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INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1652

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DYNAMOMETER EFFECTIVENESS CHARACTERIZATION TEST FOR PASSENGER CAR AND LIGHT TRUCK CALIPER DISC BRAKE FRICTION MATERIALS

***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 establishes an inertia dynamometer test procedure, using an exemplar caliper disc brake, to characterize the effectiveness of disc brake friction materials for passenger cars and light-duty trucks, up to and including 2700 kg (5954 lb) GVW. SAE J1652 provides a method of characterizing friction material effectiveness on a full disc brake, using test conditions that approximate those for U.S. mandated new vehicle brake tests.

1.1 Test Features—Brake effectiveness is the retarding force per unit brake application force. Effectiveness can be reported as regressed specific torque or as a brake effectiveness factor (BEF).

1.2 Test Application—Brake effectiveness values calculated from SAE J1652 may be used to aid in the selection of replacement friction materials for automotive disc brakes that are similar in design and usage to that of the exemplar brake.

2. References

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

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

SAE J661—Brake Lining Quality Control Test Procedure
SAE J866—Friction Coefficient Identification System for Brake Linings
SAE J2115—Brake Performance and Wear Test Code Commercial Vehicle Inertia Dynamometer

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

FMVSS 116
FMVSS 135

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3. Test Preparation

3.1 Dynamometer Configuration—SAE J1652 is to be run on an inertia dynamometer with the following minimum capabilities:

3.1.1 Variable speed drive system with speed resolution to ±1 rpm and calibrated to ±0.5% accuracy at 100 km/h (62 mph). The drive should have the capability to accelerate the specified inertia from 0 to 1000 rpm in 20 s.

3.1.2 Incremental inertia discs to simulate vehicle mass up to 75 kg.m^2 (55 slug ft^2) within ±1.4 kg.m^2 (±1 slug ft^2).

3.1.3 Test brake station, fully enclosed in an air duct of sufficient size that the brake hardware takes up not more than 50% of the duct cross-sectional area. The test brake fixture is constructed from a vehicle knuckle, caliper and rotor that meet original equipment specifications with an adapter to attach the knuckle to the dynamometer.

3.1.4 A pressure transducer, accurate to within ±0.5% at full scale and calibrated with a reference standard from 690 to 14 000 kPa (100 to 2030 psi).

3.1.4.1 The pressure transducer is mounted just outside the air duct to minimize transducer thermal drift. A pressure connection is made at the piston centerline on the back of the caliper. A short (about 152 mm) (6 in) brake line with 6 mm (0.25 in) inside diameter, connects the transducer to the caliper. Excessive distance between the caliper and the pressure transducer results in a high indicated pressure level before torque response. Examine instantaneous torque/pressure/time data to verify that reported pressure does not exceed 345 kPa (50 psi) when torque reaches 30 N·m (22 ft-lb).

3.1.5 A tailstock section and load cell connected to the test brake knuckle. Load cell is to be calibrated over the range from 7 to 2700 N·m (5 to 1991 ft-lb) and measure brake torque with an accuracy of ±0.5% at 2700 N·m. (1991 ft-lb).

3.1.6 A closed-loop servo control system to control brake applications under specified pressure or torque control conditions. Servo control system capabilities include:

a. Linear pressure rise rates free of inflection points, so that all 100 Hz data points are within the specified ramp rate band, over the range from 345 kPa (50 psi) through 95% of maximum during the ramp portion of a brake application.
b. Torque ramp, free of inflection points other than those due to friction material characteristics, over the range from 54 N·m (40 ft-lb) through 95% of maximum during the ramp portion of a brake application.
c. Not more than 5% torque or pressure over-shoot beyond preset level.
d. For torque control applications, transition from pressure ramp control to torque control is achieved within ±3% of the preselected sustained torque level.
e. Ability to maintain an average sustained torque level within ±1% of a specified level. The torque range during the sustained portion of a torque control application should not exceed 34 N·m (26 ft-lb).

3.1.7 A negative pressure, closed-loop brake cooling system to maintain required cooling air flow rate and temperature during the entire test procedure. A metal screen with nominal 6 to 12 mm (0.24 to 0.47 in) openings in the air duct about 30 cm (12 in) upstream of the brake is recommended to improve air flow uniformity.

3.1.8 An automated and integrated control and data acquisition system to control brake applications and record data as specified.

3.1.8.1 The frequency content of the information gathered in SAE J1652 is less than 15 Hz. Appropriate analog and digital filtering to insure good analog amplitude quantification is necessary. Therefore, a minimum analog filtering with a 200 Hz, low pass, two-pole filter is required along with a minimum digital sampling rate of 100 Hz. The digital filter shall not insert a relative phase shift between channels of measured data. All data, including instantaneous data points, are reported as 100 Hz filtered values.

3.2 Data Processing System—An automated data processing system is recommended to carry out specified calculations, including least squares regression analysis.

3.3 Brake Hardware Specifications

3.3.1 BRAKE CALIPER—DELCO, original equipment, right-hand, front axle disc brake caliper for 1992 GM B-CAR. GM part number 18015428.

3.3.1.1 Inspect and assemble caliper per manufacturer's recommendations. Replace caliper or knuckle if abutment surfaces show signs of peening or indentations.

