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SURFACE VEHICLE RECOMMENDED PRACTICE

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SIMULATED MOUNTAIN-BRAKE PERFORMANCE TEST PROCEDURE

***Foreword*—**This Document has also changed to comply with the new SAE Technical Standards Board Format.

This procedure was developed in response to requests for a flat-road test procedure that would simulate the power- and energy-duty cycles occurring during mountain driving. A number of different mountain roads were investigated. In general, the mountain roads in the Eastern United States tend to have steeper grades, sharper curves, and shorter descent distances as compared to many mountain roads in the Western United States. This procedure simulates the longer descents found in the Western United States and complements the fade schedules in SAE J843 which requires a higher average power input to the brakes, but for a shorter time. A general correlation with actual mountain descents has been established by analysis of actual power, energy, and temperature measurements. This procedure is intended as a development test. Line pressure usage rather than pedal force is recommended to provide a more precise measure of the input to the brakes.

1. ***Scope*—**This SAE Recommended Practice establishes a uniform procedure for a flat-road simulation of a mountain-fade test of the brake systems of light-duty trucks and multipurpose passenger vehicles up to and including 4500 kg (10 000 lb) GVW and all classes of passenger cars.

1.1 **Purpose—**The purpose of this test code is to establish brake system capabilities with regard to fade resistance, balance, stability, recovery, and maximum brake-fluid temperatures under simulated mountain driving conditions.

2. ***References***

2.1 **Applicable Publications—**The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

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

SAE J79—Brake Disc and Drum Thermocouple Installation
SAE J291—Determination of Brake Fluid Temperature
SAE J843—Brake System Road Test Code—Passenger Car and Light-Duty Truck

3. ***Instrumentation***

3.1 Line pressure or pedal force gauge.

3.2 Decelerometer.

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3.3 Speedometer (calibrated vehicle unit or fifth-wheel type).

3.4 Stop watch or cycle timer.

3.5 Thermometer or ambient sensitive thermocouple.

3.6 Odometer (calibrated).

3.7 Direct-reading temperature instrument.

3.8 Brake lining and brake-fluid thermocouples.

3.9 Optional instrumentation:

a. Pedal travel gauge
b. Solenoid stop counter
c. Brake-torque transducers
d. Brake-drum (or rotor) thermocouples
e. Slip rings (for brake drum or rotor temperatures)

4. Installation Details

4.1 Thermocouples

4.1.1 LINING—Install plug-type thermocouples in each brake per current SAE J843.

4.1.2 BRAKE FLUID—Install fluid thermocouples in each brake per current SAE J291.

4.1.3 BRAKE DRUM (OR ROTOR) (OPTIONAL)—Install disc/drum thermocouples in each brake per current SAE J79.

4.2 Friction Material Preparation—Attach and finish friction material per vehicle manufacturer's specification.

4.3 Brake Drum (or Rotor) and Hub Assembly—New drums or rotors are recommended. Surface finish and dimensional characteristics, with special emphasis on runout of rubbing surface, shall be in accordance with vehicle manufacturer's specifications.

4.4 Brake Assembly—Brakes shall be prepared in accordance with vehicle manufacturer's specifications. New linings and springs are recommended on all brakes. Adjust brakes to manufacturer's specifications.

4.5 Uniformity of Brake Components (Optional)—The objectives for each test shall determine the selection of uniformity requirements. Since braking-system balance during the high-temperature portion of this test may be affected by uniformity of components, care should be exercised in selecting components such that unbalance is controlled (that is, if lining stability is to be evaluated, other components such as drums or rotors should be matched or mismatched left to right with respect to surface finish, mass, runout, etc.).

NOTE—Specifications for the brake components and the installation may not be available for experimental development tests. In such cases, the selection will have to be made by the testing agency.

4.6 Vehicle Test Weight—The test weight should be selected by the user based on the test objectives. Normal practice in evaluating production vehicle is to select the manufacturer's maximum recommended weight.

4.7 Vehicle Powertrain—The powertrain should be selected by the user based on the test objectives. Normal practice in evaluating production vehicles is to select a powertrain providing the least engine braking.

