Toluca Mountain Descent Brake Thermal Roughness Vehicle Subjective 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 procedure is an evaluation of a vehicle and vehicle brake system for the phenomenon of brake thermal roughness, also known as judder or hot judder, in the Toluca Descent Route.

1.2 Applicability. This procedure is applicable to all passenger vehicles and light trucks with Gross Vehicle Weight Rating (GVWR) less than 3856 kg.

1.3 Remarks. The test schedule in this procedure is derived from thermal roughness procedures submitted for review by GM global engineering centers. This procedure includes a driving schedule to simulate the brake energy loading experienced by drivers during the Toluca mountain descent.

The following statements should be considered anecdotal until such time that research data are provided to substantiate the statements.

The vehicle evaluation in this procedure results in a subjective rating by the test team of the vibration sensed due to braking-induced thermal roughness. An optional objective measurement section using an in-vehicle measurement approach, similar to GMW14919, is included in order to establish a correlation between objective accelerometer measurements and subjective driver evaluations.

Brake thermal roughness is considered a brake corner issue. A brake laboratory dynamometer test, GMW14985, is available to evaluate the brake corner propensity for thermal roughness. The dynamometer test schedules were derived from GMW15191 and should be used as the first tool of physical evaluation during the brake development process.

This procedure uses a public road drive schedule to introduce heat into the brake corner hardware. Depending on the material, material structure, stiffness, geometry, etc., of the rotor/drum/lining, thermal variants in the rotor or drum may cause torque variation during braking, that results in vibrations noticeable to the driver and occupants of the vehicle. The roughness or vibration may propagate through the brake pedal, the steering wheel, the seat track, the floor pan, etc., depending on the vehicle.

The public road drive schedule in this procedure was developed specifically to produce the thermal roughness phenomenon as seen in Mexican market conditions. The Toluca descent test procedure is run on public federal highway M15 connecting Toluca to Mexico City between Lerma and La Venta. This route is representative of the mountain roads in central Mexico and has the highest concentration of vehicular traffic in the country. Refer to Appendix A, Figure A1, for the elevation profile of the route.

The thermal cooling capability of the brake corner affects the development of thermal roughness. The Brake Equilibrium Temperature (BET) procedure GMW14924 should be used to measure the cooling capability of the brake corner. Technical specifications define the limits for the BET by program expectations.

Vehicle sensitivity to brake roughness and vibration is an issue with all brake roughness mechanisms, but the magnitude of the vibrations during the thermal roughness event may mask any vehicle sensitivity issues. GMW14919 is applicable to understand the vehicle sensitivity contribution to thermal roughness.

Thermal roughness is also a vehicle integration issue, as there are countermeasures that can be performed on the vehicle as a whole to minimize the possible occurrence of a drive schedule that would create thermal roughness (such as powertrain grade braking).

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2 References

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

2.1 External Standards/Specifications.

CMVSS 135 FMVSS 135

2.2 GM Standards/Specifications.

GMW14919 GMW14926 GMW14985 GMW15191
GMW14924

2.3 Additional References.

- CG190 (ID)
- Global Document Management (GDM) System (https://documents.gm.com/gdm3/component/main) (ID)

(ID) = This website is limited to internal access within General Motors Company and shall not be accessed outside this company. Contact the GM Lead Engineer for further information.

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 Toluca Descent Route.

3.1.4 Asphalt or concrete vehicle track for brake burnish stops.

3.1.5 Vehicle weighing station**.**

3.2 Equipment.

3.2.1 Deceleration U-tube mounted within view of the driver.

3.2.2 Decelerometer.

3.2.3 Thermocouples for the brake friction material.

3.2.4 Ambient temperature thermocouple.

3.2.5 Vehicle speed and distance measurement equipment.

3.2.6 Brake temperature monitoring equipment visible to driver.

3.2.7 Data acquisition system capable of recording multiple temperature channels and any other requested channels (e.g., vehicle velocity, distance, deceleration, etc.)

