

**(R) BRAKE FORCE DISTRIBUTION TEST CODE—COMMERCIAL VEHICLES**

**Foreword**—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

**1. Scope**—This SAE Recommended Practice provides the test procedure and instructions for air braked combination vehicles. It also provides recommendations for:

- a. Instrumentation and equipment
- b. Vehicle preparation
- c. Calculating distribution of brake force

**1.1 Purpose**—This code provides a method to determine the brake force distribution and threshold pressures for commercial vehicles.

**2. References**

**2.1 Applicable Publications**—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1854—Brake Force/Distribution Performance Guide—Commercial Vehicles

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

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

FMVSS 121—Air Brake Systems

**3. Instrumentation and Equipment**

**3.1** Each combination vehicle should be equipped with:

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

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

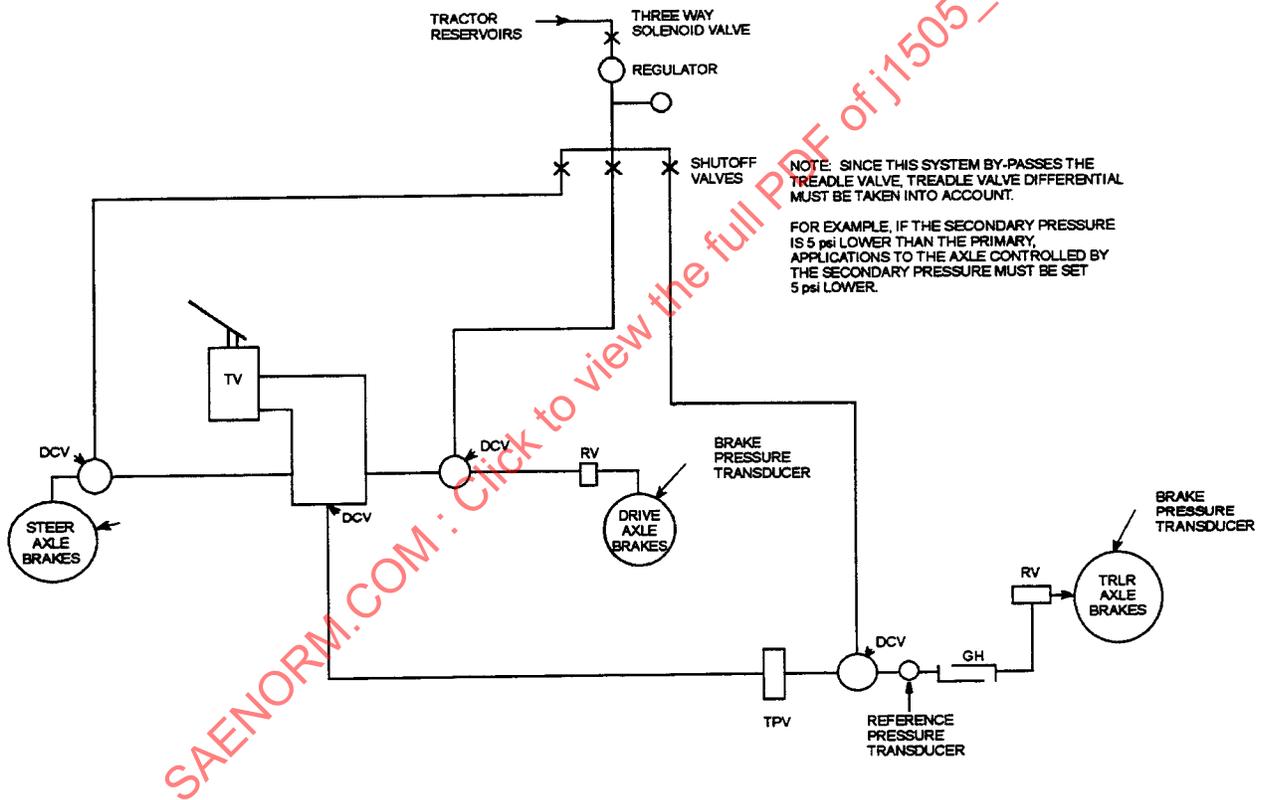
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- 3.1.3 Two pressure transducers and a recording device accurate to within 3.5 kPa ( $\pm 0.5$  psi).
- 3.1.4 Brake lining thermocouples as per SAE J2115 and a suitable temperature readout device accurate to within  $\pm 11$  °C ( $\pm 20$  °F). If 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 and evaluated independently. Valving must not disturb the inherent pressure differentials in the vehicle brake system. 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.



