



Brake Switch Interface Verification Test - FMVSS 108 Brake Lamp Activation

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 determine if the brake system operates in conjunction with the brake light switch activation in a manner that meets the applicable requirements of:

United States of America Federal Motor Vehicle Safety Standard No. 108 (FMVSS 108).

1.2 Applicability. This standard is applicable to all vehicles required to certify to FMVSS 108.

1.3 Remarks. This procedure results in an analysis that may be used to determine compliance to the applicable requirements in FMVSS 108.

2 References

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

2.1 External Standards/Specifications.

FMVSS 108

2.2 GM Standards/Specifications.

GMW3238

GMW14590

2.3 Additional References.

- CG2462 Brake Booster - ZABS Initiation Force MCS Analysis Template
- CG2463 Vehicle Grade Calculations Worksheet for Travel Based Brake Switch Type
- CG2464 Vehicle Grade Calculations Worksheet for Travel Based Brake Switch Type

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 Brake test laboratory.

3.1.4 Variable grade park brake ramp or equivalent.

3.1.5 Vehicle weighing station.

3.1.6 Milford Proving Ground (MPG) Belgian Block road course or equivalent.

3.1.7 Milford Proving Ground (MPG) Pothole road course or equivalent.

3.2 Equipment. Equipment for measurement and recording of the following is required. All instrumentation identification numbers and calibration dates shall be documented in the test record including data acquisition system(s).

3.2.1 Brake Line Pressure.

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3.2.2 Brake Pedal Travel.**3.2.3 Brake Pedal Force****3.2.4 Vehicle Speed.****3.2.5 Brake Light Switch Activation.****3.2.6 Engine Rotational Speed.****3.2.7 Brake Pedal Position.****3.2.8 Booster Vacuum.****3.3 Test Vehicle/Test Piece.**

3.3.1 Test vehicle shall be production intent with respect to brake system, brake pedal assembly, body control module calibration for brake light switch, stop lamp assembly, suspension stiffness, and mass.

3.3.2 Several random brake booster and brake master cylinder assemblies will be required to comprehend vehicle-to-vehicle variation of the apply system. Booster/master cylinder testing will follow GMW14590 apply system bench test.

3.3.3 Drawings of the brake booster and brake master cylinder may also be required.

3.4 Test Time. Test times listed are for completion of the vehicle tests for one vehicle build. Test times for bench testing of the apply system are listed in GMW14590.

Calendar time: (1 to 3) days

Test hours: (4 to 14) h

Coordination hours: (24 to 48) h

3.5 Test Required Information.

3.5.1 Document Body Control Module (BCM) calibration file identification in the test record. Review file with BCM Design Engineer to ensure that BCM is production representative with regards to brake light switch calibration.

3.5.2 There are three methods that can be utilized to provide judgment of specification compliance. These methods are analysis; vehicle test with randomly selected component variation based on lab testing; and vehicle test only which requires multiple randomly selected vehicles for a statistically significant sample size. The selected method will determine what testing is required.

3.5.3 Primary judgment using vehicle tests will be obtained using a pass margin for grade/torque calculations, and for pedal travel as specified by the program team. If pass margins fall below these specified values, further variation analysis shall be done to ensure the entire vehicle population meets the requirement. Such additional variation methodologies are either vehicle test with bench variation, component design variation stacks, or multiple vehicle tests to provide statistical details to encompass vehicle to vehicle variation.

3.6 Personnel/Skills. The responsible GM design engineer, GM performance engineer, GM performance technician, brake apply system supplier engineer, or other qualified engineer shall execute this procedure. A review by the program brake release engineer and validation analyst is suggested.

4 Procedure

4.1 Preparation. See test subparagraphs in 4.3 for applicable preparation instructions.

4.2 Conditions.**4.2.1 Environmental Conditions.**

4.2.1.1 Vehicle Tests. For wind conditions of speeds > 6.7 m/s parallel to the ramp, consult the test engineer for approval to run the ramp section of the vehicle test.

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 Ideally, the vehicle should be set up as worst case for each specific evaluation.

4.2.2.1.1 Worst case for the brake apply test 4.3.2.3 and brake release test 4.3.2.4 is lightest vehicle configuration and largest brake system (generates greatest specific brake torque).

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4.2.2.1.2 Worst case for engine drag test 4.3.2.5 is a vehicle equipped with the lowest axle output torque. To determine this, one needs to gather the following information based on the available engine transmission, and gear ratio combinations: lowest warm engine idle speed, first, and reverse gear ratio, final drive ratio, torque converter ratio, and the transmission K-factor. Once these available combinations are understood, calculate each available vehicle combination, in order to determine which configuration results in the lowest axle output torque. Equation:

$$\text{Wheel Torque} = \left(\frac{\text{Idle Speed}}{\text{K-factor}} \right)^2 \times (\text{X Gear Ratio}) \times (\text{Torque Converter Ratio}) \times (\text{Final Drive Ratio})$$

Where:

X = Either First or Reverse

4.2.2.1.3 Worst case for the unintended brake light activation tests 4.3.2.6 requires the stiffest suspension at weight condition of curb weight plus driver plus instrumentation.

4.2.2.2 The accuracy of the test and analysis results from this standard are dependent on the quality of the apply system data available at the time of the test and analysis. Use of a fingerprinted booster will help identify where in the variation population the vehicle grade test results fall during subsequent variation analysis.

