SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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Brake Force Distribution Test Procedure - Trucks and Buses

RATIONALE

New stopping distance regulations will require a shift in brake force distribution. In addition, new types of brakes such as air disc have different pressure onset and torque output characteristics that can effect low pressure brake force distribution. This procedure therefore will become a more important tool for measuring and comparing brake force distribution on trucks and buses. Experience with the original procedure has shown that test organizations using it would benefit from changes in data recording and safety procedures.

1. SCOPE

This SAE Recommended Practice provides the test procedure and instructions for air braked single unit trucks, buses, and combination vehicles. It also provides recommendations for:

a. Instrumentation and equipment

b. Vehicle preparation

c. Calculating distribution of brake force

1.1 Purpose

This procedure provides a method to determine the brake force distribution and threshold pressures for trucks and buses with a GVWR greater than 4536 kg (10 000 lb).

Other equipment and procedures could be used to determine approximate relative work or energy being absorbed by a vehicle's brakes. A "performance based brake tester" can determine low pressure/low speed torques of different brakes. A "temperature/thermal balance" can show relative temperatures of brakes, thus indicating approximate energy absorbed.

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http://www.sae.org/technical/standards/J1505_201107

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J225 Brake Force Distribution Field Test Procedure for Truck and Bus (field test procedure)

SAE J1626 Braking, Stability, and Control Performance Test Procedures for Air- and Hydraulic-Brake Equipped Trucks, Truck-Tractors and Buses

SAE J1854 Brake Force Distribution Performance Guide—Truck and Bus

SAE J2115 Air Brake Performance and Wear Test Code Commercial Vehicle Inertia Dynamometer

2.2 Related Publication

The following publication is provided for information purposes only and is not a required part of this SAE Technical Report.

2.2.1 FMVSS Publication

Available from The Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

FMVSS (Federal Motor Vehicle Safety Standard) 121 Air Brake Systems

3. INSTRUMENTATION, EQUIPMENT, AND FACILITIES

3.1 Each vehicle should be equipped with:

3.1.1 A speed measuring device capable of measuring vehicle speed to within ±0.32 km/h (±0.2 mph).

3.1.2 A means of measuring time to within ±0.1 s between two speeds such as a strip chart recorder or digital timer that receives a signal from the speed measuring device.

3.1.3 Two pressure transducers and a recording device accurate to within 3.5 kPa (±0.5 psi). Note, pressure sensors should be calibrated daily to insure accuracy at low pressures.

3.1.4 Brake lining thermocouples as per SAE J2115 and a suitable temperature readout device accurate to within ±11 °C (±20 °F). If brake lining thermocouples are not used, a contact pyrometer or other method may be used to ensure that adequate cooling time is provided between tests to ensure that brake heating and fade do not contaminate results.

3.1.5 Valving to allow brakes on each axle or axle set to be operated, controlled, and evaluated independently. Valving must not disturb the inherent pressure differentials in the vehicle brake system and provide driver override capability.

3.1.6 An external application system (see Figure 1) that can apply the braking system with a constant input is recommended. (Use of the driver's foot to apply the brakes may increase variation in the test results). This system must be designed, installed, and utilized in such a way as to take into account the inherent pressure differentials in the vehicle brake system.