ABBREVIATIONS:  
 DCV = DOUBLE CHECK VALVE  
 RV = RELAY VALVE  
 TPV = TRACTOR PROTECTION VALVE  
 GH = GLADHAND  
 TV = TREADLE VALVE

FIGURE 1—EXTERNAL SYSTEM FOR BRAKE APPLICATION

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- 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 severely reduced.

### 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 or multiple combination vehicles.
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 Adjust brakes to manufacturer's specifications.
- 5.2 Lining to drum 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 5.5 until contact area is at least 90%.
- 5.3 All components between the air compressor and each of the brake chambers must be functioning properly.
- 5.4 Initial testing each day should be preceded by a series of brake snubs which will warm the brakes to 93 to 149 °C (200 to 300 °F).
- 5.5 Testing of a new vehicle for compliance to SAE J1854 shall be preceded by a burnish procedure as specified in FMVSS 121, Section 6.1.8.1.

### 6. **Braking Distribution Tests**

- 6.1 Install and secure instrumentation and test equipment in the test vehicle. One of the pressure transducers is to be installed at the axle under test, down stream of any relay or proportioning valves; the other is to be installed at the tractor to trailer control gladhand as the reference transducer.

The axle 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 transducer at the gladhand is used to ensure that the desired input level is achieved. All data are related back to the reference level for braking force distribution calculations. The axle transducer may be omitted if the relationship between the reference pressure and the brake pressure is known and it is certain that the brakes are fully applied when the data collection is initiated.

- 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 and be sufficient to prevent wheel lock-up of one axle with respect to the others.

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Test No. \_\_\_\_\_ Test Date \_\_\_\_\_  
 Test Facility and Location \_\_\_\_\_  
 Tractor Year, Make, and Model \_\_\_\_\_  
 Trailer Year, Make, and Model \_\_\_\_\_  
 Tractor V.I.N. \_\_\_\_\_ Trailer V.I.N. \_\_\_\_\_  
 G.A.W.R.: Tractor: Front \_\_\_\_\_ Rear \_\_\_\_\_ Trailer \_\_\_\_\_  
 Weight Distribution:  
 Tractor: Front \_\_\_\_\_ Rear \_\_\_\_\_ Total \_\_\_\_\_  
 Trailer Axle(s) \_\_\_\_\_  
 Gross Total \_\_\_\_\_

Brakes:		Type <sup>1</sup>	Size	Make	Lining
Tractor: Front		_____	_____	_____	_____
Rear		_____	_____	_____	_____
Trailer:		_____	_____	_____	_____
Brake Drum/Rotor:		Make	Type <sup>2</sup>	Part No.	
Tractor: Front		_____	_____	_____	
Rear		_____	_____	_____	
Trailer:		_____	_____	_____	

Actuation Details:

			Adjustment		
	<u>Air Chamber</u>	Slk. Adj. Lgth. or Wedge		Stroke @ 550 kPa (80 psi)	Cam <sup>4</sup> Rotation
	<u>Make/Model/Size</u>	<u>Angle</u>	<u>Type<sup>3</sup></u>		
Tractor: Front	_____	_____	_____	_____	_____
Rear-fwd.	_____	_____	_____	_____	_____
Rear-rear	_____	_____	_____	_____	_____
Trailer: Front	_____	_____	_____	_____	_____
Rear	_____	_____	_____	_____	_____

