SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

An American National Standard

SAE J212

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(R) Brake System Dynamometer Test Procedures—Passenger Car

Foreword—This SAE Recommended Practice is based upon SAE J843 and is intended to provide a laboratory simulation of vehicle brake system performance (based on simultaneous testing of one front and one rear brake). Certain details of this dynamometer procedure have been purposely left flexible because of varying equipment, and results should not be construed as providing absolute correlation with road tests.

1. Scope—This SAE Recommended Practice establishes a uniform laboratory dynamometer method of testing all classes of passenger car brake systems.

1.1 Purpose—The purpose of the document is to establish brake system capabilities with regard to:

a. Deceleration versus input, as affected by speed, brake temperature, and usage.
b. Brake system integrity.
c. Stopping ability during emergency or inoperative power-assist conditions.

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

3. Equipment and Instrumentation

3.1 Equipment

a. An inertia-type dual-brake dynamometer
b. Means for varying brake cooling
c. Means for simulating partial brake system failure (half of system open to atmosphere)
d. Means for applying brake system pressure at a specific rate

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3.2 Instrumentation

3.2.1 REQUIRED

a. Means for recording hydraulic line pressures
b. Means for recording brake torques
c. Means for recording brake lining temperatures
d. Means for recording shaft speed
e. Cooling air temperature indicators
f. Revolutions to stop indicator for measurement of equivalent stopping distance

3.2.2 OPTIONAL INSTRUMENTATION

a. Cooling air velocity indicators
b. Drum or disc temperature indication and/or recording equipment
c. Fluid displacement indicators
d. Stopping time indicator

3.3 System Accuracy

3.3.1 ACCURACY OF INSTRUMENTATION—The overall system accuracy for all recording or indicating instruments shall be ±2% of full-scale or better.

3.3.2 CONTROL PARAMETER ACCURACY

3.3.2.1 Line pressure, torques, and temperatures shall be maintained within ±5% of the desired value.

3.3.2.2 Speed shall be maintained within ±2% of the desired value.

3.3.2.3 Test moment of inertia shall be within ±2.03 kg·m^2 (±1.5 slug·ft^2) of value calculated from 4.7.

4. Test Preparation and Installation Details

4.1 Friction Material Preparation—Attach and finish friction material per manufacturer's specifications, unless otherwise noted.

4.2 Thermocouples—Install plug-type thermocouples in each brake per SAE J79 or as shown in Figure 1. All thermocouples are to be located in the approximate center of the most heavily loaded shoe, one per brake. Indicate location on data sheet.

4.3 Brake Drum or Disc Assembly—New drums or discs should be used for each test. Surface finish, dimensional characteristics (with special emphasis on thickness variation and runout of rubbing surface), and material properties shall be in accordance with manufacturer's specifications.

4.4 Brakes shall be prepared in accordance with manufacturer's specifications. Adjust brake to manufacturer's specifications where applicable.

4.5 Brake Mounting—Shall be mounted essentially as in service.

4.6 Hydraulic System—Shall incorporate pressure proportioning valve and/or hold-off valve, if used on the vehicle being simulated.

