



Inertia Dynamometer Brake Lining Wear Versus Temperature

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard describes an inertia dynamometer test used to measure brake lining wear rates over a range of brake operating temperatures.

1.2 Applicability. All passenger car and light truck brake corners.

1.3 Remarks. This standard is intended to quantify brake lining wear rate as a function of brake operating temperature. This procedure is based on Japanese Automobile Standards Organization (JASO) Wear Procedure JASO C427-83 and SAE International (SAE) Wear Procedure SAE J2707. The procedure can be used to compare the wear rate performance among various lining materials, validate per subsystem performance requirements, and to empirically determine the mathematical expression for lining wear for predictive modeling.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

JASO C427-83 SAE J2707

2.2 GM Standards/Specifications.

GMW14925 GMW14974 GMW14986 GMW15142

2.3 Additional References.

- CG1292
- Global Document Management (GDM), <https://gmweb.gm.com/sites/GDM/Pages/default.aspx> (ID)

(ID) = This website is limited to internal access within General Motors and is not available outside the company. Contact the GM Lead Engineer for further instructions.

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 Milford Proving Ground Chassis Component Development (CCD) inertia brake dynamometer or equivalent test facility shall be used.

3.1.4 Milford Proving Ground Brake Component Development (BCD) inertia brake dynamometer or equivalent dynamometer shall be used which has been previously accredited through the Test Improvement Process (TIP).

3.2 Equipment.

3.2.1 An inertia brake dynamometer capable of performing torque control, pressure control, corrected pressure control, ramp, and modulated brake applies.

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3.2.2 The following measurements shall be made and digitally recorded at 500 Hz:

3.2.2.1 Dynamometer speed (in kilometers/hour).

3.2.2.2 Brake apply pressure (in kilopascals).

3.2.2.3 Brake torque (in Newton-meters).

3.2.2.4 Brake rotor or drum temperature (in degrees Celsius).

3.2.2.5 Fluid displacement (in cubic millimeters).

3.2.2.6 Cooling air temperature (in degrees Celsius).

3.2.2.7 Cooling air relative humidity (percent relative humidity).

3.3 Test Vehicle/Test Piece. Production representative brake corner hardware shall be used to produce the tailstock assembly.

3.4 Test Time.

Calendar time: 5 days to 10 days

Parts Preparation Time: 2 hours

Setup Time: 2 hours

Test hours: 50 hours to 100 hours

Coordination hours: 2 hours to 4 hours

3.5 Test Required Information. The following measurements shall be made and digitally recorded at 10 Hz.

3.5.1 Output voltage from the electronic wear sensor, when applied with a 10 V input power source throughout test. Data should be logged during brake applies and in between brake applies.

3.6 Personnel/Skills. One (1) technician trained for the operation of an inertia brake dynamometer and to perform the duties described in Section 4 is required.

4 Procedure

4.1 Preparation.

4.1.1 Embedded rotor or drum thermocouple shall be installed per GMW14974.

4.1.2 The assembled corner Lateral Run Out (LRO) shall not exceed 50 μm . The corner LRO shall be measured on the outboard face of the rotor at a radius 10 mm inside of the rotor outer diameter using a dial indicator.

4.2 Conditions.

4.2.1 Environmental Conditions. Cooling air is provided to the brake. Cooling air temperature shall be between +10 °C and +30 °C. Cooling air humidity control is not required.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 The dynamometer inertia shall be set as described in GMW15142 using Gross Vehicle Weight (GVW) parameters.

4.3 Instructions.

4.3.1 Testing shall be performed without brake lining noise insulators. Measure and record the start of test brake lining thickness per GMW14986 (Brake Lining Thickness Measurement) and lining mass. Measure and record the start of test rotor mass and rotor thickness. Rotor thickness should be measured in at least six (6) angular positions, equally spaced, at a radial position 10 mm inside the outer diameter of the rotor plate. The default pressure apply ramp rate shall be 25 MPa/s throughout the test. Reference Figures A6 thru A8 (Appendix A) for a detailed visual breakdown of how to apply the various optional test sections.

4.3.2 Perform a full GMW14925 test (without park brake test sections) to burnish the brake hardware.

4.3.3 For drum brakes only, perform 800 additional burnish stops under the same conditions as the brake burnish schedule in GMW14925.

4.3.4 Allow the brake rotor to cool to +50 °C with 70 km/h cooling air speed and 10 km/h dynamometer speed.

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4.3.5 Measure and record the post burnish brake lining thickness according to GMW14986 and lining mass. Measure and record the post GMW14925 rotor mass and rotor thickness.

4.3.6 Seventy Five Degrees Celsius (75 °C) Wear Section for Low Metallic (Met) Applications Only. Perform torque control stops from 50 km/h initial speed to 1 km/h final speed at 0.3G deceleration, and cooling air speed set to 0 km/h until Initial Brake Temperature (IBT) reaches +75 °C. Perform additional stops from an IBT of +75 °C and with the cooling air speed set to 50 km/h until 1000 stops in all have been made.

4.3.7 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.8 Perform torque control stops from 50 km/h initial speed to 1 km/h final speed at 0.3G deceleration, and cooling air speed set to 0 km/h until IBT reaches +100 °C. Perform additional stops from an IBT of +100 °C and with the cooling air speed set to 50 km/h until 1000 stops in all have been made.