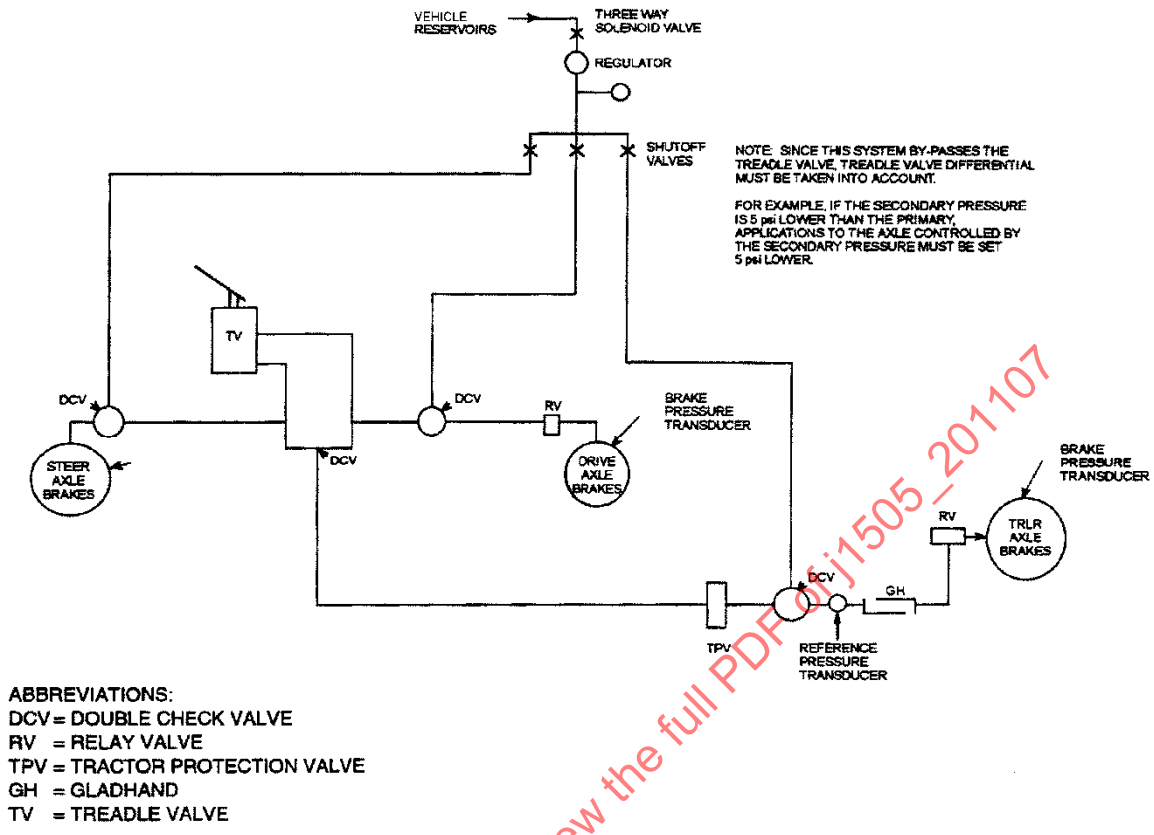

FIGURE 1 - EXTERNAL SYSTEM FOR BRAKE APPLICATION

3.1.7 A system such as a treadle stop may be used provided that the brakes are applied at a controlled rate so as to minimize pressure overshoot during the brake application. Caution must be exercised when applying the brakes on individual axles during partial system testing. The stopping ability of the vehicle will be reduced.

3.1.8 Measure and record ambient temperature and wind conditions, including wind speed and direction.

3.1.9 Test should be run on a straight 3.6 m (12-ft) wide roadway with a dry Portland cement concrete or equivalent surface to reduce the likelihood of wheel lock-up. The vehicle shall be aligned with the center of the roadway at the beginning of each stop. The roadway should be dry and flat with no more than a 1% grade in all directions, including crown. Due to reduced stopping ability of the vehicle, the roadway should either be part of a circular path, or must contain sufficient run-out area, so in event of unanticipated braking force reduction or equipment failure, the vehicle has sufficient track length to coast to a stop.

4. VEHICLE INFORMATION AND DATA

4.1 Vehicle information sheet (Figure 2) to be filled in prior to starting test.

4.2 Test data sheet (Figure 3) to be used as a work sheet during testing.

4.3 Vehicle information and test data sheets may be used for or extended to single unit trucks, buses, or multiple combination vehicles.

