



High Performance Vehicle Brake Test for Race Track Duty Cycle

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 determines the brake system performance of a high performance vehicle during an aggressive, brake fade-inducing drive schedule.

1.2 Applicability. This standard applies to high performance passenger cars, high performance light duty trucks, and high performance light duty multipurpose vehicles.

1.3 Remarks. This standard quantifies brake system performance for enthusiast or extreme usage type maneuvers where repeated brake usage creates a possible brake fade situation. It is based on a repetitive braking cycle suitable for flat track (straight line) testing and for analysis. The cycle is tunable to vehicle capability and race track severity by adjusting the braking speed and cooling dwell time according to logical rules. The test cycle is constructed to align in severity with a target race track.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14927

GMW15102

GMW17109

2.3 Additional References.

- Global Document Management (GDM) System (<https://documents.gm.com/gdm3/component/main>) (ID)
- Vehicle Technical Specification (VTS)

(ID) = This link is limited to internal access within General Motors and shall not be accessed outside this 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 Circular test track, or equivalent, for twenty-five (25) continuous acceleration and deceleration driving cycles. The road surface shall have a peak coefficient of friction level of 0.9 or higher.

3.1.4 Vehicle weighing station, providing at least the mass (weight) per each axle.

3.1.5 Vehicle ballast station.

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3.2 Equipment.

3.2.1 Service brake pedal force transducer.

3.2.2 Service brake pedal travel transducer (or signal from pedal travel sensor from test vehicle's Local Area Network (LAN)).

3.2.3 Accelerometer.

3.2.4 Brake booster vacuum transducer installed on the booster side of the check valve.

3.2.5 Engine vacuum sensor (if applicable).

3.2.6 Hydraulic line pressure transducers at each brake corner.

3.2.7 Fifth wheel or Global Positioning System (GPS)-based speed and position sensor. If fifth wheel is not rated for the test speed, use a GPS-based sensor.

3.2.8 Ambient temperature thermocouple.

3.2.9 Brake fluid thermocouples (usually installed in bleeder screw location). If inner and outer bleed screws are available, both should be thermocoupled if possible (with preference given to the outer bleed screw if only one is used).

3.2.10 Brake lining thermocouples. Brake lining thermocouples should be installed in both inboard and outboard pads per instructions in GMW15102.

3.2.11 Digital data acquisition system capable of 100 Hz sample rate for at least 25 channels. Data acquisition memory must be capable of recording the entire test sequence as one continuous file.

3.2.12 Stopwatch or similar timer.

3.2.13 Stop counter.

3.2.14 Optional instrumentation.

3.2.14.1 Rotor thermocouples.

3.2.14.2 Yaw rate sensor.

3.2.14.3 Hydraulic displacement transducers

3.2.14.4 Torque wheels.

3.3 Test Vehicle/Test Piece. In selection of the test vehicle, consideration is to be given to the combination of axle ratio, type and size of tires, type of wheels and wheel covers, engine, body type and front to rear mass (weight) distribution. The test vehicle should be representative of the extreme characteristics of the vehicle family.

3.3.1 Test Vehicle Chassis Controls. The test vehicle shall be equipped with the most current chassis controls calibration available. If so equipped, the chassis controls should be run in the track mode or competitive mode setting. It is highly recommended that the responsible chassis controls engineer be consulted to determine the settings and calibrations needed to be most representative of race track usage.

3.4 Test Time. Test time is an estimate of the amount of time needed to perform the procedure. Preparation, other downtime, actual test time, and data analysis time is captured in the total calendar time.

Calendar time: 5 days to 6 days

Test hours: 24 hours to 30 hours

Coordination hours: 6 hours to 8 hours

Note: Testing is weather dependent. Weather delays are not accounted for in the estimates.

3.5 Test Required Information.

3.5.1 The ambient temperature will affect the cooling during the abuse fade tests. Always note the ambient temperature and use engineering judgment when comparing results from tests run at significantly different ambient temperatures.

3.5.2 Hydraulic displacement transducers may be used for the abuse test to determine whether the master cylinder has reached full stroke (bottomed out).

3.5.3 Torque wheels may be used, but should not be used at test speeds beyond torque wheel speed rating. Also note that the different vent area of the torque wheel may affect the brake temperatures on a fade test.

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3.6 Personnel/Skills. An experienced, trained brake technician or engineer is required for vehicle preparation, instrumentation, and test driving. The driver will need to have all certifications required for the facility being used to drive up to the target test speed for short periods of time. Very high speeds (200 km/h to 300 km/h) may be required for some vehicles.

4 Procedure

4.1 Preparation.

4.1.1 Document basic information such as vehicle make, model, year, vehicle identification number, mileage, car number and full brake system, and tire and wheel description in the test record.

4.1.2 If an as received floor check is requested, install the instrumentation necessary to perform the initial floor check. Perform the floor check following instructions in GMW14927 Brake System Floor Check Procedure.

