



Brake Development Test

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. The purpose of this standard is to evaluate hydraulic brake system performance with a sequence of brake tests on a single brake material build.

1.2 Applicability. This procedure is applicable for passenger cars, multipurpose passenger vehicles, trucks, and buses with a Gross Vehicle Weight Rating (GVWR) of 3500 km (7716 lb) or less.

1.3 Remarks. The tests in this procedure may be selected or deselected according to the needs of the program test plan. The selected tests should be run in the order consistent with this procedure.

Depending on the tests selected, the results from this procedure may be used to predict or validate performance on the Federal Motor Vehicle Safety Standard (FMVSS) 135 and may be used to predict or validate performance on GM brake system technical specifications, such as platform Vehicle Technical Specification (VTS) or Brake Subsystem Technical Specifications (SSTS).

This standard is the recommended development test for FMVSS 135. This procedure also evaluates many performance metrics in the GM vehicle and brake SSTS and may be used for development or validation of these metrics.

Each test in this procedure has a separate procedure, either a FMVSS test or a GM internal procedure. These separate procedures should be reviewed for details about the tests. Only details about the sequencing and the test conditions are stated in this procedure.

The Data Sheets Pack is part of this procedure and shall be used to perform this test. If any discrepancies between this procedure document and the Data Sheets Pack exist, the Data Sheets Pack shall take precedence. The content owner of this procedure should be notified of the discrepancies. The Data Sheets Pack is available from Brake Development at Milford Proving Ground as published in Global Document Management (GDM) system or its successor.

2 References

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

2.1 External Standards/Specifications.

ASTM E1136	ASTM E1337-90	FMVSS 135
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2.2 GM Standards/Specifications.

GMW14924	GMW14948	GMW15102	GMW15112
GMW14927	GMW14974	GMW15103	
GMW14930	GMW14976	GMW15104	

2.3 Additional References.

Data Sheet Pack (<https://documents.gm.com/gdm3/drl/objectId/0b0163bc809850cb>) (ID)

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

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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 Vehicle weighing station capable of measuring, at least, the mass (weight) at each axle; Ballast materials.

3.1.4 Road Test Surface.

3.1.4.1 Pavement Friction. Unless otherwise specified, the road test surface produces a Peak Friction Coefficient (PFC) of 0.9 when measured using an American Society for Testing and Materials (ASTM) E1136 standard reference test tire, in accordance with ASTM Method E1337-90, at a speed of 64.4 km/h, without water delivery. The test road used shall have the PFC measured monthly and a correction algorithm for PFC shall be used when appropriate.

3.1.4.2 Gradient. Except for the parking brake gradient holding test, the test surface has no more than a 1% gradient in the direction of testing and no more than a 2% gradient perpendicular to the direction of testing.

3.1.4.3 Lane Width. Road tests are conducted on a test lane 3.5 m wide.

3.1.5 Vehicle Center of Gravity (CG) height measurement facility that accommodates both lightly loaded and gross loaded conditions.

3.2 Equipment.

3.2.1 The following measurements are required at time of test:

- Vehicle odometer mileage.
- Vehicle tire pressures.
- Test site wind velocity.

3.2.2 Equipment to measure the PFC of the test road surface is required. The PFC measurement should be measured on at least a monthly basis. The latest PFC measurement must be known at time of test. Consult with request engineer to determine if measurements on the day of testing are required.

3.2.3 Data acquisition and recording equipment that supports a sample rate of 100 Hz on all channels is required. The sample rate for all temperature channels is 10 Hz and the sample rate for all other channels is 100 Hz unless otherwise specified.

3.2.4 The data must be automatically recorded in phase continuously throughout each test run such that values of the variables can be cross referenced in real time. The required data channels for each test section are listed in the Data Sheets Pack.

3.2.5 All instrumentation and test equipment is to be calibrated as required. Record instrumentation identification and calibration in the test Data Sheets Pack unless the information is otherwise preserved in the testing laboratory records.

3.3 Test Vehicle/Test Piece.

3.3.1 The test vehicle and brake subsystem should be representative of production to the extent possible. A pretest analysis of platform variation should be used to select the most representative vehicle(s) for test.

3.3.2 New brake pads and/or linings, rotors and/or drums, park brake friction material, park brake cables, and tires are recommended for start of test build. A separate set of tires of the same part number may be mounted on the torque wheels and used for those sections of the test requiring torque wheels.

3.4 Test Time. The following is an estimate on the amount of time needed to perform the entire procedure. The test duration time is weather dependent.

Calendar time:	24 days to 30 days
Test time:	48 hours to 60 hours
Coordination time:	16 hours to 20 hours

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3.5 Test Required Information. Test engineer must approve the brake system prior to test. Any test brake parts or test tires not in new condition must be approved by test engineer.

3.6 Personnel/Skills. An experienced, trained brake tester is required for vehicle instrumentation and test performance.

4 Procedure

4.1 Preparation.

4.1.1 All vehicle and brake system information requested shall be recorded on the input sheet in the test Data Sheets Pack. The insertion of this data in the Data Sheets Pack will allow the headers on the test instruction sheets to be automatically completed.

