



Brake Pedal Feel 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 may be used to measure the relationships between brake pedal force, brake pedal travel, and vehicle deceleration and to measure brake line pressure response to pedal input. This standard may also be used to generate all the pedal feel and response metrics needed to calculate the Brake Feel Index (BFI).

1.2 Applicability. This standard is applicable for all vehicles.

1.3 Remarks. The BFI may be calculated from the data from this test, from data from other tests which measure the required metrics, from model data, or from any combination of these methods.

The development of the BFI has been documented in report PG56471 BFI and a memorandum titled BFI Revision. These documents contain information on the subjective ratings to objective test measurements correlation that was used to determine the equation for the BFI. In 2003, the BFI was modified to include the linearity of the brake apply system. The modified calculation is detailed in evaluation report P000916 BFI Version 2.

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 GMW15106

2.3 Additional References.

The supplier shall work with the GM Design Responsible Engineer to comprehend these requirements.

- Report PG56471 Brake Feel Index
- Evaluation Report P000916, Brake Feel Index Version 2

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 including suitable ballast material.

3.2 Equipment.

3.2.1 Data acquisition and recording equipment is required. The minimum sample rate for all temperature data is 10 Hz. The required sample rate for all other data is 100 Hz, except for the line pressure response test where the sample rate for these data should be 200 Hz. If the data acquisition system is capable, the sample rate for line pressure response should be increased to 500 Hz.

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3.2.2 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.

3.2.3 The line pressure response test requires the use of a brake machine capable of the following:

3.2.3.1 Applying the brake pedal to the target pedal force at a rate where at least 80% of the target pedal force is reached within 0.05 s after apply and have less than 40% overshoot.

3.2.3.2 Maintaining the target pedal force within 10% of steady state within 0.15 s of pedal apply.

3.2.3.3 Releasing the brake pedal at a rate faster than the mechanical return of the pedal.

3.2.4 All instrumentation and test equipment is to be calibrated as required. Record instrumentation identification and calibration dates in the test records.

3.2.5 Instrumentation is required to measure the brake performance metrics listed in 3.2.5.1 thru 3.2.5.8 during the specified section of this test procedure.

3.2.5.1 Brake Burnish. Thermocouples installed in the brake pads and/or linings.

3.2.5.2 As Received and Initial Floor Checks. Pedal force; pedal travel; booster vacuum (if applicable).

3.2.5.3 Instrumented Floor Checks. Pedal force; pedal travel; booster vacuum (if applicable); line pressure at each brake corner.

3.2.5.4 Brake Pedal Preload. Pedal force; pedal travel; booster vacuum (if applicable).

3.2.5.5 Ramp Stops. Pedal force; pedal travel; booster vacuum (if applicable); vehicle deceleration; vehicle speed; brake temperature; line pressure at each brake corner.

3.2.5.6 Vacuum Level Test (if applicable). Pedal force; pedal travel; booster vacuum; vehicle deceleration; vehicle speed.

3.2.5.7 Static Line Pressure Response. Pedal force; pedal travel; booster vacuum (if applicable); line pressure at each brake corner.

3.2.5.8 Dynamic Line Pressure Response. Pedal force; pedal travel; booster vacuum (if applicable); vehicle deceleration; vehicle speed; brake temperature; line pressure at each brake corner.

3.3 Test Vehicle/Test Piece.

3.3.1 The test vehicle and brake subsystem should be representative of production to the extent possible.

3.3.2 New brake pads and/or lining, rotors and/or drums, and tires are recommended at start of test.

3.4 Test Time. Test time is estimated at 3 days to 5 days. The test time includes one (1) shift for the 200 stop burnish of the brake system. This test time is weather dependent.

Calendar time: 3 days to 5 days

Test time: 24 hours

Coordination time: 2 hours to 4 hours

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 test technician or engineer is required to perform the instructions in section 4.

4 Procedure

4.1 Preparation.

4.1.1 Vehicle and brake system information should be recorded in the test record.

4.1.2 The test weights and weight distributions should be specified in the test request.

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4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Road surface must be dry.

4.2.1.2 The ambient temperature shall be any temperature between -20 °C and 40 °C.

4.2.1.3 Track tests should be run while adhering to the following:

- For wind speeds not greater than 5 m/s (11 mph) run stops in either direction.
- For wind speeds of 6 m/s to 9 m/s (13 mph to 20 mph) parallel to the road, run stops with the wind direction.
- For crosswinds at speeds of 6 m/s to 9 m/s (13 mph to 20 mph), run stops in either direction.
- Do not run if wind speed exceeds 9 m/s (20 mph).

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) and Dynamic Rear Proportioning (DRP). If equipped with ABS or ABS/DRP, the systems should be fully operational during the testing.

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

4.2.2.3 Brake Floor Check. A floor check is the measurement of the brake pedal travel and brake pedal force during an apply of the pedal with the vehicle stationary and the brake power assist unit (brake booster) set to a specified vacuum or pressure. The instructions for performing a floor check are in GMW14927.

4.2.2.4 Brake Line Pressure Measurement. The vehicle shall be fitted with pressure transducers at each brake corner for the line pressure response test. Floor checks before and after the installation of the pressure transducers shall be used to verify that the instrumentation did not unduly affect the hydraulic system performance.