3.3.1.2 Inspect seals and boots before each test and replace with original equipment parts when there is any indication of wear or thermal abuse.

3.3.1.3 Inspect caliper slide pins before each test and replace with original equipment parts when there is any indication of bending or Brinell marks. After assembly, verify a low caliper slide force.

3.3.2 KNUCKLE—DELCO, original equipment, right hand brake knuckle. GM part number 18016024.

3.3.2.1 Check caliper to knuckle clearance before each test. Inspect for dirt or corrosion build-up on the caliper/knuckle interface and for out-of-square mounting of the caliper on the knuckle. The manufacturer's specified clearance (total both sides) between the caliper housing and stops on the knuckle assembly is 0.4 to 0.9 mm (0.016 to 0.035 in).

3.3.3 FRICTION MATERIAL ASSEMBLIES—GM B-CAR front axle disc brake assemblies. Friction material attachment to the backing plate should correspond to how parts are marketed. FMSI 7214-D52 for integrally molded or FMSI 7214A-D52 for riveted parts.

3.3.3.1 For riveted assemblies, minimum rivet break away torque is 544 mN.m (77 oz in) with semi-tubular rivets or 339 mN.m (48 oz in) with eyelets.

3.3.3.2 Except where parts are manufactured with an insulator attached to the backing plate, tests should be run without external noise or thermal insulators. Where specified in the original equipment disc brake assembly, an insulator may be used between the friction material and backing plate.

3.3.3.3 Critical pad and assembly dimensions for riveted parts are detailed in Appendix A. Integrally molded parts should have functionally equivalent dimensions.

3.3.4 ROTOR—DELCO, 305 mm (12 in) outside diameter, GM part number 18016226. Rotors are nondirectionally ground with a 0.5 to 1.5 μm (20 to 59 μin) Ra SCALE surface finish.

3.3.4.1 Each test is run with a new original equipment rotor. Rotors should not be lathe cut or ground before use.

3.3.4.2 Just prior to starting a test, clean rotor with isopropyl alcohol and paper towels.

3.3.5 Rotor and friction material storage and handling should be such as to avoid rust, contamination, nicks or other physical damage to test parts.

3.3.6 THERMOCOUPLE INSTALLATION—See Appendices A and B for details of pad and rotor thermocouple installations.

3.3.6.1 Use #24 AWG "J" type thermocouple wire (solid, glass on glass), at least 60 cm (24 in) long for rotor and pad thermocouple wires.

3.3.6.2 For rotor and pad thermocouples, use a 3.18 mm (0.125 in) OD X 3.18 mm (0.125 in) long, silver soldered, copper thermocouple plug per SAE J2115. It is recommended that plugs be formed slightly out of round to insure a secure fit into the drilled hole.

3.3.6.3 For inner pad, drill a 3.0 mm (0.120 in) hole through steel backing plate and friction material. Hole location is to be on the line of the pad long axis, 13 mm (0.51 in) forward of the center point. Use a setting tool to locate thermocouple plug 1.50 mm (0.060 in) below wear surface.

3.3.6.4 For outer pad, drill a 3.0 mm (0.120 in) hole through the steel backing plate and friction material. Hole location is to be at the midpoint of the pad long axis, 20 mm (0.78 in) from pad outside diameter. Use a setting tool to locate thermocouple plug, 1.50 mm (0.060 in) below the wear surface.

3.3.6.5 For the rotor, drill a 2.95 mm (0.116 in) hole through the inner pad rotor face. Locate hole between ribs at the center point between pad ID and OD. Debur hole and mount thermocouple 1.0 mm (0.040 in) below rotor wear surface.

3.3.7 BRAKE FLUID—Glycol-based, original equipment quality brake fluid such as DOW HD50-4 or equivalent, that meets minimum requirements of FMVSS 116, is recommended.

3.3.7.1 If an alternate fluid has been used, flush system thoroughly and replace seals prior to running SAE J1652.

3.4 Brake Installation

3.4.1 FIXTURE ALIGNMENT

3.4.1.1 Check knuckle to drive axle run-out at two bearing lands with tailstock locked. Adjust to not more than 0.10 mm (0.004 in) run-out before proceeding to 3.4.1.2.

3.4.1.2 Install rotor and measure run-out with rotor free turning. Replace rotor if run-out exceeds 0.10 mm (0.004 in). Rotor run-out is measured on the inner pad face, 13 mm (0.5 in) from rotor outside diameter.

3.4.1.3 Engage rotor to the drive and recheck run-out at low speed with tailstock locked. Run-out should not exceed 0.10 mm (0.004 in).

3.4.2 CALIPER LOCATION

3.4.2.1 Long axis of caliper should be parallel within ±15 degrees of air flow direction. Dynamometer rotation must be consistent with vehicle orientation for a right-hand brake.

3.4.2.2 Dynamometer cooling air is either horizontal from left or vertical from top. Caliper location should be as shown in Appendix C.

3.4.3 Mount friction material assemblies in caliper and assemble brake.

3.4.4 Bleed caliper thoroughly after mounting on knuckle.

3.4.5 Connect rotor thermocouple to a slip ring and pad thermocouples to tailstock connectors. Use thermocouple extension wire between slip ring and circuit card.