NOTE— The variation in engine braking among powertrains will normally have only a small effect on test results but may have a significant effect on brake performance obtained during actual mountain descents. The reason is that drag affects the power absorbed by the powertrain only when the vehicle is coasting or when the brakes are applied. This is a small part of the total time for the test but may be a large part of the total time for actual mountain descents. Caution should be exercised in interpreting comparative results between vehicles having widely differing drag characteristics.

Since vehicle drag affects braking severity during actual descents, drag should be measured and recorded with the data.

The final speed for the snub may be adjusted as a function of vehicle drag. At this date, there is insufficient information to define the adjustment to the snub final speed as a function of vehicle drag, or if such a correction will simulate braking duty as a function of vehicle drag. The snub final speed of 27 km/h (17 mph) stated in 5.5 is based on best simulation of mountain descents for full-size domestic vehicles equipped with automatic transmissions and standard-axle ratios.

5. Test Procedure

5.1 Test Notes

5.1.1 With the exception of the burnish portion of this test, all test stops and snubs shall be conducted on a substantially level (not to exceed ±1% grade), dry, smooth, hard-surfaced roadway of Portland cement concrete (or other surface with equivalent coefficient of surface friction) that is free from loose materials.

5.1.2 During all phases of this procedure, any unusual performance such as wrap-up or noise characteristics are to be noted and recorded. Note any uncontrollable braking action causing the vehicle to pull or swerve out of a 3.66 m (12 ft) wide roadway lane.

5.1.3 Initial brake temperature is the lining temperature 0.3 km (0.2 mile) before stop or snub (average temperature of brakes on hottest axle), brakes off.

5.1.4 Because variations in ambient temperature have a significant effect on test results, this test should be conducted within a range of ambient temperature of 4 to 32 °C (40 to 90 °F). Record ambient temperature as indicated on data sheets. Wind velocity should be less than 16 km/h (10 mph) and should be recorded.

5.1.5 Decelerations used in test stops and snubs refer to values at which the decelerometer is held approximately constant during the stop or snub by varying the input pressure.

5.1.6 Deceleration and line pressure readings shall not be taken below 8 km/h (5 mph).

5.1.7 All stops and snubs should normally be made with vehicle in normal driving gear.

5.1.8 Paragraphs 5.3 to 5.10 of this procedure shall be run continuously without interruption; 102 min, 30 s are required to complete these paragraphs.

5.1.9 To permit a check of consistency in performing the test, each segment of the test (except 5.2 and 5.11) should be timed, and vehicle mileage covered should be recorded. The average speed provides the parameter for measuring consistency.

5.1.10 The test should be terminated if the pedal force reaches 900 N (200 lb) (or a line pressure equivalent to 900 N (200 lb) pedal force) and/or, if the pedal travel becomes excessive, or at any time the vehicle is considered to be unsafe.

5.2 Burnish—Condition the braking system as follows:

a. Stop speed—64 to 0 km/h (40 to 0 mph)
b. Stop deceleration—3.66 m/s^2 (12 ft/s^2)
c. Stop interval—As required to achieve 120 °C (250 °F) initial-brake temperature or a maximum of 1.6 km (1 mile)

NOTE—The 1.6 km (1 mile) maximum must be observed even though the initial temperature exceeds 120 °C (250 °F).

d. Cooling speed—64 km/h (40 mph) (moderate acceleration to cooling speed)
e. Stops required—200 (first 10 stops shall be used as a general check of instrumentation, brakes, and vehicle function)
f. Optional—Inspect and adjust brakes after burnish cycle. Record if either operation is performed.
g. Record odometer and time at end of first stop, maximum line pressure, stop interval, and initial-brake temperature for the first and every twentieth stop, and odometer and time at end of last stop.

5.3 Initial-Brake Temperature—Warm the brakes to 65 to 95 °C (150 to 200 °F) initial-brake temperature using the burnish procedure and shorten the interval if necessary. Record odometer at the last stop used to warm the brakes. Proceed immediately to 5.4.