4.1.3 Build brake system per test request. New brake hardware is recommended.

4.1.4 Perform the build floor check following instructions in GMW14927.

4.1.5 Install the brake line pressure transducers. Perform the Start of Test (SOT) floor check following instructions in GMW14927. Compare the SOT floor check data with the build floor check data. If necessary, perform brake bleeds and floor checks to return brake system to original performance.

4.1.6 Finish installation of instrumentation. Set data acquisition system to record all temperature channels at 10 Hz and all other data channels at 50 Hz (or at appropriate scan rates for data acquisition system being used). Data is to be recorded as one continuous file. Memory capability of the data acquisition system should be checked before starting fade test.

4.1.7 Fill fuel tank to capacity. Maintain fuel level above 75% during the testing if possible.

4.1.8 Adjust tire pressure to manufacturer's specifications and record.

4.1.9 Ensure tire speed rating at test pressure, meets or exceeds test speed.

4.1.10 Check wheel lug nut or wheel bolt torques.

4.1.11 Ensure that all safety requirements for the test facility are followed.

4.1.12 All vehicle openings are to be closed except as required for instrumentation or ventilation. Record any exceptions.

4.1.13 Check vehicle trim heights. Adjust to specified levels if required.

4.1.14 Check wheel alignment if requested.

4.1.15 Any Antilock Brake System (ABS), rear wheel antilock, or four wheel antilock systems should be functional.

4.1.16 Any Dynamic Rear Proportioning (DRP) or electronic brake distribution system should be functional.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 The ambient temperature should be between -10 °C and 40 °C.

4.2.1.2 Wind speed should be less than 32 km/h in any direction.

4.2.1.3 The track 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 This standard may be modified to the specifications of a specific program requirement; e.g., different speed, number of stops, deceleration level, vehicle loading or stop interval. Any modifications should be indicated in the test request, the test record, and the test report.

4.2.2.2 This standard should be restricted to performance, extreme use, or specialty vehicles.

4.3 Instructions.

4.3.1 Brake Burnish.

4.3.1.1 Burnish the brake system according to the race track preparation burnish procedure in GMW17109. An alternate (usually supplier recommended) procedure may be specified.

4.3.1.2 The burnish schedule used should be documented in the test record.

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4.3.2 Determining Braking Cycle Parameters (Speed and Dwell Time).

4.3.2.1 Determine the acceleration distance. The acceleration distance is the length of the target race track that can be used for uninterrupted acceleration prior to the highest speed braking event on the track. The distance is specific to the target race track and should be specified by the test requestor. The default distance is 1.2 km (0.75 mi), which is appropriate for the Milford Road Course at the General Motors Milford Proving Ground, as a target track.

Load test vehicle to lightly loaded vehicle weight (including driver). Measure the test weight and record on the data sheets.

4.3.2.2 Configure the data recorder display to show cumulative distance travelled from a data recording trigger point. Start data recording.

4.3.2.3 Measure the acceleration of the vehicle from 50 km/h until the vehicle has covered the specified distance. Stabilize the vehicle at 50 km/h. Accelerate at Wide Open Throttle (WOT), driver's maximum effort while avoiding wheel spin, using gear selection appropriate for the vehicle speed, until the specified distance has elapsed (it is permissible to overshoot the distance to ensure that this checkpoint is contained within the recorded data). Repeat as requested.

4.3.2.4 Calculate the cooling interval time (dwell time at the target braking speed) to achieve the cycle Braking Energy over Cooling Opportunity (BECO) ratio per the instructions in Appendix B, Sections B1 and B2. BECO is a property of the vehicle and the race track. For reference values of BECO, see Appendix B, Figure B1.

4.3.2.5 Vehicle Technical Specification (VTS) Track 2a (Performance Designations Only). Calculate the number of braking repetitions to achieve equivalent energy between the GMW15343 duty cycle and one lap of the target track per instructions in Appendix B, Section B3. The default number of braking repetitions (for use when insufficient data can be retrieved or generated to complete the calculations in Appendix B, Sections B1 thru B3) is three (3).

4.3.2.6 Alternate Parameters for Testing at Speed-Limited Facilities. For best test correlation, every effort shall be made to achieve the required target braking speed. However, if the required target braking speed cannot be reached due to facility limitations, then a lower braking speed may be used. The high speed dwell time should be adjusted so that the target BECO is still reached, and a note of the deviation from procedure shall be recorded in the data summaries of the test. If neither the target speed nor the target BECO can be reached, then an alternate facility shall be used. It is recommended that the target speed be kept in a range to where the initial kinetic energy of the vehicle is within 10% of the intended level (for example, a vehicle with a target speed of 250 km/h should try to run with at least 237 km/h if in a speed-limited situation).

4.3.3 General Instructions.

4.3.3.1 For ABS vehicles, the brake pedal apply should be a ramp apply at a rate between 150 N/s and 200 N/s to the force necessary to achieve the target deceleration. Pedal force should then be modulated to maintain the target deceleration. Unless otherwise specified, the target deceleration shall be 9.8 m/s², or the threshold of wheel slip and ABS activation (whichever is lower).