***4. Test Parameters and Control Specifications*—**(See 7.4)

4.1 Wheel Load—783 kg (1726 lb).

4.2 Tire Rolling Radius—304.8 mm (12.0 in).

4.3 Test Inertia—72.5 kg.m^2 ± 1.4 kg.m^2 (53.5 slug ft^2 ± 1 slug ft^2). (See 7.5)

4.4 Brake Apply Speed (ISPD km/h)—Hold to ±1% of specified.

4.5 Final Speed (FSPD km/h)—Speed at brake release.

4.6 Stopping Distance (STPD m)—For GM B-Car front disc, stopping distance is 1.915 (# revolutions from brake apply to brake release).

4.7 Sustained Torque (SUTD N·m)—Applicable to torque and pressure controlled applications only. Use the distance averaged torque over the range from level reached through 522 rpm for fade snubs or 70 rpm for full stops.

4.7.1 Sustained torque is 725 N·m ± 7 N·m (535 ft-lb ± 5 ft-lb) for all torque control applications in the test.

4.8 Average Torque (AVTD, N·m)—Applicable to torque and pressure controlled applications only. Use the distance averaged torque within the window from 54 N·m (40 ft-lb) at brake apply to 70 rpm for full stops or 522 rpm fade snubs.

4.9 Maximum Torque (MXT, N·m)—For ramp applications, maximum torque is the maximum 100 Hz torque value between threshold and brake release. For torque and pressure controlled applications, maximum torque is the maximum 100 Hz torque value within the window from 54 N·m (40 ft-lb) through 70 rpm for full stops or through 522 rpm for fade snubs.

4.10 Regressed Specific Torque (RGST N·m/kPa)—Regressed specific torque is the calculated slope of the linear least squares regression for pressure and torque within the window specified for each type of application.

4.11 Coefficient of Determination (R^2)—The coefficient of determination is the square of the correlation coefficient between observed and fitted torque values and is generated as part of the least square regression analysis. Analysis of instantaneous data is recommended for R^2 values less than 0.990.

4.12 Sustained Pressure (SPRD, kPa)—Applicable to torque and pressure control applications only. Use the distance averaged pressure over the range from level reached through 70 rpm for full stops or 522 rpm for fade snubs. For pressure control applications, sustained pressure should be within ±1% of specified.

4.13 Average Pressure (APRD, kPa)—Applicable to torque and pressure control applications only. Use the distance averaged pressure over the range from 54 N·m (40 ft-lb) initial torque through 70 rpm for full stops or 522 rpm for fade snubs.

4.14 Maximum Pressure (MXPR, kPa)—For ramp applications, maximum pressure is the maximum 100 Hz pressure value over the range from 54 N·m (40 ft-lb) through brake release. For torque and pressure controlled applications, maximum pressure is the maximum 100 Hz pressure value within the window from 54 N·m (40 ft-lb) through 70 rpm for full stops or through 522 rpm for fade snubs.

4.15 Hold Off Pressure (PHO, kPa)—The calculated pressure value obtained from the least square regression line at zero torque.

4.16 Initial Temperatures (IN1 rotor, IN2 inner pad, IN3 outer pad, DEGREES C)—Initial temperatures are measured at brake apply.

4.16.1 Use initial rotor temperature (IN 1) for all temperature controlled brake applications. Initial rotor temperatures should be within ±3 °C (±5 °F) of specified.

4.17 Final Temperature (FN1 Rotor, FN2 inner pad, FN3 outer pad, DEGREES C)—Final temperatures are measured 5 s after brake release.

4.18 Cycle Time (CYCT, SEC.)—Actual time (brake apply to brake apply) between each brake application.

4.18.1 Once the instrument check has started, the test is to be completed without intermediate shutdown or delays between sections. A delay of up to 10 min may be required between the instrument check and start of the burnish to generate data from the instrument check section. One additional brief shutdown is allowed prior to stop number 150 during the burnish. Record time and reason in test report.

4.19 Drag Torque (N·m)—Drag torque is the sustained torque level when brake is released and drive is rotating. If drag torque exceeds 14 N·m (10 ft-lb) during instrument check cooling curve, abort test and inspect friction assemblies, caliper, rotor, knuckle and alignment. Repair or replace parts and start a new test with the same rotor and pads. If drag torque exceeds the specified limit a second time, replace rotor and pads. If drag torque exceeds 14 N·m (10 ft-lb) for 15 s consecutively during any portion of the test, include the level in test report.

4.20 Pressure Ramp Rate (kPa/s)—Pressure ramp rate is 5170 kPa/s ± 275 kPa/s (750 psi/s ± 40 psi/s) for all applications in the test. For torque and pressure control applications, hold 5170 kPa/s ± 275 kPa/s (750 psi/s ± 40 psi/s) ramp rate through at least 97% of specified sustained torque or pressure.

4.20.1 Pressure ramp rate is calculated from the slope of the pressure/time curve over the range from 690 kPa (100 psi) to 90% of target sustained torque, sustained pressure or maximum torque achieved in ramp applications. Use 100 Hz instantaneous torque/pressure/time data as the basis for calculating pressure ramp rates.

4.21 Brake Release—For ramp applications, brake release is at 2710 N·m (2000 ft-lb) or 13 800 kPa (2000 psi) or 26 rpm, whichever occurs first. For torque and pressure control stops, brake release is at 26 rpm. For torque control fade snubs, brake release is at 487 rpm.