		<u>Tire(s)</u>		<u>Measured Static</u>
	<u>Type<sup>5</sup></u>	<u>Size</u>	<u>Press.</u>	<u>Rolling Radius</u>
Tractor: Front	_____	_____	_____	_____
Rear-fwd.	_____	_____	_____	_____
Rear-rear	_____	_____	_____	_____
Trailer: Front	_____	_____	_____	_____
Rear	_____	_____	_____	_____

Special conditions which might affect brake performance: \_\_\_\_\_

<sup>1</sup> Cam, disc, wedge, etc.  
<sup>2</sup> Cast or composite drum, vented or non-vented rotor, etc.  
<sup>3</sup> Automatic, manual, etc.  
<sup>4</sup> With or opposite drum, etc.  
<sup>5</sup> Single or dual, radial or bias-ply, etc.

FIGURE 2—VEHICLE INFORMATION SHEET

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Tractor: \_\_\_\_\_ Trailer: \_\_\_\_\_ Total Weight: \_\_\_\_\_ lb (kg)

Measured Deceleration Times, seconds:

Operational Brakes	Run #	CONTROL LINE PRESSURE psi (kPa)					
			103 kPa (15 psi)	138 kPa (20 psi)	276 kPa (40 psi)		
Front	1						
	2						
	3						
	4						
Control Gladhand Pressure at Front Brake Threshold							
Increasing Pressure: LF _____ RF _____							
Decreasing Pressure: LF _____ RF _____ Overall Average _____ = Threshold Pressure							
Average: LF _____ RF _____							
Rear	1						
	2						
	3						
	4						
Control Gladhand Pressure at Rear Brake Threshold							
Increasing Pressure: LI _____ RI _____ LR _____ RR _____							
Decreasing Pressure: LI _____ RI _____ LR _____ RR _____ Overall Average _____ = Threshold Pressure							
Average: LI _____ RI _____ LR _____ RR _____							
Trailer	1						
	2						
	3						
	4						
Control Gladhand Pressure at Trailer Brake Threshold							
Increasing Pressure: LF _____ RF _____ LR _____ RR _____							
Decreasing Pressure: LF _____ RF _____ LR _____ RR _____ Overall Average _____ = Threshold Pressure							
Average: LF _____ RF _____ LR _____ RR _____							
All	1						
	2						
	3						
	4						

Coastdown Deceleration Times: (seconds)  
 1- \_\_\_\_\_ 2- \_\_\_\_\_ 3- \_\_\_\_\_ 4- \_\_\_\_\_

Start: Odo- \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Amb. Temp: \_\_\_\_\_ °F Wind Vel: \_\_\_\_\_ Wind Dir: \_\_\_\_\_  
 Finish: Odo- \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_  
 Amb. Temp: \_\_\_\_\_ °F Wind Vel: \_\_\_\_\_ Wind Dir: \_\_\_\_\_  
 Driver: \_\_\_\_\_ Observer: \_\_\_\_\_

FIGURE 3—BRAKE FORCE DISTRIBUTION TEST DATA SHEET

6.3 Determine the gladhand (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 gladhand (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 fully released is determined.

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Record the gladhand (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 the 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.

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 gladhand (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, speeds should be reduced to limit energy input to the braking system in accordance with Table 1:

**TABLE 1—**

GCW kg	GCW lb	Test Starting	Test Starting	Timed Speeds	Timed Speeds	Timed Speeds	Timed Speeds
		Speed km/h	Speed mph	Initial km/h	Initial mph	Final km/h	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 gladhand) 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 gladhand (reference) pressure levels to cover desired operating spectrum. As a minimum, pressure levels of 103, 138, and 276 kPa (15, 20, and 40 psi) are recommended. 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, 6.4.2, 6.4.3 and 6.4.4 for each axle (or axle set).