Test No.:_____ Test Date(s) – From: _____ To: _____
Test Organization: _____ Test Location: _____
Vehicle Year, Make, and Model: _____
Vehicle VIN: _____ D.O.M: _____ Wheelbase, mm (in): _____
Trailer Year, Make, and Model: _____
Trailer VIN: _____
GAWR Vehicle: Front _____ Rear _____ Trailer _____
Weight Distribution:
Vehicle: Front _____ Rear _____ Trailer _____
Trailer Axles (s) _____
Gross Total _____

BRAKES:

		Type[1]	Size	Make	Lining Make	Lining Edge Codes
Vehicle:	Front					
	Rear					
Trailer:						

BRAKE DRUM/ROTOR:

		Type[2]	Make	Weight (optional)	Dust Shields (Y/N)
Vehicle:	Front				
	Rear				
Trailer:					

ACTUATION DETAILS:

		Air Chamber Make/Model/Size	Slack Adjusters Length or Wedge Angle	Adjustment Type[3]	Adjustment Stroke @ 551 kPa (80 psi)	Cam[4] Rotation
Vehicle:	Front					
	Rear-fwd.					
	Rear-rear					
Trailer:	Front					
	Rear					

TIRES:

		PSI	Size	Type[5]	Data Book SLR mm (in)
Vehicle:	Front				
	Rear-fwd.				
	Rear-rear				
Trailer:	Front				
	Rear				

SPECIAL CONDITIONS:
Special conditions or equipment, which might affect brake performance: _____
_____
_____

(1) Cam, disc, wedge, etc.
(2) Cast or composite drum, vented or non-vented rotor, etc.
(3) Automatic, manual, etc.
(4) With or opposite forward drum rotation
(5) Single or dual, radial or bias-ply, etc.
(6) If stroke cannot be measured (disc, wedge brakes), leave section blank. Refer to manufacturer's manual to assure proper adjustment is maintained.

FIGURE 2 – VEHICLE INFORMATION SHEET

Vehicle: _____ Trailer: _____ Total Weight: _____ lb (kg)

Measured Deceleration Times, seconds:

Operational Brakes	Run #	CONTROL LINE PRESSURE, kPa (psi)						
		35 kPa (5 psi)	69 kPa (10 psi)	103 kPa (15 psi)	138 kPa (20 psi)	207 kPa (30 psi)	276 kPa (40 psi)	
Front	1							
	2							
	3							
	4							
Control Glad-hand Pressure at Trailer Brake Threshold **Increasing Pressure: LF _____ RF _____** **Decreasing Pressure: LF _____ RF _____ Overall Average _____ = Threshold** **Average: LF _____ RF _____ Pressure**								
Rear	1							
	2							
	3							
	4							
Control Glad-hand Pressure at Trailer Brake Threshold **Increasing Pressure: LF _____ RF _____ LR _____ RR _____** **Decreasing Pressure: LF _____ RF _____ LR _____ RR _____ Overall Average _____ = Threshold** **Average: LF _____ RF _____ LR _____ RR _____ Pressure**								
All	1							
	2							
	3							
	4							

Coastdown Deceleration Times (seconds):

1 -_____ 2 -_____ 3 -_____ 4 -_____

Start Odom: _____ Date: _____ Time: _____

Amb. Temp: _____ Wind Vel.: _____ Wind Dir.: _____

Finish Odom: _____ Date: _____ Time: _____

Amb. Temp: _____ Wind Vel.: _____ Wind Dir.: _____

Driver: _____ Observer: _____

FIGURE 3 - BRAKE FORCE DISTRIBUTION TEST DATA SHEET

5. VEHICLE CONDITION

Brake force distribution may be determined for any lining condition new or in service; however, to ensure the accuracy and validity of results, the following conditions should be met:

5.1 Inspect the brake lining and mating surface. Replace if abnormal conditions exist or worn beyond manufacturers recommended limits. Adjust brakes to manufacturer's specifications.

5.2 Lining to drum or disc contact should be at least 90% of contact area. If contact area is not at least 90%, burnish procedure may be continued as specified in 5.6 until contact area is at least 90%.

5.3 Inspect tires and replace if worn beyond manufacturers recommended limits or abnormal tire condition. Adjust tire pressure per vehicle manufacturer's load recommendations.

5.4 All components between the air compressor and each of the brake chambers must be functioning properly.

5.5 Initial testing each day should be preceded by a series of brake snubs which will warm the hottest brake to 93 to 149 °C (200 to 300 °F).

