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Brake Force Distribution Test Code — Commercial Vehicles

SAE Recommended Practice
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Report of the Truck and Bus Brake Committee, approved May 1985.

1. Purpose—This code provides a method to determine the brake force distribution for commercial vehicles.

2. Scope—This code provides the test procedure and instructions for air braked combination vehicles. It also provides recommendations for:

2.1 Instrumentation and equipment.

2.2 Vehicle preparation.

2.3 Calculating distribution of brake force.

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 ± 0.2 mph (±0.32 km/h).

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 ± 0.5 psi (3.5 kPa).

3.1.4 Brake lining thermocouples as per SAE J786a and a suitable temperature readout device accurate to within ± 20°F (±11°C). 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 Fig. 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.

4. Vehicle Information and Data

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

4.2 Test data sheet (Fig. 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 Linings should be in good condition, free from oil, grease, glazing, or exposure to excessive heat. Drums should be clean and free from cracks.

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 200–300°F (93–149°C).

5.5 Testing of a new vehicle for compliance to a recommended practice currently under development shall be preceded by a burnish procedure as specified in Federal Motor Vehicle Safety Standard No. 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

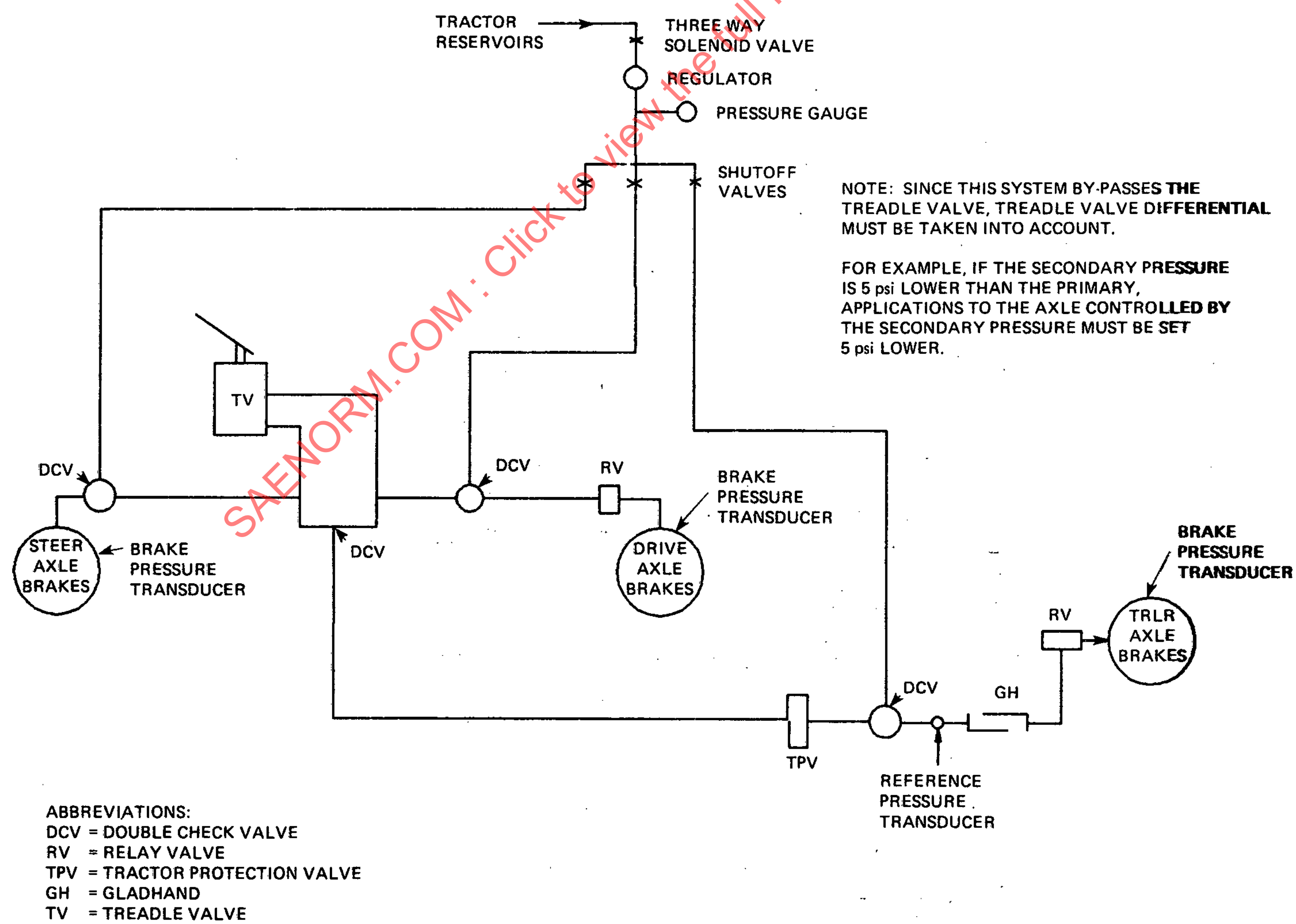

FIG. 1—EXTERNAL SYSTEM FOR BRAKE APPLICATION

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

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 brake torque is first evident on Fig. 3. Continue to increase pressure to approximately 40 psi (275 kPa) and then slowly decrease it until the point at which the brake is fully released is determined. Record the gladhand (reference) pressure level at brake release on Fig. 3. The average of these two recorded values is defined as the brake push-out pressure. Calculate the push-out 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 [200–300°F (93–149°C) hottest brake is recommended] by making snubs or by cooling as necessary.