3.2.8 Recommended optional instrumentation.

3.2.8.1 Triaxial accelerometers at the driver's side floor, seat bottom, seat back, steering wheel, steering column, left outboard seat track, spindles (as near as possible to the wheel spin axis), caliper bracket shoulder area (one channel in rotor tangential direction) and a data acquisition system capable of measuring at least a 256 Hz scan rate. (See GMW14919 for details). The driver's side floor accelerometer must be able to measure a nearly constant acceleration.

3.2.8.2 Non-contact rotor thickness variation measurement equipment, if requested.

3.3 Test Vehicle/Test Piece.

3.3.1 Test vehicle should be representative with respect to vehicle mass, vehicle mass distribution, ride height, front fascia design, wheel vent area, brake cooling enhancements (if any), brake corner hardware, and corner suspension.

3.3.2 New brake rotors, drums, pads, and linings at each vehicle corner are recommended. The measurement of Rotor Thickness Variation (RTV) and Assembled Lateral Run Out (ALRO) (at locations outlined in GMW14926) is recommended before and after running this procedure. The initial RTV shall not exceed 5 µm or the RTV specified for rotor under test. The initial ALRO shall not exceed 50 µm or the ALRO specified for the corners under test.

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3.4 Test Time.

Calendar time:	7 days/test
Test hours:	36 hours to 48 hours
Build time:	0.5 days/build
Coordination hours:	8 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills.

3.6.1 Personnel to set up vehicle for test and to drive the burnish and test schedule are required.

3.6.2 An observer to ride in the vehicle to help in the subjective rating and the documentation of the rating is required.

4 Procedure

4.1 Preparation.

4.1.1 Obtain signoff that the vehicle is representative. Check and adjust tire pressures as needed. Weigh vehicle. Document the information in the test record.

4.1.2 Install thermocouples in brake linings. Use plug-type thermocouples installed in the approximate center of the facing length and width of the most heavily loaded shoe or disc pad, one (1) per brake. For brake drum shoe, recess the thermocouple 1 mm (0.040 in) under the surface. For disc brake pad recess the thermocouple 2 mm (0.080 in) under the surface. A second thermocouple may be installed at the beginning of the test sequence if the lining wear is expected to reach a point causing the first thermocouple to contact the metal rubbing surface of a drum or rotor. For center-grooved shoes or pads, thermocouples are installed within 3 mm (0.12 in) to 6 mm (0.24 in) of the groove and as close to the center as possible.

4.1.3 Place the ambient temperature thermocouple inside a containing tube. The tube shall be mounted on the outside of the vehicle exposed to the free air stream. Recommended mounting position is on the right front quarter panel.

4.1.4 Install the brake hardware. Tighten fasteners to manufacturer's recommended torque requirements. Measure the rotor thickness variation of rotors before installation, if requested.

4.1.5 Complete installation of instrumentation and data acquisition system. Make certain that driver can monitor vehicle speed, deceleration, distance, and brake temperatures as needed.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 The test may be conducted in any ambient temperature and wind conditions. Note, however, that the brake cooling will be affected by the ambient conditions. Document the conditions in the test record.

4.2.1.2 Road surface must be dry.

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 If comparing several vehicles, always use the same burnish and vehicle loading, and run the tests in similar ambient conditions.

4.2.2.2 Having an observer in the vehicle is required. For safety and accuracy of execution of the drive schedule, the driver should be freed from having to write down the subjective rating for each stop while driving the schedule.

4.2.2.3 Lightly Loaded Vehicle Weight (LLVW) is recommended for the drive schedule; however, gross vehicle loading may be added to the test sequence in addition to the lightly loaded condition, if requested. LLVW for this test is defined as the weight of the vehicle as received for test, plus the driver, plus any instrumentation, plus the observer, plus fuel load of full to 75% capacity. If an observer is not to ride in the vehicle during test, add 60 kg additional load. Document the vehicle weight in the test record.

4.2.2.4 Use drive or in-gear transmission position. Downshifting to reduce vehicle speed is not allowed for the drive schedule.

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