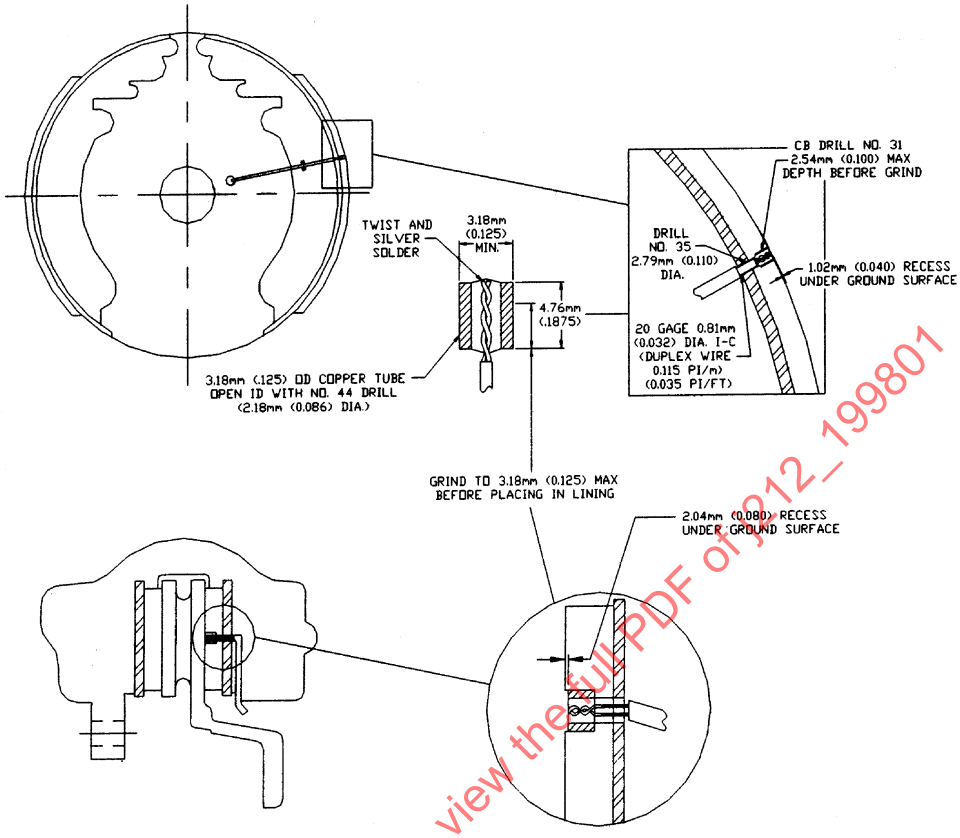


FIGURE 1—TYPICAL PLUG THERMOCOUPLE INSTALLATIONS

4.7 Test Moment of Inertia—Calculate the moment of inertia required as follows in Equation 1:

$$I = \frac{Wr^2}{2g} \qquad \text{(Eq. 1)}$$

where:

I = Moment of inertia, $kg \cdot m^2$ ($slug \cdot ft^2$)
W = Weight of vehicle, N (lb) x 0.86 (0.86 is a correction factor for parasitic losses) Vehicle test weight is normally curb weight +2669 N (600 lb)
r = Effective tire radius, m (ft)
g = Gravity, 9.8 m/s^2 (32.2 ft/s^2)

4.8 Test rpm—As required to simulate specific test speeds. Calculate rpm as follows in Equation 2:

$$rpm = \frac{22.56 \times km/h}{r} \quad \text{or} \quad rpm = \frac{14.02 \times mile/h}{r} \qquad \text{(Eq. 2)}$$

where:

rpm = Revolutions per minute of the tire
km/h = specified test speed in kilometers per hour
mile/h = specified test speed in miles per hour
r = From 4.7

4.9 Test Deceleration—All control decelerations shall be converted to torque for the dynamometer settings by Equation 3:

$$T = \frac{Wra}{2g} \qquad \text{(Eq. 3)}$$

where:

T = Torque required, N·m (lb·ft)
a = Control deceleration, m/s^2 (ft/s^2)
W, r, g = From 4.7

5. Test Procedure—Performance

5.1 Test Notes

5.1.1 During all phases of this procedure, any unusual performance characteristics such as noise, roughness, etc., are to be noted and recorded.

5.1.2 Initial brake temperature is defined as the lining temperature at which the brake application is initiated.

5.1.3 If the brakes require warming to the prescribed initial temperature, use the burnish procedure, except cycle is not to be less than 45 s.

5.1.4 "Sustained" torque or line pressure normally is interpreted herein to mean that torque or line pressure at which a leveling off occurs during a stop. If no leveling off occurs, "sustained" values should be recorded as that indicated at one-half the stopping time.