6.4.2 Accelerate the vehicle to 45 mph (73 km/h), 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 40.0 mph (64.37 km/h). Continue to decelerate until the vehicle reaches 35.0 mph (56.33 km/h) and immediately release the brakes. Measure the time between 40.0 and 35.0 mph (64.37 and 56.33 km/h), i.e. delta V = 5 mph (8.047 km/h), average V = 37.5 mph (60.35 km/h) and record on Fig. 3. Lower speed levels can be used if desired; however, the speed change measured should be maintained at 5 mph (8.047 km/h). 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 80 000 lbs (36 300 kg) GCW.

For vehicles greater than 80 000 lbs (36 300 kg) GCW, speeds should be reduced to limit energy input to the braking system in accordance with the following table:

GCW		Test Starting Speed		Timed Speeds			
				Initial		Final	
lbs	kg	mph	km/h	mph	km/h	mph	km/h
100 000	45 400	37	60	32	51.50	27	43.45
120 000	54 400	33	53	28	45.06	23	37.01
140 000	63 500	29	47	24	38.62	19	30.58

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

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 ____________
Trailor Axle(s) ____________
Gross Total ____________

Brakes:	Type[1]	Size	Make	Lining
Tractor: Front				
Rear				
Trailer:				

Brake Drum/Rotor:	Make	Type[2]	Part No.
Tractor: Front			
Rear			
Trailer:			

Actuation Details:

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

	Tire(s) Type[5]	Tire(s) Size	Tire(s) Press.	Measured Static Rolling Radius
Tractor: Front				
Rear-fwd.				
Rear-rear				
Trailer: Front				
Rear				

Special conditions 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 drum, etc.
[5] Single or dual, radial or bias-ply, etc.

FIG. 2—VEHICLE INFORMATION SHEET

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 the desired operating spectrum. As a minimum, pressure levels of 15, 20, and 40 psi (103.4, 137.9, and 275.8 kPa) 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 to 6.4.4 for each axle (or axle set).

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

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

7. ***Analysis of Data (Fig. 4)***

7.1 Definition of Terms

t = time in seconds.

d = deceleration in ft/s² (m/s²).

d_i = 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_a = deceleration with all brakes operational (corrected for drag).

d_c = average deceleration with no brakes applied—coast down 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 combination vehicle weight in pounds (kilograms).

g = 32.2 ft/s² (9.81 m/s²).

