



Inertia Dynamometer Brake Rotor Coning Evaluation

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 documents an inertia dynamometer test procedure to assess brake rotor coning and thermal deformation.

1.2 Applicability. This procedure is applicable to all passenger car and light truck brake corners.

1.3 Remarks. This standard assesses brake rotor coning as a function of brake operating temperature. This standard creates the elevated brake power and operating temperature environment when a brake rotor may exhibit directional thermal deformation known as **coning** along with the brake pulsation phenomenon sometimes referred to as **hot judder**. This type of brake pulsation occurs only at elevated brake operating temperatures. The dynamometer test schedules outlined in this procedure and GMW14985 were derived from GMW15919 and should be used as the first tool of brake roughness/pulsation physical evaluation during the brake development process.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14925

GMW14985

GMW15142

GMW15919

GMW14974

2.3 Additional References.

- Evaluation Report Template
- Global Document Management (GDM) System
- Rotor Coning Schedule (Base and Vehicle Maximum Speed (Vmax))

3 Resources

3.1 Facilities. The Milford Proving Ground Brake Systems Laboratory inertia brake dynamometer or equivalent test facility shall be used.

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.

3.2 Equipment.

3.2.1 An inertia brake dynamometer capable of constant pressure control applies.

3.2.2 A dial indicator and a micrometer with a minimum resolution of 1 μm .

3.2.3 Non-contact capacitance proximity sensors with a minimum resolution of 1 μm and a frequency response of at least 1000 Hz. A voltmeter shall be used to calibrate the probe-to-rotor air gap for each proximity sensor.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

February 2015

Page 1 of 11

3.2.4 The following measurements shall be made and digitally recorded at 500 Hz.

- a. Dynamometer speed in kilometers/hour.
- b. Time in seconds.
- c. Brake apply pressure in kilopascals.
- d. Brake torque in newton-meters.
- e. Brake rotor/drum temperature in degrees Celsius.
- f. Cooling air temperature in degrees Celsius.
- g. Cooling air speed in kilometers/hour.

3.2.5 Throughout the brake warm-up stops and Base Rotor Coning Schedule, the measurements (3.2.5.1 and 3.2.5.2) shall be made and digitally recorded at 1000 Hz.

3.2.5.1 Rotor Lateral Runout (LRO) (micrometers), Rotor Thickness Variation (micrometers) and Rotor Coning (micrometers) at one to three points along the brake swept area on both the inboard and outboard rotor faces. See Figure A1, Appendix A.

Note: The minimum point is at the specified outer diameter location.

3.2.5.2 Rotor positional marker voltage.

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

3.4 Test Time.

Calendar time: 1 day
Test hours: 8 hours
Coordination hours: 2 hours

3.5 Test Required Information. Not applicable.

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

4 Procedure

4.1 Preparation.

4.1.1 An embedded rotor thermocouple shall be installed per GMW14974.

4.1.2 The pretest and posttest assembled corner LRO shall not exceed 50 μm . The corner LRO shall be measured on the inboard face of the rotor at a radius 10 mm inside of the rotor outer diameter using a dial indicator or non-contact proximity sensors. The assembled LRO shall be measured and recorded at both pretest and posttest conditions.

4.1.3 The initial Rotor Thickness Variation (RTV) shall not exceed 5 μm . The RTV shall be measured at a radius 10 mm inside of the rotor outer diameter.

4.1.4 Non-contact proximity sensors shall be placed on the assembly to measure rotor thermal deformation and coning. The proximity sensors should be mounted as close to the brake caliper as possible, shown in Figure A2, Appendix A. Each proximity sensor should be calibrated properly using a voltmeter prior to the beginning of the test. The transducers shall be placed as shown in Figure A1, Appendix A.

4.2 Conditions.

4.2.1 Environmental Conditions. Cooling air is provided to the brake corner during the test. 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 See GMW15142 for loading conditions. The inertia equivalent to the gross vehicle loading condition weight is recommended, however, the equivalent lightly loaded vehicle loading inertia may be added to the test sequence, if requested.

4.3 Instructions.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

February 2015

Page 2 of 11



Documents

Document Sharing Hub

4.3.1 Run the test per instructions listed in Table A1, Appendix A.

4.3.2 Perform beginning of test through the 200 stop burnish section of GMW14925.

4.3.3 Perform brake warm-up stops until rotor temperature is greater than 100 °C, and then perform the Base Rotor Coning Schedule for a total of one (1) snub.

4.3.4 Assess the condition of the brake hardware and the proximity sensors and repeat 4.3.3 until five cycles of the Base Rotor Coning Schedule have been completed. Allow the rotor to cool to < 65 °C after each snub with a cooling air speed of 30 km/h before performing the warm-up stops 4.3.3.