5.1.5 "Final" torque or line pressure readings shall be taken at an rpm equivalent to 8.05 km/h, (6 mile/h).

5.1.6 The cooling speed (speed at which the rotating portion of the brake is moving between successive brake applications) shall be set at approximately stop speed for all phases. Stop speed is that at which the brake is applied.

5.1.7 During all phases of this procedure, cooling air speeds for each brake must be controlled to produce the brake temperatures normally experienced on the particular vehicle or vehicle brake system being simulated. In other words, for each brake system, a particular set of cooling air control settings must be worked out on a "baseline" test for which comparable vehicle test data is available. It is especially important that proper temperatures be attained during burnish, fades, and recoveries.

5.1.8 Rate of pressure rise during all phases of test shall be 6895 to 13 790 kPa/s (1000 to 2000 $lbf/in^2/s$).

5.2 Preburnish Check—In order to allow for a general check of instrumentation, brakes, and dynamometer function, run the following stops: 10 stops, 48.3 km/h (30 mile/h), 3.05 m/s^2 (10ft/s^2), 90 s cycle.

5.3 First (Preburnish) Effectiveness Check

5.3.1 INITIAL BRAKE TEMPERATURE (EACH STOP)—93 °C (200 °F) (hottest brake).

5.3.2 STOP SPEED—48.3 and 96.6 km/h (30 and 60 mile/h).

5.3.3 TEST METHOD—Curve to be defined at each speed by adequate number of points. Optional methods are as follows (specify which used):

5.3.3.1 A minimum of five consecutive stops at constant line pressure increments. If this method is used, use line increments of not over 690 kPa (100 lbf/in^2) at 48.3 km/h (30 mile/h) to 9.1 m/s^2 (30 ft/s^2); of not over 1034 kPa (150 lbf/in^2) at 96.6 km/h (60 mile/h) to 9.1 m/s^2 (30 ft/s^2) and of not over 1379 kPa (200 lbf/in^2) at 128.8 km/h (80 mile/h) to 9.1 m/s^2 (30 ft/s^2) (on second and final effectiveness tests only).

5.3.3.2 A series of consecutive stops at constant deceleration increments. If this method is used, make checks at 1.5, 3, 4.5, 6.1, 7.6, and 9.1 m/s^2 (5, 10, 15, 20, 25, and 30 ft/s^2) at each speed.

5.3.4 REPORT—Maximum line pressure on constant declaration stops, and minimum torque on constant pressure stops.

5.4 Burnish

5.4.1 STOP SPEED—64.4 km/h (40 mile/h).

5.4.2 STOPS REQUIRED—200.

5.4.3 STOP DECELERATION—3.7 m/s^2 (12 ft/s^2).

5.4.4 STOP CYCLE—As required to maintain 121 °C (250 °F) initial brake temperature on hottest brake, or a maximum of 90s.

5.4.5 REPORT—Maximum line pressure every 20 stops.

5.5 Second (Burnish) Effectiveness Test—Repeat 5.3, except add 128.8 km/h (80 mile/h) stop speed.

5.6 High-Speed Stop Test

5.6.1 STOP SPEED—As achieved by maximum attainable acceleration for 1.61 km (1.0 miles) from zero speed but not to exceed 160.9 km/h (100 mile/h) (to be determined with actual vehicle being simulated.)

5.6.2 STOPS REQUIRED—1.

5.6.3 STOP DECELERATION—4.6 m/s^2 (15 ft/s^2).

5.6.4 INITIAL BRAKE TEMPERATURE—66 °C (150 °F) (hottest brake).

5.6.5 REPORT—Maximum line pressure and decelerations if 4.6 m/s ^{2} (15 ft/s^2) cannot be held.

5.7 First Reburnish—Repeat 5.4, except 35 stops.

5.8 First Fade and Recovery Test

5.8.1 BASELINE CHECK STOPS

5.8.1.1 *Stop Speed*—48.3 km/h (30 mile/h).