4.3.3.2 This procedure is not recommended for vehicles that not equipped with ABS.

4.3.3.3 For vehicles with automatic transmissions, place vehicle in highest forward gear. Accelerations should be maximum effort WOT to the extent possible while still avoiding wheel spin. Decelerations shall be in done in the same gear.

4.3.3.4 For vehicles with manual transmissions, the accelerations should be performed at driver maximum effort, using gear selection appropriate for the vehicle speed. The throttle apply should be lifted during each transmission shift. For decelerations, follow instructions in the test request. The stops may be done in neutral or may be done with the transmission left in the highest forward gear with the clutch disengaged just before engine stall.

4.3.3.5 For vehicles so equipped, the ABS and DRP should be operational during the test. If so equipped, the Traction Control System (TCS) and Vehicle Stability Enhancement System (VSES) should be functional, unless the TCS/VSES has an on/off switch available for driver selection. If an on/off switch is available, the system(s) should be turned off.

4.3.3.6 For vehicles equipped with driver-selectable performance modes (such as a race track mode, or performance mode), the highest performance mode should be selected. These modes typically affect antilock

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brake and brake proportioning calibrations, as well as suspension damping, vacuum pump, and potentially other settings, which can affect brake system performance during the test.

4.3.4 High Speed Flat Track Braking Test for Race Track Correlation (VTS Track Level 2b and Higher).

4.3.4.1 Perform 1.9 m/s² snubs from 80 km/h to 30 km/h until the front brake temperatures reach an Initial Brake Temperature (IBT) of between 90 °C and 100 °C.

Note: This IBT applies only at the start of test to the first acceleration and brake apply.

4.3.4.2 Stop vehicle.

4.3.4.3 Start data acquisition system.

4.3.4.4 Accelerate at maximum effort WOT to the target test speed. A tolerance of +3/-0 km/h is permitted.

4.3.4.5 Immediately proceed to a ramp apply of the brake pedal and hold pedal force to maintain 9.8 m/s² target, or vehicle maximum deceleration until vehicle speed is reduced to 50 km/h.

4.3.4.6 Immediately accelerate at maximum effort to the target test speed (+3/-0 km/h).

4.3.4.7 Maintain the target test speed until the high speed dwell time has elapsed.

4.3.4.8 Immediately repeat the braking and acceleration sequence until 25 stops have been performed or until a deceleration of at least 4.9 m/s² cannot be maintained. Proceed immediately to cooldown.

Note: Driver of vehicle shall make note of any roughness during testing.

4.3.4.9 Cooldown. Drive vehicle at constant speed of 100 km/h for a distance of 2 km.

4.3.5 High Temperature Soak.

4.3.5.1 Immediately following the cooldown, proceed to the closest designated stopping point (maximum 500 m from end of last snub).

4.3.5.2 Record data until brake friction material and fluid temperatures have decreased to within 10 °C above ambient, or for 30 minutes (whichever occurs first).

4.3.6 End of Test Instruction. Follow end of test instructions in the test request. Perform an end of test floor check, if requested. If removing test parts, label the brake parts with test identification number, location on vehicle during test, and any other information requested by the test engineer.

4.3.7 High Speed Flat Track Braking Test for Race Track Correlation (VTS Track Level 2a).

4.3.7.1 Perform 1.9 m/s² snubs from 80 km/h to 30 km/h until the front brake temperatures reach an IBT of between 90 °C and 100 °C.

Note: This IBT applies only at the start of test to the first acceleration and brake apply.

4.3.7.2 Stop vehicle.

4.3.7.3 Start data acquisition system.

4.3.7.4 Accelerate at maximum effort WOT to the target test speed. A tolerance of +3/-0 km/h is permitted.

4.3.7.5 Immediately proceed to a ramp apply of the brake pedal and hold pedal force to maintain 9.8 m/s² target, or vehicle maximum deceleration until vehicle speed is reduced to 50 km/h.

4.3.7.6 Immediately accelerate at maximum effort to the target test speed (+3/-0 km/h).

4.3.7.7 Maintain the target test speed until the high speed dwell time has elapsed.

4.3.7.8 Immediately repeat the braking and acceleration sequence until the specified number of stops have been performed (according to calculations in Appendix B, Sections B1 thru B3) or until a deceleration of at least 4.9 m/s² cannot be maintained.

4.3.7.9 Stop vehicle and remain stopped for 2 minutes (continue data recording).

4.3.7.10 Repeat 4.3.7.4 thru 4.3.7.9 until five (5) complete cycles (repeated brake snubs and 2 minute cooling interval) have been completed. Proceed immediately to high temperature soak.

Note: Driver of vehicle shall make note of any roughness during testing.

4.3.8 High Temperature Soak for Track 2a.

4.3.8.1 Immediately following the last snub of the fade test, proceed to the closest designated stopping point (maximum 500 m from end of last snub).

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