4.1.2 The test weights and weight distributions should be determined and recorded in the Data Sheets Pack. Use pretest analysis that comprehends the complete range of vehicles using the brake system to determine these numbers.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Ambient Temperature. The ambient temperature is any temperature between -10 °C and 40 °C.

4.2.1.2 Wind Speed.

4.2.1.2.1 All test sections, except fade sections, should be run while adhering to the following:

- For wind speeds not greater than 5 m/s, run stops in either direction.
- For wind speeds of 6 m/s to 9 m/s parallel to the road, run stops with the wind direction.
- For crosswinds at speeds of 6 m/s to 9 m/s, run stops in either direction.
- Do not run if wind speed exceeds 9 m/s.

4.2.1.2.2 Fade test sections should be run with a wind speed of not greater than 5 m/s. Occasional gusting above this limit is permitted. If wind is consistently gusting above this speed, do not run fade testing until wind speed decreases to less than 5 m/s and gusting is only an occasional occurrence.

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 Antilock Brake System (ABS). If a car is equipped with an Antilock Brake System (ABS), the ABS is fully operational for all tests, except where specified.

4.2.2.2 Automatic Brake Adjusters. Automatic brake adjusters are operational throughout the entire test sequence.

4.2.2.3 Ballast. Instrumentation and driver are considered part of the ballast.

4.2.2.4 Brake Line Pressure Measurement. The vehicle shall be fitted with pressure transducers in each hydraulic circuit. On hydraulically proportioned circuits, the pressure transducer shall be downstream of the operative proportioning valve. Floor checks before and after the installation of the pressure transducers shall be used to verify that the instrumentation did not unduly affect the system performance.

4.2.2.5 Brake Temperature Measurement. The brake temperature is measured by 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 under the surface. For disc brake pad recess the thermocouple 2 mm 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 to 6 mm of the groove, and as close to the center as possible.

4.2.2.6 Brake Torque Measurement. The vehicle shall be fitted with torque wheels at each wheel position, including slip ring assemblies and wheel speed indicators to permit wheel lock to be detected. For the torque wheel test, a separate set of tires, identical to those used for all other tests may be used.

4.2.2.7 Engine. Engine idle speed and ignition timing are set according to the manufacturer's recommendations. If the vehicle is equipped with an adjustable engine speed governor, it is adjusted according to the manufacturer's recommendations.

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4.2.2.8 Fuel Tank Loading. The fuel tank is filled to 100% of capacity at the beginning of testing and may not be less than 75% of capacity during any part of the testing unless otherwise specified for a particular portion of the test. If it is necessary to have the fuel level below full in order to obtain the weight percentage for Lightly Loaded Vehicle Weight (LLVW), the fuel should not be allowed to drop below 75% of that initial level during the LLVW testing.

4.2.2.9 Gross Vehicle Weight Rating Loading. For the tests at GVWR, the vehicle is loaded to its GVWR such that the mass distribution on each axle, as measured at the tire ground interface, is as close to the specified distribution as possible without the use of extreme measures and the total weight does not exceed the GVWR.

4.2.2.10 Initial Brake Temperature. The Initial Brake Temperature (IBT) is to be specified for each section of the test. If the IBT has not been reached at the start of a run, the brakes are heated to the IBT by making one or more brake applications from a speed of 50 km/h, at a deceleration rate not greater than 3 m/s².

4.2.2.11 Instruction for Stops in Gear. For tests in gear, a stop or snub is made in accordance with the following procedures:

- With the transmission selector in the control position recommended by the manufacturer for driving on a level surface at the applicable test speed, exceed the test speed by 6 km/h to 12 km/h.
- Close the throttle and coast in gear.
- When the test speed is reached apply the brakes.
- To avoid engine stall, a manual transmission may be shifted to neutral (or the clutch disengaged) when the vehicle speed is below 30 km/h.

4.2.2.12 Instruction for Stops in Neutral. For tests in neutral, a stop or snub is made in accordance with the following procedures:

- Exceed the test speed by 6 km/h to 12 km/h.
- Close the throttle and coast in gear to approximately 3 km/h above the test speed.
- Shift to neutral.
- When the test speed is reached, apply the brakes.

4.2.2.13 Lightly Loaded Vehicle Weight Loading. For the tests at LLVW, the vehicle is loaded to the LLVW mass distribution, as measured at the tire ground interface, such that the total mass is as close to the LLVW as possible without the use of extreme measures.

4.2.2.14 Stopping Distance Data Corrections.

4.2.2.14.1 Initial Speed Correction. Stopping distances reported in the Data Sheets Pack are to be corrected for initial stopping speed using the following formula, providing that the actual initial speed deviated from the desired initial speed by no more than 3.2 km/h.

$$S_c = (S_m - (0.1 * V_a)) * (V_r^2 / V_a^2) + (0.1 * V_r)$$

Where:

S_c = Corrected stopping distance, m

S_m = Measured stopping distance, m

V_r = Requested initial speed, km/h

V_a = Actual initial speed, km/h

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