5.8.1.2 *Stops Required*—3.

5.8.1.3 *Stop Deceleration*—3.1 m/s^2 (10 ft/s^2).

5.8.1.4 *Initial Brake Temperature*—66 °C (150 °F) hottest brake each stop.

5.8.1.5 *Report*—Maximum line pressures.

5.8.2 FADE

5.8.2.1 *Stop Speed*—96.6 km/h (60 mile/h).

5.8.2.2 *Stops Required*—10.

5.8.2.3 *Stop Deceleration*—4.6 m/s^2 (15 ft/s^2).

5.8.2.4 *Initial Brake Temperature*—66 °C (150 °F).

5.8.2.5 *Stop Cycle*—35 s.

5.8.2.6 *Report*—Maximum line pressure, initial brake temperature, cooling air temperature, deceleration values.

5.8.3 NOTE—Run 90 s at 48.3 km/h (30 mile/h) after last fade stop and make first recovery stop.

5.8.4 RECOVERY

5.8.4.1 *Stop Speed*—48.3 km/h (30 mile/h).

5.8.4.2 *Stops Required*—12.

5.8.4.3 *Stop Deceleration*—3.1 m/s^2 (10 ft/s^2).

5.8.4.4 *Stop Cycle*—2 min.

5.8.4.5 *Report*—Same as for fade run (5.8.2.6).

5.9 First Effectiveness Spot Check

5.9.1 STOP SPEED—96.6 km/h (60 mile/h).

5.9.2 STOPS REQUIRED—2.

5.9.3 STOP DECELERATION—4.6 m/s^2 (15 ft/s^2).

5.9.4 INITIAL BRAKE TEMPERATURE—93 °C (200 °F) hottest brake each stop.

5.9.5 REPORT—Maximum line pressure.

5.10 Second Reburnish—Repeat 5.4, except 35 stops.

5.11 Second Fade and Recovery Test—Repeat 5.8, except 15 fade stops in 5.8.2.2.

5.12 Second Effectiveness Spot Check—Repeat 5.9.

5.13 Third Reburnish—Repeat 5.4, except 35 stops.

5.14 Final Effectiveness Test—Repeat 5.5.

5.15 Fourth Reburnish—Repeat 5.4, except 35 stops.

5.16 Emergency Brake System and Inoperative Power System Test

5.16.1 TEST NOTES

5.16.1.1 Calculate wheel revolutions equivalent to 182.9 m (600 ft) for the vehicle being simulated.

5.16.1.2 Obtain "with vacuum" and "no vacuum" pedal force-line pressure calibration curves for the vehicle being simulated.

5.16.1.3 All stops in this section are to be made at constant line pressure from 96.6 km/h (60 mile/h) at an initial brake temperature at 66 °C (150 °F) (hottest brake).

5.16.2 STOPPING TEST WITH FAILED FRONT SYSTEM

5.16.2.1 Determine the constant master cylinder hydraulic pressure to stop in the equivalent 152.4 m, +0 m, –18.3 m (500 ft, +0 ft, –60 ft) using the rear brake only (front system open to atmosphere).

5.16.2.2 *Report*—Constant master cylinder pressure to stop with rear brake only (P_r), the "with vacuum" pedal force to produce P_r (F_r), the actual revolutions to stop (RTS_r).

5.16.3 STOPPING TEST WITH FAILED REAR SYSTEM

5.16.3.1 Determine the constant master cylinder hydraulic pressure to stop in the equivalent of 182.9 m, +0 m, –18.3 m (600 ft, +0 ft, –60 ft) using the front brake only (rear system open to atmosphere).

5.16.3.2 *Report*—Constant master cylinder pressure to stop with front brake only (P_f), the "with vacuum" pedal force to produce P_f (F_f), the actual revolutions to stop (RTS_f).