4.22 Ranges for Data Collection and Regressed Specific Torque—Calculations are summarized in Table 1.

4.22.1 DATA COLLECTION RANGES—For all brake applications, data collection starts at the first 100 Hz data point after reaching 54 N·m (40 ft-lb) torque. This data point should be within 10 ms after reaching 54 N·m (40 ft-lb). For ramp applications, data is collected through 2710 N·m (2000 ft-lb) or 13 800 kPa (2000 psi) or 26 rpm, whichever occurs first. For torque and pressure control stops, data is collected through 70 rpm. For torque control fade snubs, data is collected through 522 rpm.

TABLE 1—RANGES FOR DATA COLLECTION AND REGRESSED SPECIFIC TORQUE CALCULATIONS

Type of Application	Data Collection Range	Regressed Specific Torque Calc. Range
Ramp	54 N·m (40 ft-lb) through first of 2710 N·m (2000 ft-lb) or 13 800 kPa (2000 psi) or 26 rpm	Within the window from 54 N·m (40 ft-lb) to 2066 N·m (1524 ft-lb) or to 13 100 kPa (1900 psi)
Torque Control Stops	54 N·m (40 ft-lb) through 70 rpm	Within the window from 54 N·m (40 ft-lb) to 718 N·m (530 ft-lb)
Torque Control Snubs	54 N·m (40 ft-lb) through 522 rpm	Same as torque control stops
2068 kPa Pressure Control Stops	Same as torque control stops	Within the window from 54 N·m (40 ft-lb) to 813 N·m (600 ft-lb) or to 1965 kPa (285 psi)
3450 kPa Pressure Control Stops	Same as torque control stops	Within the window from 54 N·m (40 ft-lb) to 1355 N·m (1000 ft-lb) or to 3275 kPa (475 psi)

4.22.2 REGRESSED SPECIFIC TORQUE CALCULATION RANGES—For ramp applications, regressed specific torque is calculated within the window from 54 N·m (40 ft-lb) to 2066 N·m (1524 ft-lb). If torque does not reach 2066 N·m (1524 ft-lb) before pressure reaches 13 800 kPa (2000 psi), calculate regressed specific torque to 13 100 kPa (1900 psi).

For torque control applications, regressed specific torque is calculated within the window from 54 N·m (40 ft-lb) to 718 N·m (530 ft-lb).

For 2068 kPa (300 psi) pressure control stops, regressed specific torque is calculated within the window from 54 N·m (40 ft-lb) to 813 N·m (600 ft-lb) or, if torque does not reach 813 N·m (600 ft-lb), to 1965 kPa (285 psi).

For 3450 kPa (500 psi) pressure control stops, regressed specific torque is calculated within the window from 54 N·m (40 ft-lb) to 1355 N·m (1000 ft-lb) or, if torque does not reach 1355 N·m (1000 ft-lb) to 3275 kPa (475 psi).

4.23 Brake Cooling—Maintain a fixed cooling air velocity, predetermined to meet the instrument check cooling rate band as specified in Appendix D during and between all sections of the test.

4.24 Cooling Air

4.24.1 Cooling air temperature in the duct, 60 cm (24 in) upstream of the brake fixture, is specified at 21 to 38 °C (70 to 100 F) during all test sections.

4.24.2 It is recommended that air temperature and relative humidity in the duct be recorded for each test.

4.25 Brake Cooling Speed—Brake cooling speed between applications is at the braking speed for the following cycle.

4.26 During instrument check and post test cooling curves, evaluate drag torque per 4.19.

5. *Test Procedure*

5.1 Synopsis—See Table 2 for a synopsis of the test procedure.

TABLE 2—SAE J1652 PROCEDURE OUTLINE

	Number of Applications	Speed km/h	Speed (mph)	Sustained Torque N·m (ft-lb)	Sustained Pressure kPa (psi)	Initial Rotor Temp. °C (°F)
Instrument Check	5	50-3	(31-2)	725 (535)		100 (212)
	5	100-3	(62-2)	725 (535)		100 (212)
	3	50-3	(31-2)		2068 (300)	100 (212)
	5	50	(31)	Ramps		100 (212)
	5	100	(62)	Ramps		100 (212)
Run instrument check cooling curve and verify test conditions						
Burnish	200	80-3	(50-2)	725 (535)		100 (212)
Post Burnish	5	50	(31)	Ramps		100 (212)
Effectiveness	5	100	(62)	Ramps		100 (212)
	3	100-3	(62-2)		3450 (500)	100 (212)
Fade Heating Cycle	15	120-56	(75-35)	725 (535)		100 (212) first snub then 45 s cycle time
Hot Effectiveness	2	100	(62)	Ramps		35 & 30 s cycle times
	2	100-3	(62-2)		3450 (500)	315 (600)
Cooling Cycle	4	50-3	(31-2)	725 (535)		60 s cycle
Recovery Effectiveness	2	100	(62)	Ramps		60 s cycle
Reburnish	35	80-3	(50-2)	725 (535)		100 (212)
Final Effectiveness	5	50	(31)	Ramps		100 (212)
	5	100	(62)	Ramps		100 (212)
	5	130	(80)	Ramps		100 (212)
Run post test cooling curve						

5.2 Instrument Check

5.2.1 The instrument check section verifies brake cooling rate, thermocouple response, pressure ramp rates and brake release points, as well as brake drag and rotor run-out specifications.