NOTE— If only a limited range of ambient temperature exists, the brakes can be warmed by making 10 stops from 64 km/h (40 mph) at a 60 s interval. This procedure specifies the braking duty and would result in lower initial-brake temperatures for systems that have good heat dissipation and, therefore, more nearly reflects real-world conditions. The disadvantage is that the initial-brake temperature becomes dependent upon the ambient temperature. This procedure is, therefore, only recommended for a test series in which small changes in ambient temperature are expected.

5.4 First (Cold) Effectiveness Check—Immediately after the previous stop, moderately accelerate to 97 km/h (60 mph) and drive at 97 km/h (60 mph) for 200 s including acceleration time. Make check stops as follows:

a. Stop speed—97 to 0 km/h (60 to 0 mph)
b. Stop deceleration—4.6 m/s^2 (15 ft/s^2)
c. Stops required—3
d. Cooling speed—97 km/h (60 mph) (moderate acceleration at cooling speed)
e. Stop interval—Begin stop every 200 s
f. Record—Maximum line pressure for each stop, brake lining, and fluid temperatures immediately before each stop, and odometer at the end of the third stop

5.5 First Simulated Mountain Descent—Immediately after effectiveness check stop 3, moderately accelerate to 56 km/h (35 mph) and drive at 56 km/h (35 mph) for 15 s including acceleration time. Begin the simulated descent as follows:

a. Snub speeds—56 to 27 km/h (35 to 17 mph)
b. Snub deceleration—2.4 m/s^2 (8 ft/s^2)
c. Snubs required—80
d. Snub interval—Begin snub every 15 s
e. Speed between snubs—56 km/h (35 mph) with moderate acceleration
f. Record—Maximum line pressure every fourth snub, brake lining, and fluid temperatures immediately before every eighth snub, and odometer at the end of the last snub

5.6 Second (Hot) Effectiveness Check—Immediately after the last snub in the simulated descent, moderately accelerate to 97 km/h (60 mph) and drive at 97 km/h (60 mph) for 50 s including the acceleration time. Make check stops as follows:

a. Stop speeds—97 to 0 km/h (60 to 0 mph)
b. Stop deceleration—4.6 m/s^2 (15 ft/s^2)
c. Stops required—3
d. Cooling speed—97 km/h (60 mph) (moderate acceleration to cooling speed)
e. Stop interval—Begin stop every 50 s
f. Record—Maximum line pressure for each stop, brake lining, and fluid temperatures immediately before each stop, and odometer at the end of the third stop

5.7 Recovery—Immediately after the third stop in the second effectiveness check, moderately accelerate to 64 km/h (40 mph) and drive at 64 km/h (40 mph) for 120 s including the acceleration time. Make recovery stops as follows:

a. Stop speed—64 to 0 km/h (40 to 0 mph)
b. Stop deceleration—3.7 m/s^2 (12 ft/s^2)
c. Stops required—10
d. Cooling speed—64 km/h (40 mph) (moderate acceleration to cooling speed)
e. Stop interval—Begin stop every 120 s
f. Record—Maximum line pressure for each stop, brake lining, and fluid temperatures immediately before each stop, and odometer at the end of the last stop

5.8 Second Simulated Mountain Descent—Immediately after the tenth stop in the first recovery, moderately accelerate to 56 km/h (35 mph) and drive at 56 km/h (35 mph) for 15 s including acceleration time. Repeat the simulated descent as stated in 5.5.

5.9 Soak—Immediately after the final snub in the second mountain descent, drive the vehicle the minimum distance possible to allow the vehicle to be parked in a windless area with the engine running at idle, and soak for 20 min. At 1 min intervals during the soak, apply the brakes to the average line pressure measured in 5.4 and hold for approximately 5 s before releasing. Note if pedal is spongy or goes to floor and if brake-warning indicator illuminates during the applications. Record brake lining and fluid temperatures immediately before each fourth application. Do not proceed to 5.10 if the pedal travel is excessive during the final check at the end of the soak.