5.16.4 STOPPING TEST WITH INOPERATIVE POWER SYSTEM

5.16.4.1 From the "no vacuum" pedal force-line pressure calibration curve, determine the master cylinder hydraulic pressure (P_{nv}) produced by a pedal force of 890 N (200 lb).

5.16.4.2 Determine the revolutions to stop (RTS_{nv}) for a master cylinder hydraulic line pressure of P_{nv} using both front and rear brakes.

5.16.4.3 *Report*—Revolutions to stop (RTS_{nv}).

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

6. *Report Forms*

6.1 Brake Dynamometer Test Data—See Figure 2.

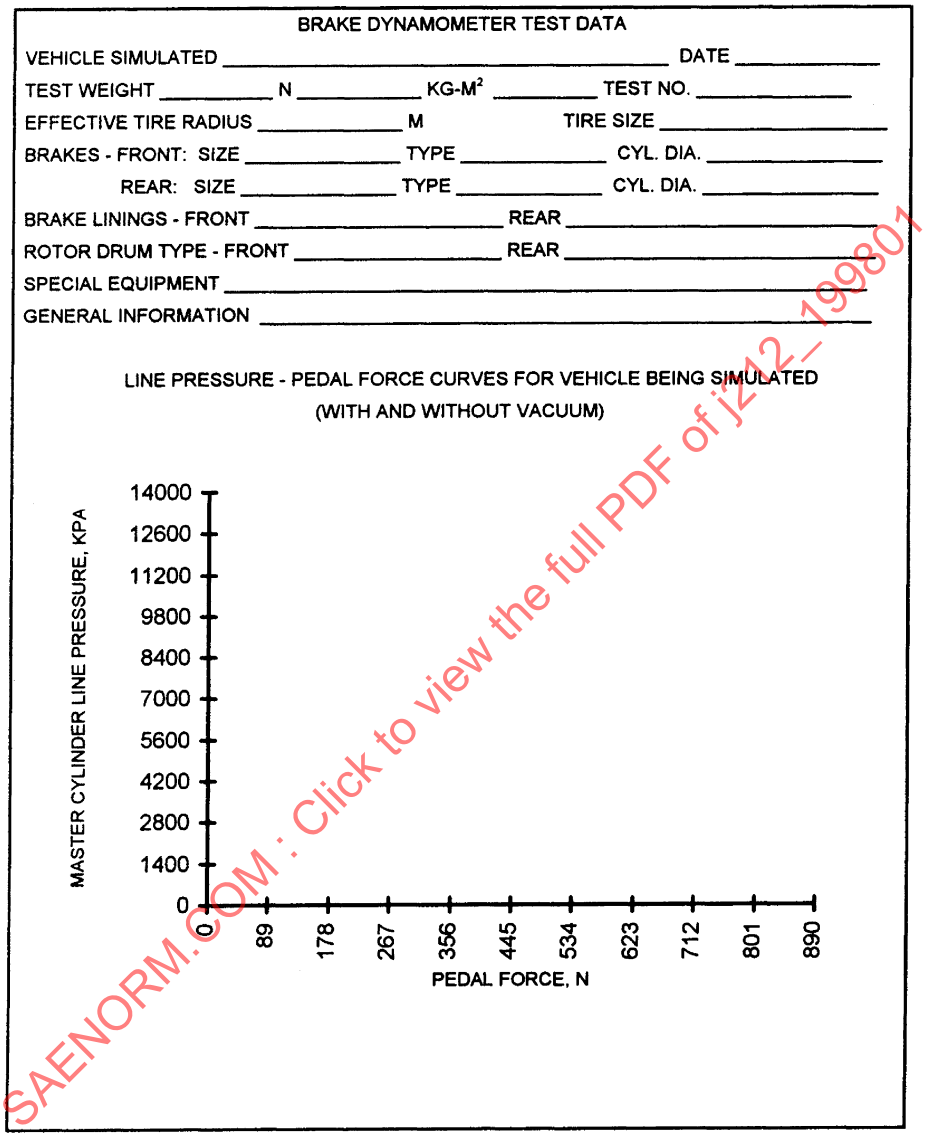


FIGURE 2—BRAKE DYNAMETER TEST DATA

6.2 Preburnish Check, Preburnish Effectiveness, and Burnish Report Form—See Figure 3.

PREBURNISH CHECK, PREBURNISH EFFECTIVENESS, AND BURNISH REPORT FORM

TEST NO. _____
VEHICLE _____
DATE _____

PREBURNISH CHECK

STOP	LINE PRESSURE	COMMENTS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

PREBURNISH EFFECTIVENESS

50 KPH			100 KPH		
DECELERATION	LINE PRESSURE	TEMPERATURE	DECELERATION	LINE PRESSURE	TEMPERATURE

COMMENTS:

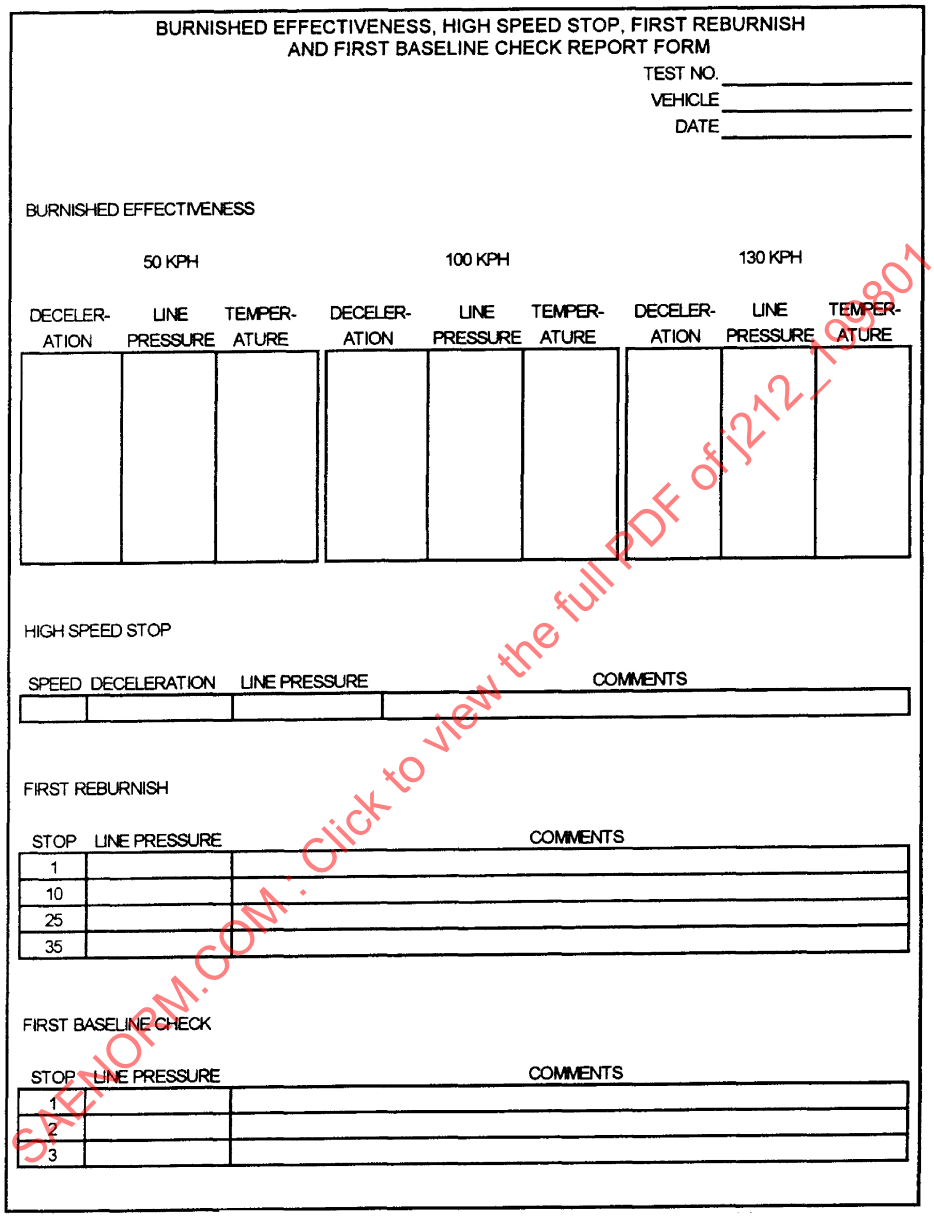
BURNISH

STOP	LINE PRESSURE	COMMENTS
1		
20		
40		
60		
80		
100		

STOP	LINE PRESSURE	COMMENTS
120		
140		
160		
180		
200		

FIGURE 3—PREBURNISH CHECK, PREBURNISH EFFECTIVENESS, AND BURNISH REPORT FORM

6.3 Burnished Effectiveness, High-Speed Stop, First Reburnish, and First Baseline Check Report Form— See Figure 4.



BURNISHED EFFECTIVENESS, HIGH SPEED STOP, FIRST REBURNISH AND FIRST BASELINE CHECK REPORT FORM

TEST NO. _____
VEHICLE _____
DATE _____

BURNISHED EFFECTIVENESS

50 KPH			100 KPH			130 KPH		
DECELER-ATION	LINE PRESSURE	TEMPER-ATURE	DECELER-ATION	LINE PRESSURE	TEMPER-ATURE	DECELER-ATION	LINE PRESSURE	TEMPER-ATURE

HIGH SPEED STOP

SPEED	DECELERATION	LINE PRESSURE	COMMENTS

FIRST REBURNISH

STOP	LINE PRESSURE	COMMENTS
1		
10		
25		
35		

FIRST BASELINE CHECK

STOP	LINE PRESSURE	COMMENTS
1		
2		
3		

FIGURE 4—BURNISH EFFECTIVENESS, HIGH-SPEED STOP, FIRST REBURNISH, AND FIRST BASELINE CHECK REPORT FORM

6.4 First Fade, First Recovery, and First Effectiveness Spot Check Report Form—See Figure 5.

FIRST FADE, FIRST RECOVERY, AND FIRST EFFECTIVENESS SPOT CHECK REPORT FORM