5.2.2 Run instrument check applications, including drag to heat and cooling curve, at the cooling air velocity previously determined to meet the cooling curve band.

5.2.2.1 It is recommended that brake cooling rate be verified by running a preliminary instrument check, drag and cooling curve with previously tested pads and rotor. Adjust air flow and baffles as required before initiating a test with new parts.

5.2.3 TORQUE CONTROL APPLICATIONS—Make five torque controlled applications from 50 to 3 km/h (31 to 2 mph) at 725 N·m (535 ft-lb) sustained torque and 100 °C (212 °F). Make five additional torque controlled applications from 100 to 3 km/h (62 to 2 mph) at the same sustained torque and temperature.

5.2.3.1 Use the initial 50 km/h (31 mph) applications to achieve 100 °C (212 °F) then hold 100 °C (212 °F) through remaining applications.

5.2.3.2 Analyze 50 and 100 km/h (31 and 62 mph) applications to verify 5170 kPa/s ± 275 kPa/s (750 psi/s ± 40 psi/s) pressure ramp rate. Also check sensitivity of servo control system per 3.1.6 specifications.

5.2.4 CONSTANT PRESSURE APPLICATIONS—Make three pressure controlled applications from 50 to 3 km/h (31 to 2 mph) at 2068 kPa (300 psi) sustained pressure and 100 °C (212 °F).

5.2.4.1 Generate at least one expanded graph of in-stop torque versus time to analyze torque range per revolution. Torque range should not exceed 34 N·m (25 ft-lb) per revolution during the last half of the application.

5.2.5 RAMP APPLICATIONS—Make five ramp applications from 50 km/h (31 mph) at 100 °C (212 °F) then five additional ramp applications from 100 km/h (62 mph) at 100 °C (212 °F).

5.2.5.1 Analyze the 50 and 100 km/h (31 and 62 mph) ramp application data to verify correct brake release points and pressure ramp rate, as well as linearity of torque and pressure curves over the specified range.

5.2.5.2 The 50 and 100 km/h (31 and 62 mph) ramp applications serve as a measure of preburnish effectiveness.

5.2.6 INSTRUMENT CHECK COOLING CURVE—Immediately following the final 100 km/h (62 mph) ramp application, increase speed to 50 km/h (31 mph), apply 135 N·m (100 ft-lb) torque and drag (45 s on, 10 s off) to 230 °C (446 °F). Release brake, maintain 50 km/h (31 mph) with pre-established air flow and allow brake to cool. During cooling, measure rotor and pad temperatures, as well as brake drag torque at 15 s intervals (3 s on) from 205 °C (401 °F) for 240 s.

5.2.6.1 On completion of the instrument check cooling curve accelerate to 80 km/h (50 mph) and initiate BURNISH applications.

5.2.7 POST INSTRUMENT CHECK VERIFICATION OF TEST CONDITIONS—During the instrument check, or the early portion of the burnish, verify that the following test specifications are satisfied. If one or more of these conditions is not met, stop the test, make adjustments as required and repeat 5.2.3 through 5.2.6.1 with the same pads and rotor. If results still do not meet requirements of 5.2.7.1 through 5.2.7.6, abort the test.

5.2.7.1 Ramp rates during 50 and 100 km/h (31 and 62 mph) torque control applications should be 5170 kPa/s ± 275 kPa/s (750 psi/s ± 40 psi/s) as specified in 4.20.1.

5.2.7.2 Maximum torque range per revolution during the last half of the 2068 kPa (300 psi) applications should not exceed 34 N·m (25 ft-lb).

5.2.7.3 Brake release during the 50 and 100 km/h (31 and 62 mph) ramp applications should be at 2710 N·m ± 54 N·m (2000 ft-lb ± 40 ft-lb) or 13 800 kPa ± 275 kPa (2000 psi ± 40 psi).

5.2.7.4 Rotor temperature (IN1) during cooling curve meets Appendix D band.

5.2.7.5 Sustained torque (brake drag) during cooling curve should not exceed 14 N·m (10 ft-lb).

5.2.7.6 For torque control applications, specified pressure ramp rate is maintained through at least 700 N·m (516 ft-lb).

5.3 Burnish

5.3.1 Make 200 torque control applications from 80 to 3 km/h (50 to 2 mph) at 725 N·m (535 ft-lb) sustained torque and 100 °C (212 °F).

5.3.1.1 Warm brake to 100 °C (212 °F) by making a minimum number of 45 s interval applications at the specified speed and sustained torque. Count as part of the 200 total applications.

5.3.2 Immediately after the final burnish application, accelerate to 50 km/h (31 mph) for post burnish ramps.

5.4 Post Burnish Ramps

5.4.1 Make five ramp applications from 50 km/h (31 mph) at 100 °C (212 °F) then five additional ramp applications from 100 km/h (62 mph) at 100 °C (212 °F).

5.4.2 Immediately after the final 100 km/h (62 mph) post burnish ramp, accelerate to 100 km/h (62 mph) for post burnish pressure control stops.