5.10 Third (Cold) Effectiveness Check—Immediately after the soak, repeat 5.4.

5.11 Reburnish—Repeat 5.2 except 35 stops required. Record odometer and time at end of the first stop, maximum line pressure, stop interval, and initial-brake temperature for the first and every fifth stop, and odometer and time at the end of the stop.

5.12 Fourth (Cold) Effectiveness Check—Immediately after the last burnish stop, repeat 5.4.

5.13 Final Inspection—Disassemble all brakes, inspect, and record all pertinent observations.

6. Vehicle-Drag Measurement (Optional)—Make 10 closed-throttle coast-downs with the transmission in the gear being simulated (usually top gear, but could be a lower gear). Ambient wind velocity should be less than 8 km/h (5 mph). The direction should be alternated to reduce the effects of ambient wind. The coast-downs should be started at 64 km/h (40 mph).

7. Report Forms and Data Sheets—See Figure 1 to Figure 14.

Vehicle

Make _____ Model _____ Year _____
Engine _____ Transmission _____ Axle Ratio _____
Test Weight _____ Curb Weight _____
Tire Type and Size _____ Other Information _____
_____

Brake System

Front: Size _____ Type _____ Cyl Dia _____
Rear: Size _____ Type _____ Cyl Dia _____
Front Lining _____
Master Cylinder Dia _____ Power System _____
Other Information _____
_____

Test Information

Location _____ Surface _____
Start Date _____ Completion Date _____
Mileage Travelled _____ Amb Temp Range _____
Wind Velocity _____ Direction _____
Driver _____ Observer _____
Instrument Description _____
_____

Comments

_____
_____
_____
_____
_____
_____
_____
_____

Abbreviations

IBT	Average temperature of linings on hottest axle, 0.3 km (0.2 mile) before stop
LP	Maximum line pressure during stop
LFLT	Temperature of left front lining immediately before stop
RFLT	Temperature of right front lining immediately before stop
LRLT	Temperature of left rear lining immediately before stop
RRLT	Temperature of right rear lining immediately before stop
LFFT	Temperature of left front fluid immediately before stop
RFFT	Temperature of right front fluid immediately before stop
LRFT	Temperature of left rear fluid immediately before stop
RRFT	Temperature of right rear fluid immediately before stop

FIGURE 1—GENERAL DATA SIMULATED MOUNTAIN BRAKE PERFORMANCE TEST

Test No. _____
Vehicle _____
Tested by _____
Date _____

Burnish (Paragraph 5.2)—200 stops, 64 to 0 km/h (40 to 0 mph), 3.7 m/s² (12 ft/s²), 120 °C (250 °F) initial brake temperature for each stop (but 1.6 km (1 mile) maximum interval).

Odometer at end of first stop _____
Time at end of first stop _____

Stop	Dist	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
1			Comments:							
20			Comments:							
40			Comments:							
60			Comments:							
80			Comments:							
100			Comments:							
120			Comments:							
140			Comments:							
160			Comments:							
180			Comments:							
200			Comments:							

Odometer at end of last stop _____
Time at end of last stop _____
Average speed _____
Ambient temperature range _____

FIGURE 2—BURNISH

Initial Brake Temperature (Paragraph 5.3)—Make burnish stops as required to warm brakes to 65 to 95 °C (150 to 200 °F) initial brake temperature.

Odometer at end of last stop used to warm brakes _____

Time at end of last stop used to warm brakes (time zero) _____

Ambient temperature _____

FIGURE 3—INITIAL BRAKE TEMPERATURE

First (Cold) Effectiveness Check (Paragraph 5.4)—3 stops, 97 to 0 km/h (60 to 0 mph), 4.6 m/s² (15 ft/s²), 200 s interval, 65 to 95 °C (150 to 200 °F) initial brake temperature for the first stop, first stop at 30 min 20 s.

