Friction (5.5”)</td>
<td>13,440 lbs.</td>
<td>39,620 lbs.</td>
<td>47,504 lbs.</td>
</tr>
<tr>
<td>AM Non-RSD Friction (5.5”)</td>
<td>13,340 lbs.</td>
<td>39,820 lbs.</td>
<td>47,502 lbs.</td>
</tr>
</tbody>
</table>

- Transportation Research Center (TRC) in Ohio
  - 4-Mile Skid Pad
  - 8 Minute Cycle Times
OEM RSD vs. Typical AM Non-RSD Performance

High Speed Full Deceleration (60mph)

Ave. 235’
Range 230’ - 241’
(Compliant)

Ave. 300’
Range: 287’ - 310’
(Non-Compliant)

Ave. 65’ Difference

OEM RSD
Brake Friction

AM Non-RSD
Brake Friction
OEM RSD vs. Typical AM Non-RSD Performance

High Speed Full Deceleration (70mph)

Ave. 414’ Range: 387’ - 444’

Ave. 51’ Difference

Ave. 465’
Range: 449’ - 482’

OEM RSD Brake Friction

AM Non-RSD Brake Friction
Similar Safety Impact in AM (even with ADB)

- Industry Perceptions about Air Disc Brakes:
  - Stop Shorter
  - Eliminate Brake Fade
  - Eliminate Brake Steer
  - Require Less Maintenance

- ONLY if replaced with “Like-for-Like” in the AM
  - Due to rigorous testing

- ADB Aftermarket at risk of following current AM drum friction practices
  - Pressure to reduce ADB AM costs
  - AM Components in most cases DO NOT follow same test protocol
Similar Safety Impact in AM (even with ADB)

**AM Pad Stopping Distance:**

- Genuine OEM Replacement Pads maintain the original OE performance
- Other AM Pad choices can increase stopping distance by **over 50 feet**.
- Industry perception is … **ADB stops shorter !!!!**

Source: 2015 Bendix testing. Stopping distances are simulated based on FMVSS-121 Hot Stop and Recovery Dynamometer Simulation.
Similar Safety Impact in AM (even with ADB)

**AM Pad Park Capability:**

- Genuine OEM replacement pads: Exceed the FMVSS-121 park requirement
- Typical AM replacement pads: May demonstrate a reduced park-hold capability
- Risk: Roll-Away

Exceeds by 18\%
Diminished Vehicle Brake Performance Trend (Lifecycle)

**Lifecycle Brake Performance (Year of Service)**

- **1st Owner**
  - Compliant: 28%
  - Non-Compliant: 22.8%

- **2nd Owner**
  - Compliant: 10.1%

- **3rd Owner**
  - Non-Compliant: 39.1%

**Roughly 2/3 will be Non-Compliant**
Summary

(2) Key Decision Points that define vehicle brake safety

- Vehicle Specifications
  - Brake Steer vs. Non-Brake Steer effect
  - Stopping Distance Delta (Cold): 20-25 feet
  - Brake Fade Impact to Stopping Distance (Hot): (add’l 50 feet)
  - While Compliant / Maybe be up to 70 feet different / Less Consistent (affecting CMS)

- Friction Replacement in the AM (not replacing “Like-for-Like”):
  - Stopping Distances increase: (by up to 80 feet) / Saved $100
  - Increased Brake Fade / Inconsistent Stopping Distances
  - Reduced Park-Hold / Risk of Roll-Aways

Lifecycle Brake Performance trending across the Industry

- Stopping Distances could vary anywhere from 200’ to 355’
- Incrementally increase with speed and heat
Thank you !!

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