TEST NO. _____
VEHICLE _____
DATE _____

FIRST FADE

STOP	DECELERATION	LINE PRESSURE	INITIAL TEMPERATURES	COMMENTS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
COOLING AIR TEMPERATURE:				

FIRST RECOVERY

STOP	DECELERATION	LINE PRESSURE	INITIAL TEMPERATURES	COMMENTS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

FIRST EFFECTIVENESS SPOT CHECK

STOP	DECELERATION	LINE PRESSURE	INITIAL TEMPERATURES	COMMENTS
1				
2				

FIGURE 5—FIRST FADE, FIRST RECOVERY, AND FIRST EFFECTIVENESS SPOT CHECK REPORT FORM

6.5 Second Reburnish, Second Baseline Check, and Second Fade Report—See Figure 6.

SECOND REBURNISH, SECOND BASELINE CHECK, AND SECOND FADE REPORT FORM

TEST NO. _____
VEHICLE _____
DATE _____

SECOND REBURNISH

STOP	LINE PRESSURE	COMMENTS
1		
10		
25		
35		

SECOND BASELINE CHECK

STOP	LINE PRESSURE	COMMENTS
1		
2		
3		

SECOND FADE

STOP	DECELERATION	LINE PRESSURE	INITIAL TEMPERATURES	COMMENTS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
COOLING AIR TEMPERATURE:				

FIGURE 6—SECOND REBURNISH, SECOND BASELINE CHECK, AND SECOND FADE REPORT FORM