5.5 Post Burnish Pressure Control Stops

5.5.1 Make two pressure control applications from 100 to 3 km/h (62 to 2 mph) at 3450 kPa (500 psi) sustained pressure and 100 °C (212 °F).

5.5.2 Immediately after the second 100 km/h (62 mph) pressure control stop, accelerate to 120 km/h (75 mph) for the fade heating cycle.

5.6 Fade Heating Cycle

5.6.1 Make 15 torque control snubs from 120 to 56 km/h (75 to 35 mph) at 725 N·m (535 ft-lb) sustained torque. Initial snub is at 100 °C (212 °F) then use 45 s brake apply to brake apply cycle times for remaining applications.

5.6.2 Immediately after the 15th fade snub, accelerate to 100 km/h (62 mph) for hot ramp applications.

5.7 Hot Ramps

5.7.1 Make two ramp applications from 100 km/h (62 mph).

5.7.1.1 Initiate first hot ramp application 35 s after the start of the 15th fade heating snub.

5.7.1.2 Initiate second hot ramp application 30 s after the start of the first hot ramp application.

5.7.2 Immediately after the second hot ramp application, accelerate to 100 km/h (62 mph) for the first hot stop application.

5.8 Hot Stops

5.8.1 Make two pressure control applications from 100 to 3 km/h (62 to 2 mph) at 3450 kPa (500 psi) sustained pressure and 315 °C (600 °F).

5.8.2 Immediately after the second pressure control hot stop, accelerate to 50 km/h (31 mph) for the first cooling cycle application.

5.9 Cooling Cycle

5.9.1 Maintain 50 km/h (31 mph) for 60 s between start of second hot stop and the start of first cooling cycle application. Make the three remaining cooling cycle applications at 120 s, start to start intervals.

5.9.2 Make four torque control applications from 50 to 3 km/h (31 to 2 mph) at 725 N·m (535 ft-lb) sustained torque.

5.9.3 Immediately after the fourth cooling cycle application, accelerate to 100 km/h (62 mph) for the first recovery ramp application.

5.10 Recovery Ramps

5.10.1 Make two ramp applications from 100 km/h (62 mph).

5.10.1.1 Initiate first recovery ramp application 60 s after the start of the fourth cooling cycle application.

5.10.1.2 Initiate second recovery ramp application 60 s after the start of the first recovery ramp application.

5.10.2 Immediately after the second recovery ramp application, accelerate to 80 km/h (50 mph) for the first reburnish application.

5.11 Reburnish

5.11.1 Make 35 torque control applications from 80 to 3 km/h (50 to 2 mph) at 725 N·m (535 ft-lb) sustained torque and 100 °C (212 °F).

5.11.2 Immediately after the final reburnish application, accelerate to 50 km/h (31 mph) for first post fade ramp application.

5.12 Post Fade Ramps

5.12.1 Make five ramp applications from 50 km/h (31 mph) then five ramp applications from 100 km/h (62 mph) and five ramp applications from 130 km/h (80 mph). Post fade ramp applications are run at 100 °C (212 °F).

5.12.2 Immediately after the final 130 km/h (80 mph) post fade ramp, accelerate to 50 km/h (31 mph) and initiate the post test cooling curve.

5.13 Post Test Cooling Curve

5.13.1 Heat rotor to 290 °C (554 °F) by applying 135 N·m (100 ft-lb) torque and drag at 50 km/h (31 mph) or use an equivalent method to heat the rotor. Release brake, maintain 50 km/h (31 mph) with preestablished air flow and allow brake to cool. During cooling, measure rotor and pad temperatures, as well as drag torque at 15 s intervals (3 s on) from 260 °C (500 °F) for 270 s.

END OF TEST (TOTAL 310 BRAKE APPLICATIONS) See 7.10.

6. Final Inspection and Test Report

6.1 Disassemble brake and inspect test parts, including rotor, friction material, and caliper/knuckle assembly.

6.1.1 Report any abnormal condition of the friction material assemblies such as cracking, crushing, loose rivets, tapered wear, or dimensional changes in steel-backing plates.

6.1.2 Report any abnormal rotor surface conditions such as cracks, heat checks, or scoring.

6.1.3 Report any dimensional changes or thermal abuse to caliper seals, boots, piston, or slide pins, as well as fluid leaks or caliper/knuckle binding.

6.2 Include Appendices D and E with instrument check and post test cooling curve results in test report.

6.3 For each brake application, calculate regressed specific torque values using a least squares regression algorithm within the ranges specified in 4.22.2 . Report burnish data for each tenth application. Report reburnish data for each fifth application.

6.3.1 Calculate and report the coefficient of determination (R^2) for each brake application.

6.3.2 Calculate and report hold off pressure from the least squares pressure/torque line at zero torque for each brake application.

6.4 Complete Appendix F check list and include in test report.

6.5 Generate a summary test report, including data for each brake application with column definitions as specified in 4.4 to 4.18.

7. Test Notes

7.1 BEF is the dimensionless ratio of brake force output to force input. If results are expressed in BEF units, specify factors used in the BEF calculation.