6.4.6 Repeat steps 6.4.1, 6.4.2, 6.4.3 and 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)

TRACTOR: \_\_\_\_\_ TRAILER: \_\_\_\_\_  
 COMBINED AXLE WEIGHT (W): \_\_\_\_\_

Operational Brakes	Run #	Deceleration (d)		
		103 kPa (15 psi)	138 kPa (20 psi)	276 kPa (40 psi)
Front Axle	1			
	2			
	3			
	4			
Total				
Average				
$d_1 = d_{AVE} - d_c$				
Rear Axle(s)	1			
	2			
	3			
	4			
Total				
Average				
$d_2 = d_{AVE} - d_c$				
Trailer Axle(s)	1			
	2			
	3			
	4			
Total				
Average				
$d_3 = d_{AVE} - d_c$				
All Axles	1			
	2			
	3			
	4			
Total Average				
$d_A = d_{AVE} - d_c$				
$\Sigma d_N = d_1 + d_2 + d_3$				
$\Sigma d_N - d_A$				
% Error				

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

Braking Distribution and Force			
	103 kPa (15 psi)	138 kPa (20 psi)	276 kPa (40 psi)
% B <sub>1</sub>			
F <sub>1</sub>			
% B <sub>2</sub>			
F <sub>2</sub>			
% B <sub>3</sub>			
F <sub>3</sub>			
$\Sigma F_N$			

Equations:

$$d = \frac{7.33}{t} - \text{English}$$

$$(1) \left( d = \frac{2.234}{t} \right) - \text{SI}$$

$$(2) \% \text{ Error} = \frac{\Sigma d_N - d_A}{d_A} \times 100$$

$$(3) F_1 = \frac{W}{g} \times d_1$$

$$(4) \% B_1 = \frac{F_1}{\Sigma F_N} \times 100$$

$$(5) \% B_1 = \frac{d_1}{\Sigma d_N} \times 100$$

Prepared By: \_\_\_\_\_  
 Date: \_\_\_\_\_

FIGURE 4—CALCULATION SHEET

**7.1 Definition of Terms**

- t = time in seconds
- d = deceleration in m/s<sup>2</sup> (ft/s<sup>2</sup>)
- d<sub>i</sub> = average deceleration of an individual axle or axle set (corrected for drag)
- 1 = tractor front axle
- 2 = tractor rear axle or axle set
- 3 = trailer axle or axle set
- d<sub>s</sub> = deceleration with all brakes operational (correct for drag)
- d<sub>c</sub> = average deceleration with no brakes applied—coastdown deceleration
- d<sub>avg</sub> = the average of the individual deceleration runs for each test condition
- d<sub>n</sub> = 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<sub>i</sub> = the percentage braking contributed by each axle or axle set of brakes
- F<sub>i</sub> = the braking force contributed by each axle or axle set of brakes
- w = total combination vehicle weight in kilograms (pounds)
- g = 9.8 m/s<sup>2</sup> (32.2 ft/s<sup>2</sup>)
- Σf<sub>n</sub> = the sum of all axle or axle set brake forces

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

$$d = \frac{\text{SI}}{t} \left( \begin{array}{c} \text{English} \\ d = \frac{7.33}{t} \end{array} \right) \quad (\text{Eq. 1})$$

Average the four coastdown decelerations to obtain d<sub>c</sub>.

NOTE— Do not average times 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<sub>c</sub>) from the average braking deceleration (d<sub>avg</sub>) to obtain d<sub>i</sub>.

**7.4** At each reference pressure evaluated, add the individual axle average braking decelerations together and perform a data check by comparing this sum (d<sub>n</sub>) to the deceleration with all brakes operational (d<sub>a</sub>) using Equation 2:

$$\% \text{ Error} = \frac{d_n - d_a}{d_a} \times 100 \quad (\text{Eq. 2})$$

A negative error (greater than 20%) at all input levels indicates possible brake fade due to the greater energy inputs per brake during the individual axle tests. This is not usually a problem at the test speeds specified in this procedure. If it is, lower test speeds may be necessary. A large random error indicates lack of repeatability in the brake application pressure level and more than four runs should be made.

**7.5** Calculate brake force for each axle or axle set using Equation 3:

$$F_i = \frac{w}{g} \times d_i \quad (\text{Eq. 3})$$

Calculate total brake force (F<sub>a</sub>) by adding the individual axle or axle set of brake forces.