4.3.9 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.10 One Hundred Twenty Five Degrees Celsius (125 °C) Wear Section for Low Met Applications Only. Perform torque control stops from 50 km/h initial speed to 1 km/h final speed at 0.3G deceleration, and cooling air speed set to 0 km/h until IBT reaches +125 °C. Perform additional stops from an IBT of +125 °C and with the cooling air speed set to 50 km/h until 1000 stops in all have been made.

4.3.11 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass

4.3.12 Repeat 4.3.8 except for IBT of +150 °C.

4.3.13 Measure and record the brake lining thickness per GMW14986 and lining mass.

4.3.14 Repeat 4.3.8 except for IBT of +200 °C and cooling air speed of 40 km/h, once the IBT has been reached.

4.3.15 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.16 Repeat 4.3.8 except for IBT of +250 °C and cooling air speed of 30 km/h, once the IBT has been reached.

4.3.17 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.18 Repeat 4.3.8 except for IBT of +300 °C and cooling air speed of 10 km/h, once the IBT has been reached, and perform 500 stops in all. If IBT has not been attained within 100 stops, proceed to 4.3.20.

4.3.19 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.20 Repeat 4.3.18 except for IBT of +350 °C and cooling air speed of 5 km/h.

4.3.21 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.22 Repeat 4.3.18 except for IBT of +400 °C and cooling air speed of 5 km/h.

4.3.23 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.24 Repeat 4.3.8 (IBT of +100 °C).

4.3.25 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass. If the truck brake sections (4.3.26 thru 4.3.29) will not be performed, record end of test rotor mass.

4.3.26 Five Hundred Degrees Celsius (500 °C) Wear Section for Truck Applications Only. Perform torque control snubs from 80 km/h initial speed to 50 km/h final speed at 0.3G deceleration, and cooling air speed set to 0 km/h until IBT reaches +500 °C. Perform additional stops from an IBT of +500 °C and with the cooling air speed set to 5 km/h until 200 stops in all have been made.

4.3.27 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.28 Six Hundred Degrees Celsius (600 °C) Wear Section for Truck Applications Only. Repeat 4.3.26 except for IBT of +600 °C.

4.3.29 Measure and record the brake lining thickness per GMW14986, rotor thickness and lining mass.

4.3.30 For Programs with Electronic Pad Wear Sensors, Evaluation for Wear Sensor State Transition Number 1. If the pad wear throughout the test has not been sufficient to transition through the first wear sensor state, mill pad thickness down to wear sensor Stage one (1) height + 0.5 mm. Repeat 4.3.18 thru 4.3.23 until stage transition is demonstrated.

4.3.31 For Programs with Electronic Pad Wear Sensors, Evaluation for Wear Sensor State Transition Number 2. If the pad wear throughout the test has not been sufficient to transition through the second wear sensor state, mill pad thickness down to wear sensor Stage 2 height + 0.5 mm. Repeat 4.3.18 thru 4.3.23 until stage transition is demonstrated.

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5 Data

5.1 Calculations.

5.1.1 Number of Stops. For each temperature increment, report the number of stops required to reach the specified IBT.

5.1.2 Brake Lining Wear. Brake lining wear (millimeters) per 1000 stops at each temperature increment shall be tabulated (see Appendix A, Table A1) and plotted (see Appendix A, Figure A1) for each lining (inboard and outboard) as well as the average. Measured lining wear for the +300 °C, +350 °C, +400 °C, +500 °C, and +600 °C shall be multiplied by the appropriate factor to represent wear per 1000 stops.

5.1.3 Tapered Lining Wear. Radial and tangential taper (micrometers per millimeter) for each lining (inboard and outboard) shall be tabulated (see Appendix A, Table A2) and plotted (see Appendix A, Figure A2).

5.1.4 Brake Lining Mass Loss. Brake lining mass loss (grams) per 1000 stops at each temperature increment shall be tabulated and plotted (see Appendix A, Figure A3). Measured mass loss for the +300 °C, +350 °C, +400 °C, +500 °C, and +600 °C sections shall be multiplied by the appropriate factor to represent the mass loss per 1000 stops.

5.1.5 Volumetric Wear. Brake lining volumetric wear (cubic millimeter per megajoule) per 1000 stops at each temperature increment shall be plotted (see Appendix A, Figure A4).

5.1.6 Average Apparent Friction. Average apparent friction shall be calculated for every 10th stop and plotted vs. stop number (see Appendix A, Figure A5) for each temperature increment.

5.1.7 GMW14925 Data. Process the GMW14925 data using standard GMW14925 data procedure.

5.2 Interpretation of Results. Results may be compared to applicable technical specifications or to the results for other brake corners.

5.3 Test Documentation. Publish test information and results according to GM company protocol using the Evaluation Report template and Global Document Management (GDM) system.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Average Apparent Friction: The distance weighted average of the instantaneous friction or output. For constant deceleration brake applies, this is determined during the steady state portion of the braking event. This excludes the initial 10% of the stop after hydraulic pressure/torque has reached steady state level and the final 10% of the stop before pressure release as the dynamometer speed approaches zero.

Brake Burnish Schedule: Two hundred (200) corrected pressure control stops at an IBT of $\leq +100$ °C, 80 km/h initial speed, 40 km/h to 60 km/h cooling air speed, 3500 kPa/s apply rate, to a 0.31G deceleration rate, with a cooling air speed of 50 km/h.

Corrected Pressure Control: Dynamometer pressure control algorithm that calculates the average deceleration attained during a constant pressure apply and corrects the pressure level for the next stop to attain a desired deceleration level.

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