Odometer at end of last stop used to warm brakes _____

Time at end of last stop used to warm brakes (time zero) _____

Ambient temperature _____

Stop	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
1	3:20		Comments:							
2	6:40		Comments:							
3	10:00		Comments:							

Odometer at end of stop 3 _____

Average speed _____

FIGURE 4—FIRST (COLD) EFFECTIVENESS CHECK

First Simulated Mountain Descent (Paragraph 5.5)—80 snubs, 56 to 27 km/h (35 to 17 mph), 2.4 m/s² (8 ft/s²), 15 s interval, first snub at 10 min 15 s.

Snub	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
4	11:00									
8	12:00		Comments:							
12	13:00									
16	14:00		Comments:							
20	15:00									
24	16:00		Comments:							
28	17:00									
32	18:00		Comments:							
36	19:00									
40	20:00		Comments:							
44	21:00									
48	22:00		Comments:							

FIGURE 5—FIRST SIMULATED MOUNTAIN DESCENT

Snub	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
52	23:00									
56	24:00		Comments:							
60	25:00									
64	26:00		Comments:							
68	27:00									
72	28:00		Comments:							
76	29:00									
80	30:00		Comments:							

Odometer at end of snub 80 _____

Average speed _____

Additional comments _____

Second (Hot) Effectiveness Check (Paragraph 5.6)—3 stops, 97 to 0 km/h (60 to 0 mph), 4.6 m/s² (15 ft/s²), 50 s interval, first stop at 30 min 50 s.

Stop	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
1	30:50		Comments:							
2	31:40		Comments:							
3	32:30		Comments:							

Odometer at end of stop 3 _____

Average speed _____

Comments _____

FIGURE 6—SECOND (HOT) EFFECTIVENESS CHECK

Recovery (Paragraph 5.7)—10 stops, 64 to 0 km/h (40 to 0 mph), 3.7 m/s² (12 ft/s²), 120 s interval, first stop at 34 min 30 s.

Stop	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
1	34:30		Comments:							
2	36:30		Comments:							
3	38:30		Comments:							
4	40:30		Comments:							
5	42:30		Comments:							
6	44:30		Comments:							
7	46:30		Comments:							
8	48:30		Comments:							
9	50:30		Comments:							
10	52:30		Comments:							

Odometer at end of stop 10 _____

Average speed _____

Comments _____

FIGURE 7—RECOVERY

Second Simulated Mountain Descent (Paragraph 5.8)—80 snubs, 56 to 27 k/h (35 to 17 mph), 2.4 m/s² (8 ft/s²), 15 s interval, first snub at 52 min 45 s.

Snub	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
4	53:30									
8	54:30		Comments:							
12	55:30									
16	56:30		Comments:							
20	57:30									
24	58:30		Comments:							
28	59:30									
32	60:30		Comments:							
36	61:30									
40	62:30		Comments:							
44	63:30									
48	64:30		Comments:							
52	65:30									
56	66:30		Comments:							

FIGURE 8—SECOND SIMULATED MOUNTAIN DESCENT

Snub	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
60	67:30									
64	68:30		Comments:							
68	69:30									
72	70:30		Comments:							
76	71:30									
80	72:30		Comments:							

Odometer at end of snub 80 _____

Average speed _____

Additional comments _____

Soak (Paragraph 5.9)—20 brake applications to average line pressure measured in the first effectiveness check at 1 min interval, first application at 73:30.

Time	Apply	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
76:30	4		Comments:							
80:30	8		Comments:							
84:30	12		Comments:							
88:30	16		Comments:							
92:30	20		Comments:							

Odometer at application 1 _____

Additional comments _____

FIGURE 9—SOAK

Third (Cold) Effectiveness Check (Paragraph 5.10)—3 stops, 97 to 0 km/h (60 to 0 mph), 4.6 m/s² (15 ft/s²), 200 s interval, first stop at 95 min 50 s.

Stop	Time	LP	LFLT	RFLT	LRLT	RRLT	LFFT	RFFT	LRFT	RRFT
1	95:50		Comments:							
2	99:10		Comments:							
3	102:30		Comments:							

Odometer at end of stop 3 _____

Average speed _____

Comments _____

FIGURE 10—THIRD (COLD) EFFECTIVENESS CHECK