5.6 In order to satisfy SAE J1854 guidelines, the vehicle brakes shall be burnished prior to testing with the procedure as specified in SAE J1626 Section 11 or FMVSS 121 Section 6.1.8.

6. BRAKING DISTRIBUTION TESTS

6.1 Install and secure instrumentation and test equipment in the test vehicle. One of the pressure transducers should be installed at the axle under test, down stream of any relay, proportioning valves, ABS, or other valving; the other should be installed at the tractor to trailer, truck to trailer control glad-hand, or on the primary pressure line from the foot valve on a straight truck as the reference transducer.

The axle pressure transducer is moved from axle-to-axle as necessary and is used to ensure that brakes are fully activated (i.e., at steady-state) before data collection occurs. The reference pressure transducer is used to ensure that the desired input level is achieved. All data is related back to the reference level for braking force distribution calculations.

6.2 Weigh the test vehicle in the as-tested configuration on an axle-by-axle or axle-set basis. Weight should be distributed approximately in accordance with GAWRs (Gross Axle Weight Rating) and be sufficient to prevent wheel lock-up of one axle with respect to the others.

6.3 Determine the glad-hand (reference) pressure level at which braking starts to occur at each brake by raising the vehicle and rotating the wheel by hand while gradually increasing input to the brake system. Record the glad-hand (reference) pressure level at which the brake torque is first evident on Figure 3. Continue to increase pressure to approximately 276 kPa (40 psi) and then slowly decrease it until the point at which the brake is shown to be fully released by rotation of the wheel by hand.

Record the glad-hand (reference) pressure level at brake release on Figure 3. The average of these two recorded values is defined as the brake threshold pressure. Calculate the threshold pressure for each brake and average these values for each axle or tandem set.

6.4 Test the braking on each axle (or axle set) of the combination vehicle independently using the following procedure.

6.4.1 Bring all of the vehicles brakes to the desired initial temperature (93 to 149 °C [200 to 300 °F] hottest brake is recommended) by making snubs. Record temperature of all brakes. On subsequent snubs, control the hottest brake of the axle or axle set being tested to the same temperature as initially recorded on that brake by making snubs or cooling as necessary. Note – if different vehicle brake configurations are to be tested (valves, brakes, linings, etc.) the initial temperatures of the brakes established during the initial warm up in this section can be used as an indicator of "temperature/thermal balance" of the different configurations, and confirmation of brake force distribution changes.

6.4.2 Accelerate the vehicle to 73 km/h (45 mph), shift to neutral or de-clutch and immediately apply the brakes to the desired glad-hand (reference) pressure level. Pressure overshoot is not permitted. Ensure that a constant pressure is achieved at the test brakes before the vehicle decelerates to 64.4 km/h (40.0 mph). Continue to decelerate until the vehicle reaches 56.3 km/h (35.0 mph) and immediately release the brakes. Measure the time between 64.4 and 56.3 km/h (40.0 and 35.0 mph), i.e., delta V = 8 km/h (5 mph), average V = 60.4 km/h (37.5 mph) and record on Figure 3. Lower speed levels can be used if desired; however, the speed change measured should be maintained at 8 km/h (5 mph). Speeds above those shown should not be used as significant in-stop fade can occur due to high energy input to the brakes.

NOTE: The speeds indicated have been determined to work well on vehicles up to 36 300 kg (80 000 lb) GCW.

For vehicles greater than 36 300 kg (80 000 lb) GCW (Gross Combination Weight), speeds should be reduced to limit energy input to the braking system in accordance with Table 1:

TABLE 1 - TEST SPEEDS FOR VEHICLES GREATER THAN 36 300 kg (80 000 lb) GCW

GCW kg	GCW lb	Test Starting Speed km/h	Test Starting Speed mph	Timed Speeds Initial km/h	Timed Speeds Initial mph	Timed Speeds Final km/h	Timed Speeds Final mph
45 400	100 000	60	37	51.5	32	43.5	27
54 400	120 000	53	33	45.1	28	37.1	23
63 500	140 000	47	29	38.6	24	30.6	19

6.4.3 Repeat 6.4.1 and 6.4.2 at the same input level (at the control glad-hand) for a total of 4 runs, 2 in each direction on the same area of the roadway to allow grade effects to be averaged out. If an external application system is not used, variation resulting from use of the driver's foot may require additional runs to be made.