7.2 Low caliper slide force can normally be verified by manually moving caliper after assembly. The manufacturer's recommended practice is as follows: The piston and inboard pad are first pushed back into the caliper at least 1.30 mm (0.050 in). A screwdriver is inserted into the vent area of the rotor and brought up against the knuckle to keep the rotor from turning. A dial indicator is clamped to one of the wheel studs and the indicator pin zeroed against the outboard flange of the caliper housing. A pull scale with 445 N (100 lbf) capacity is hooked through the caliper window and the caliper is drawn outboard with the pull scale. Pull scale readings are recorded at displacements of 0.13, 0.25, and 0.50 mm (0.005, 0.010, and 0.020 in). If the caliper slide force is at or below 245 N (55 lbf) over the 0.13 to 0.50 mm (0.005 to 0.020 in) range, proceed with the test. If the caliper slide force exceeds 245 N (55 lbf), replace and lubricate the caliper mounting bushings.

7.3 Brake fluid chemistry can have an effect on seal roll-back. Also, silicone-based fluids are more compressible than glycol-based fluids at high temperature.

7.4 The procedure specifies the reporting of certain data beyond that required for calculating material effectiveness. Examples include maximum and sustained pressure and torque and end of stop temperatures. This information is included to assist in data analysis.

7.5 SAE J1652 is written around the 1992 GM B-CAR front axle disc brake and the specified inertia is based on vehicle measured data at 0.3 g decel. To run the test with other foundation brakes or for other applications, test inertia should correspond as closely as possible to the actual axle brake force fraction at gvw and 0.3 g decel for the vehicle application being simulated.

The brake cooling band specified in SAE J1652 is based on the B-CAR front disc data at 30 mph and 27 C (80 °F). If the test is run with other foundation brakes, the vehicle cooling rate should be determined so that the dynamometer cooling rate corresponds as closely as possible to the vehicle being simulated.

7.6 Hold off pressure can be useful to identify nonlinearity in the torque slope. Review of instantaneous torque/pressure/time data is recommended to analyze unusual results.

7.7 Instantaneous torque just prior to brake apply should not exceed 7 N·m (5 ft-lb).

7.8 A plot of the log of (rotor temperature - ambient temperature) versus time is a useful alternative to plotting rotor temperature versus time. Brake drag makes this semi-log plot nonlinear, especially at the lower temperatures.

7.9 Torque fluctuation per revolution during the low speed portion of a stop can be a useful measure of rotor run-out, flatness or thickness variation.

7.10 No unspecified brake applications are to be run before, during or after the test.

7.11 The post test cooling curve is included for diagnostic purposes only and meeting the specified band is not necessarily a criterion for a valid test. If the post test cooling curve is within the specified band, this indicates that air flow and temperature have not changed through the test. If the post test cooling curve deviates from the band, or if final drag torque exceeds the specification, this may indicate friction material or caliper drag or that there has been a change in air flow rate or temperature. Further investigation is required.

7.12 All data within the specified range is to be included in calculations for each application. No data is to be excluded during or after transition from ramp control to torque or pressure control.