ΣF_n = the sum of all axle/axle set/brake forces.

7.2 Calculate the deceleration for each of the coast down runs using:

English / Metric

$$d = \frac{7.33}{t} \qquad \left(d = \frac{2.234}{t}\right) \qquad \text{(Equation 1)}$$

Average the four coast down decelerations to obtain d_c.

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 coast down deceleration (d_c) from the average braking deceleration (d_{avg}) to obtain (d_i).

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_n) to the deceleration with all brakes operational (d_a) using:

$$\%\ \text{Error} = \frac{d_n - d_a}{d_a} \times 100 \qquad \text{(Equation 2)}$$

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:

$$F_i = \frac{w}{g} \times d_i \qquad \text{(Equation 3)}$$

Calculate total brake force (F_n) by adding the individual axle or axle set of brake forces.

Plot brake force (F_i) for each axle vs. gladhand reference pressure level on a common plot to show actual braking force distribution (See example, Fig. 5.) Each curve has its origin ($F_i = 0$) at the average push-out pressure determined in paragraph 6.3. Straight line segments should be used to connect the individual data points.

Plot total tractor brake force for each data point. The origin of the curve will be at the lowest average tractor push-out pressure determined in paragraph 6.3. Note that variation in push-out pressure for individual axles will change the slope of the curve as each axle begins braking.

7.6 Calculate the percent of total vehicle braking at each gladhand reference pressure for each axle by using the braking forces from the force distribution described in paragraph 7.5 and the following equation:

$$\%\ B_i = \frac{F_i}{\Sigma F_n} \times 100 \qquad \text{(Equation 4)}$$

Increments no larger than 1 psi (7 kPa) up to 15 psi (105 kPa) gladhand (reference) pressure, 2 psi (14 kPa) up to 20 psi (138 kPa) and 5 psi (35 kPa) above 20 psi (138 kPa) are recommended.

Plot the braking distribution for each axle or axle set of brakes over the range 0–100% and 0–40 psi (276 kPa). (See example, Fig. 6.)

7.7 If the vehicle weight is not known, brake force cannot be determined, but braking distribution may be calculated for each of the reference pressure level data points as follows:

$$\%\ B_i = \frac{d_i}{\Sigma d_n} \times 100 \qquad \text{(Equation 5)}$$

Braking distribution may be calculated for intermediate points by assuming a vehicle weight and calculating braking force as in paragraph 7.5. Braking distribution may then be calculated as in paragraph 7.6.

Tractor: ______________ Trailer: ______________ Total Weight: ______________ lb (kg)

Measured Deceleration Times, seconds:

Operational Brakes	Run #	CONTROL LINE PRESSURE psi (kPa)						
			15(103)	20(138)	40(276)			
Front	1							
	2							
	3							
	4							

Control Gladhand Pressure at Front Brake Push-Out
Increasing Pressure: LF ______ RF ______
Decreasing Pressure: LF ______ RF ______ Overall Average ______
Average: LF ______ RF ______

Operational Brakes	Run #		15(103)	20(138)	40(276)			
Rear	1							
	2							
	3							
	4							

Control Gladhand Pressure at Rear Brake Push-Out
Increasing Pressure: LI ______ RI ______ LR ______ RR ______
Decreasing Pressure: LI ______ RI ______ LR ______ RR ______ Overall Average ______
Average: LI ______ RI ______ LR ______ RR ______

Operational Brakes	Run #		15(103)	20(138)	40(276)			
Trailer	1							
	2							
	3							
	4							

Control Gladhand Pressure at Trailer Brake Push-Out
Increasing Pressure: LF ______ RF ______ LR ______ RR ______
Decreasing Pressure: LF ______ RF ______ LR ______ RR ______ Overall Average ______
Average: LF ______ RF ______ LR ______ RR ______

Operational Brakes	Run #		15(103)	20(138)	40(276)			
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: ______________

FIG. 3—BRAKE FORCE DISTRIBUTION TEST DATA SHEET