4.3.5 Perform brake warm-up stops until rotor temperature is > 100 °C, and then perform the Vehicle Maximum Speed (Vmax) Rotor Coning Schedule for a total of one (1) snub.

4.3.6 Assess the condition of the brake hardware and the proximity sensors and repeat 4.3.3 until five cycles of the Vmax Rotor Coning Schedule have been completed. Allow the rotor to cool to < 65 °C after each snub with a cooling air speed of 30 km/h before performing the warm-up stops in 4.3.5.

5 Data

5.1 Calculations. Any needed calculations are described in 5.1.1.

5.1.1 Data Presentation.

5.1.1.1 Calculate average coning values obtained by the proximity sensors at the before and after brake apply conditions. These values shall be calculated for each individual coning stop during the whole test. A summary table showing the average Outboard (OB) and Inboard (IB) (of rotor face) coning values shall be included as shown in Table B1 of Appendix B. The OB and IB coning values shall be plotted as a function of the coning stop number for the before and after brake apply condition as shown in Figure B1 of Appendix B. An example plot of the IB vs. OB coning change with respect to the stop number is shown in Figure B2, Appendix B.

5.1.1.2 Perform order tracking on torque time data for each stop to determine the peak-to-peak Brake Torque Variation (BTV) resulting from the first four orders. Using the peak-to-peak torque variation and phase angle of each of the first four orders, reconstruct each stop. Record the peak-to-peak BTV (newton·meters and percent), average torque, average apparent friction, initial brake temperature and maximum brake temperature for each snub/stop.

5.1.1.3 Calculate the maximum in-stop RTV. Perform order tracking on RTV time data for each stop to determine the maximum order component of the in-stop RTV. Record the maximum in-stop RTV and dominant order component for each thermal roughness stop.

5.1.1.4 Calculate the rotor coning value with proximity sensor data recorded just prior to and just after the application of caliper pressure during the Rotor Coning Schedule. The final rotor coning value and the change in the rotor coning value during each snub should be reported. The calculated rotor coning value should be plotted versus stop number for each coning section.

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 the test information and results according to GM corporate protocol using the Evaluation Report Template and Global Document Management (GDM) system.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Base Rotor Coning Schedule: Snubs are made from 115 km/h to 5 km/h with a first stop Initial Brake Temperature (IBT) of 100 °C, 2 km/h cooling air speed, 20 000 kPa/s pressure apply rate, and 2000 kPa constant pressure control.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

February 2015

Page 3 of 11



Documents
Document Sharing Hub

Brake Torque Variation: Brake Torque Variation is the difference between the maximum and minimum braking torque during a braking event. The peak-to-peak BTV refers to the difference between the maximum and minimum braking torque during one revolution of a braking event.

Constant Pressure Control: A dynamometer control algorithm that maintains the brake pressure at a constant level during a brake apply.

Initial Brake Temperature: The brake rotor temperature at the start of the braking event.

Rotor Coning: The rotor coning value is the difference between the outboard, outer diameter probe-to-rotor air gap and outboard, inner diameter probe-to-rotor air gap. This rotor coning value should be calculated with proximity sensor data recorded just prior to and just after the application of caliper pressure during the Rotor Coning Schedule.

Rotor Thickness Variation: Rotor thickness variation is the difference between the maximum total rotor lateral runout and the minimum total rotor lateral runout during one revolution. Total LRO is the sum of inboard and outboard rotor cheek LRO at each measurement position.

Snub: The braking deceleration of a vehicle from a higher reference speed to a lower reference speed greater than zero.

Vmax Rotor Coning Schedule: Snubs are made from Vmax initial speed (160 km/h, if unknown) to 5 km/h with a first stop IBT of 100 °C, 2 km/h cooling air speed, 20 000 kPa/s pressure apply rate and 5000 kPa constant pressure control.

7.2 Acronyms, Abbreviations, and Symbols.

BTV	Brake Torque Variation
CD	Center Diameter
GDM	Global Document Management
GSSLT	Global Subsystem Leadership Team
IB	Inboard (rotor face)
IBT	Initial Brake Temperature
ID	Inner Diameter
LRO	Lateral Runout
OB	Outboard (rotor face)
OD	Outer Diameter
RTV	Rotor Thickness Variation
Vmax	Vehicle Maximum Speed

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW17340

9 Release and Revisions

This standard was originated in January 2015. It was first approved by Chassis Brake Global Subsystem Leadership Team (GSSLT) in February 2015. It was first published in February 2015.

Issue	Publication Date	Description (Organization)
1	FEB 2015	Initial publication.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

February 2015

Page 4 of 11



Documents
Document Sharing Hub