PREPARED BY THE SAE BRAKE COMMITTEE SC2—LININGS

APPENDIX A

GMB-CAR FRONT DISC BRAKE ASSEMBLIES

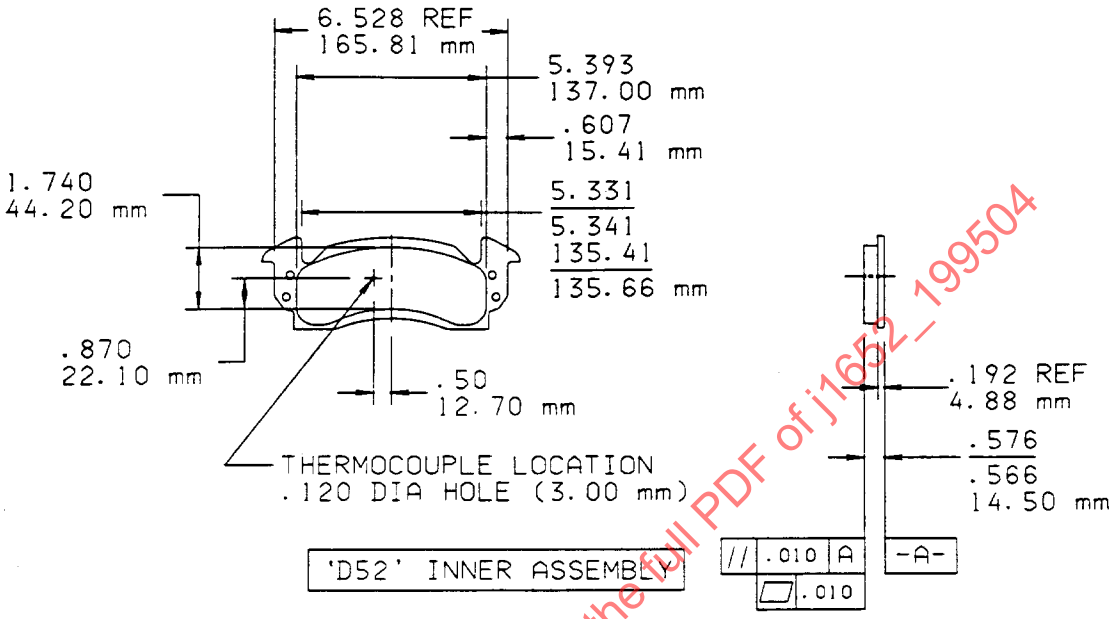

FIGURE A1—GMB-CAR FRONT DISC BRAKE ASSEMBLY—'D52' INNER ASSEMBLY

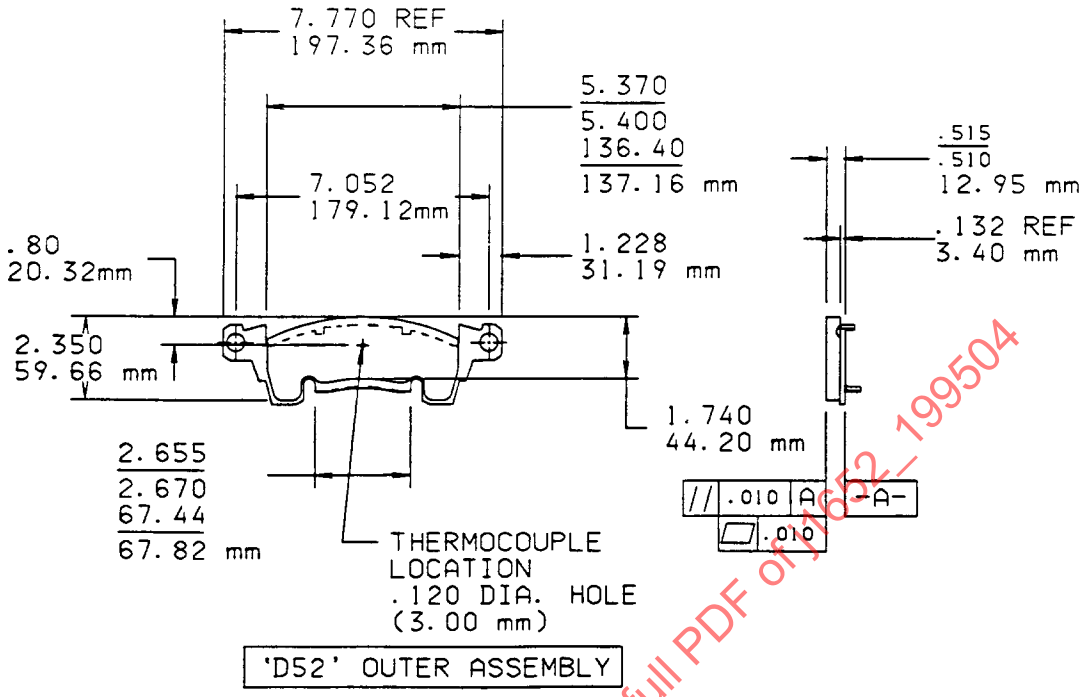

FIGURE A2—GMB-CAR FRONT DISC BRAKE ASSEMBLY—'D52' OUTER ASSEMBLY

APPENDIX B

ROTOR THERMOCOUPLE INSTALLATION

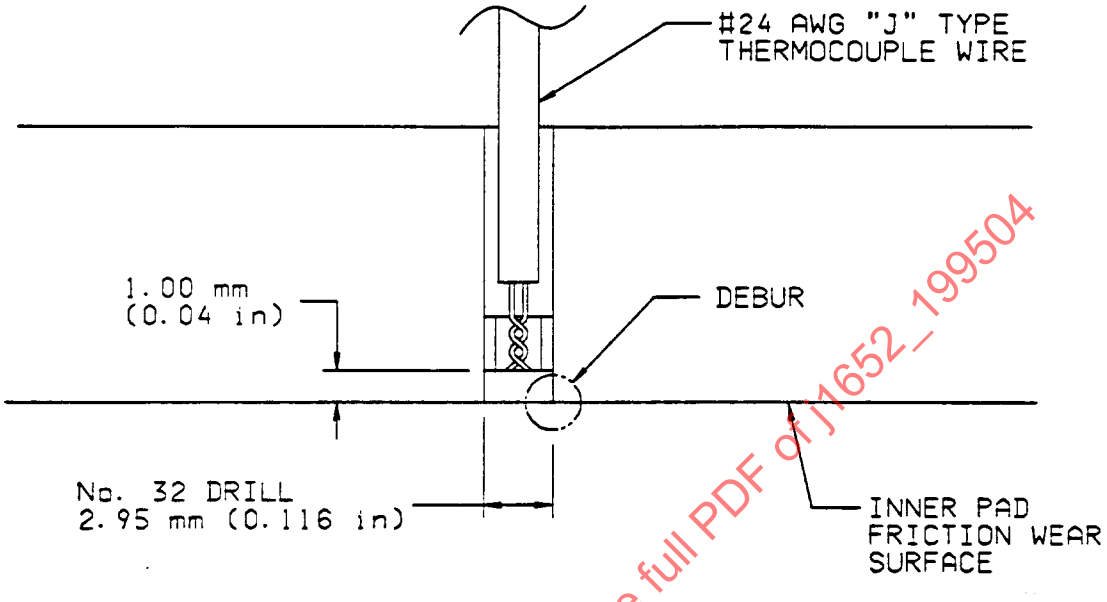

FIGURE B1—ROTOR THERMOCOUPLE INSTALLATION