4.2.2.5 Brake Proportioning Valve. If a car is equipped with a brake proportioning valve, the proportioning valve should be fully operational for the testing.

4.2.2.6 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; that is the inboard pad for disc brakes, the leading shoe or secondary shoe for drum brakes. 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.

4.2.2.7 Gross Vehicle Weight Rating (GVWR) Loading. For the tests at GVWR, the vehicle is loaded to the specified 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. The maximum percent front load distribution is recommended.

4.2.2.8 Initial Brake Temperature (IBT). The initial brake temperature is to be specified for the ramp stops. 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. Brakes should be cooled, as needed, by driving at speeds up to 100 km/h.

4.2.2.9 Lightly Loaded Vehicle Weight (LLVW) Loading. For the tests at LLVW, the vehicle is loaded to the specified LLVW 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. The maximum percent front load distribution is recommended.

4.2.2.10 Tire Inflation Pressure. Tires are inflated to the pressure recommended by the vehicle manufacturer for the GVWR of the vehicle.

4.2.2.11 Vehicle Openings. All vehicle openings (doors, windows, hood, trunk, convertible top, cargo doors, etc.) are closed except as required for instrumentation purposes.

4.2.2.12 Vehicle Positioning and Steering for Ramp Stops.

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4.2.2.12.1 The vehicle is aligned in the center of the lane at the start of each brake application. Steering corrections are permitted during each stop.

4.2.2.12.2 Stops are made without any part of the vehicle leaving the lane and without rotation of the vehicle about its vertical axis of more than ± 15 degrees from the center line of the test lane at any time during any stop.

4.2.2.13 Wheel Lockup. Unless otherwise specified, no lockup of any wheel is allowed for longer than 0.1 s at speeds greater than 15 km/h.

4.3 Instructions.

4.3.1 Setup.

4.3.1.1 Install plug type thermocouples in test linings and/or pads per 4.2.2.6.

4.3.1.2 If an optional "As Received" floor check is requested, perform a floor check installing only the required instrumentation. Do not break into the brake hydraulic system or change the test brake parts. Allow the test engineer to review the data before continuing.

4.3.1.3 Install the test brake parts, including drums and/or rotors, return and hold-down springs, and thermocoupled friction material. Set brake clearances to manufacturer's specification. Check that automatic brake adjusters are operational.

4.3.1.4 Install the test tires on the vehicle wheels. Inflate the tires to manufacturer's recommended pressure for GVWR. When appropriate, install these wheel/tire units on the vehicle.

4.3.1.5 If requested, check and reset, if necessary, the suspension adjustment such as castor, camber, and toe-in. Unless otherwise specified, make these measurements at LLVW.

4.3.1.6 If requested, check all vehicle fluid levels (oil, coolant, etc.) and fill to maximum recommended capacity.

4.3.1.7 With the test brake parts installed, perform an initial floor check before breaking into the hydraulic system for placement of line pressure transducers.

4.3.1.8 Install the line pressure transducers in the hydraulic system at each brake corner.

4.3.1.9 Perform a floor check with the line pressure transducers installed. Compare the pedal travel versus pedal force from these data to the data measured in 4.3.1.7. If necessary, perform brake bleeds and floor checks until the measured data before and after the installation of the pressure transducers verify that the instrumentation has not unduly affected the hydraulic system. Allow the test engineer to review the data before continuing.

4.3.2 Brake Preload.

4.3.2.1 Start the engine. Turn off the air condition (A/C). Let engine idle for at least 2 minutes to warm engine. For standard engine manifold vacuum assist systems, establish a booster vacuum level of 69 kPa to 70 kPa by applying and releasing the throttle and/or the brake pedal. For hydraulic assist systems, obtain a full charge on the accumulator, if possible. For some hydraulic assist systems, the accumulator is charged by turning the steering wheel to full lock for 2 s to 3 s. For vacuum systems with electric or mechanical vacuum pumps, consult the requesting engineer for the required power assist level. If the method to charge the system is not known, use the assist level that occurs at engine idle.

4.3.2.2 Start data acquisition. Record data at 100 Hz sample rate.

4.3.2.3 Apply the brake pedal at a rate of 20 N/s $\pm$ 2 N/s to a pedal force of 90 N $\pm$ 5 N.

4.3.2.4 Release pedal. Stop data acquisition.

4.3.2.5 Repeat 4.3.2.1 thru 4.3.2.4 until a total of three (3) runs have been recorded.

4.3.3 Brake Burnish. Perform a 200 stop brake burnish per instructions in GMW15102 or GMW15106 (whichever is applicable for test vehicle) with vehicle at GVWR.

4.3.4 Brake Pedal Feel Ramp Stops.

4.3.4.1 Set up vehicle for GVWR ramp stops.

4.3.4.2 Perform the ramp stops on a dry, high coefficient of friction surface. Record each stop, including a few seconds before the brake pedal apply and a few seconds after the brake pedal release.

4.3.4.3 Establish the initial brake temperature of ≥ 65 °C and ≤ 100 °C.

4.3.4.4 Accelerate the vehicle to 5 km/h to 10 km/h above the 100 km/h target test speed.

4.3.4.5 Close the throttle and coast in gear to approximately 3 km/h above the test speed.

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