6.4.4 Repeat 6.4.1 to 6.4.3 for a range of glad-hand (35, 69, 103, 138, 207 and 276 kPa or 5, 10, 15, 20, 30, and 40 psi) pressure levels to cover desired operating spectrum. Terminate test run if wheel lock occurs. Because all axles must be run over the same range to calculate distribution, it is desirable to test the axle which is expected to lock at the lowest pressure first to establish the range for the other axles.

6.4.5 Repeat steps 6.4.1 through 6.4.4 for each axle (or axle set).

6.4.6 Repeat steps 6.4.1 through 6.4.4 with all brakes operational (to serve as a data check).

6.4.7 Repeat steps 6.4.2 and 6.4.3 with no braking (coastdown test) to determine parasitic drag.

7. ANALYSIS OF DATA (FIGURE 4)

Vehicle: _____ Trailer: _____ Total Weight (W): _____ lb (kg)

Operational Brakes	Run #	Deceleration (d)					
		35 kPa (5 psi)	69 kPa (10 psi)	103 kPa (15 psi)	138 kPa (20 psi)	207 kPa (30 psi)	276 kPa (40 psi)
Front Axle	1						
	2						
	3						
	4						
Total							
Average							
$d_1 = d_{avg} - d_c$							
Rear Axle	1						
	2						
	3						
	4						
Total							
Average							
$d_1 = d_{avg} - d_c$							
Trailer Axle	1						
	2						
	3						
	4						
Total							
Average							
$d_1 = d_{avg} - d_c$							
All Axles	1						
	2						
	3						
	4						
Total							
Average							
$d_1 = d_{avg} - d_c$							
$?d_n = d_1 + d_2 + d_3$							
$?d_n - d_a$							
% Error							

Coastdown (d_c)	
Run #	d
1	
2	
3	
4	
Total	
Average	

Brake Distribution and Force						
	35 kPa (5 psi)	69 kPa (10 psi)	103 kPa (15 psi)	138 kPa (20 psi)	207 kPa (30 psi)	276 kPa (40 psi)
$\%B_1$						
F_1						
$\%B_2$						
F_2						
$\%B_3$						
F_3						
$?F_N$						

Prepared by: _____

Date: _____

FIGURE 4 - CALCULATION SHEET

7.1 Definition of Terms

t = time in seconds

d = deceleration in m/s^2 (ft/s^2)

d_i = average deceleration of an individual axle or axle set (corrected for drag)

1 = vehicle front axle

2 = vehicle rear axle or axle set

3 = trailer axle or axle set

d_s = deceleration with all brakes operational (correct for drag)

d_c = average deceleration with no brakes applied—coastdown deceleration

d_{avg} = the average of the individual deceleration runs for each test condition

d_n = the sum of the individual average decelerations for each axle or axle set

% Error = the sum of the individual axle average decelerations compared to the average deceleration with all brakes applied

$\%B_i$ = the percentage braking contributed by each axle or axle set of brakes

F_i = the braking force contributed by each axle or axle set of brakes

w = total vehicle and/or combination weight in kilograms (pounds)

g = 9.8 m/s^2 (32.2 ft/s^2)

ΣF_A = the sum of all axle or axle set brake forces

7.2 Calculate the deceleration for each of the coastdown runs using Equation 1:

$$\begin{pmatrix} \text{SI} \\ d = \dfrac{2.234}{t} \end{pmatrix} \quad \begin{pmatrix} \text{English} \\ d = \dfrac{7.33}{t} \end{pmatrix} \qquad \text{(Eq. 1)}$$

Average the four coastdown decelerations to obtain d_c.

NOTE: Do not average time first, or grade effects will not be removed from the data correctly.

7.3 Use Equation 1 to calculate deceleration for each of the runs with braking. Average the four decelerations for each axle or axle set at each pressure level. Subtract the average coastdown deceleration (d_c) from the average braking deceleration (d_{avg}) to obtain d_i.