4.2.2.3 Changes to the vehicle after model year regulatory validation may require a new test and analysis.

4.3 Instructions.

4.3.1 Analysis-Only Evaluation.

4.3.1.1 Use of analysis only is currently limited to Zero Adjust Brake Switches (ZABS). The analysis method is based on a Montecarlo simulation of the brake apply and brake switch force balance. The Montecarlo Simulation (MCS) spreadsheet CG2462 (Microsoft Excel format) is located in the GM Global Document Management (GDM) system. See Appendix A, Figure A1 for an example simulation input and results sheet.

4.3.1.2 To provide judgment on systems with ZAB switches using analysis, the following information is required.

4.3.1.2.1 ZABS switch production preload force statistical data, mean and standard deviation. If production values are not available, design nominal values, and tolerance ranges can be utilized as 3 sigma assumptions.

4.3.1.2.2 Brake Apply System Data: Specifically, booster cut-in and cut-out forces. If these data are unavailable, multiple apply system bench tests utilizing GMW14590 can be used, with descriptive statistics applied to the results. The required values for apply system parameters are cut-in force mean and standard deviation and cut-out force mean and standard deviation.

4.3.1.3 The switch and apply system data can then be input into the Montecarlo simulation. The spreadsheet will run the MCS, and the output of simulated results will be displayed.

4.3.2 Vehicle Test. To provide judgment on systems with ZABS switches that do not have the required bench testing, use vehicle testing. For travel based switches, plunger or Brake Actuation Sensor (BAS), use vehicle testing.

4.3.2.1 Vehicle Test Preparation.

4.3.2.1.1 Perform an as-received brake floor check. Pedal force, pedal travel and booster vacuum (when applicable) should be measured and recorded. Allow the test engineer to review the results and set a target value.

4.3.2.1.2 If requested, install a fingerprinted booster in the test vehicle. A fingerprinted booster is one that has been run on GMW14590 and has a known lost travel value. Perform another as received floor check. Bleed the brake system as needed to return pedal feel to target value.

4.3.2.1.3 Install brake line pressure transducers at each brake corner. Perform a start of test floor check. Pedal force, pedal travel, booster vacuum (when applicable), and brake line pressures should be measured and recorded. Compare the floor check results and bleed system as needed to return pedal feel to target value.

4.3.2.1.4 Complete the instrumentation of the vehicle. See 3.2.

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4.3.2.1.5 Re-run brake floor check with all instrumentation to confirm bleed quality. Once bleed quality is confirmed, record an apply with all data channels including pedal travel, pedal force, brake line pressure, and brake light switch activation. Review results with test engineer. Floor check data should be input into the data worksheet to evaluate "Static Evaluation" results. If static results show compliance (see note) to requirement, stop. Proceed to 4.3.2.6 Unintended Brake Light Activation Test.

Note: Static results shall be evaluated for worst case for compliance to the requirement which includes brake system, and switch variation.

4.3.2.1.6 Weigh the instrumented vehicle with driver. Document this test vehicle weight in the test record.

4.3.2.1.7 Complete any conditioning of the brake corner hardware that is specified in the test request. A 200 stop brake burnish is recommended for green hardware.

4.3.2.1.8 Perform the following vehicle tests unless otherwise specified in the test request. While driving to the park brake grade or other facilities, do not apply brake pressure > 1000 kPa.

4.3.2.2 Vehicle Drag Torque Test.

4.3.2.2.1 Data required are only a documentation of the Stationary Grade in the test record for each test run. A recorded data file is not required.

4.3.2.2.2 Place vehicle on variable grade park brake ramp with vehicle facing up the grade. Vehicle should be stationary.

4.3.2.2.3 Shift the vehicle transmission to neutral. Increase the slope of the ramp in 0.5 % grade increments until vehicle begins to roll. Roll is defined as gradual and continuous vehicle movement. Document the grade just prior to the grade where vehicle roll occurred. This is the Stationary Grade for the run.

4.3.2.2.4 Remove vehicle from ramp. Drive around ramp turnaround area while gently applying the brakes < 1000 kPa pressure.

4.3.2.2.5 Repeat 4.3.2.2.1 thru 4.3.2.2.3 for a total of 3 runs. Average the grade measurements to determine the Stationary Grade.

4.3.2.3 Brake Apply Test.

4.3.2.3.1 Data required are brake pedal force, brake pedal travel, brake line pressures, vehicle speed, brake light signal, and engine speed. Data should be digitally recorded.

4.3.2.3.2 Place vehicle on variable grade park brake ramp with vehicle facing up the grade.

4.3.2.3.3 Increase slope 1.0 % grade greater than the Stationary Grade from 4.3.2.2.5.

4.3.2.3.4 Apply brakes lightly (≤ 1000 kPa pressure).

4.3.2.3.5 Shift gear selector to neutral. Fully release brake pedal. Vehicle will begin to roll.

4.3.2.3.6 Apply brake pedal slowly (≈ 20 N/s) until the brake light comes on, then the vehicle stops, then the front line pressure reaches (1000 ± 50) kPa. Maintain the brake pressure for 2 s minimum.

4.3.2.3.7 Remove vehicle from ramp. Drive around ramp turnaround area while gently applying the brakes < 1000 kPa pressure.

4.3.2.3.8 Repeat 4.3.2.3.2 thru 4.3.2.3.7 until a total of 5 runs is completed.

4.3.2.4 Brake Release Test.

4.3.2.4.1 Data required are brake pedal force, brake pedal travel, brake line pressures, vehicle speed, brake light signal, and engine speed. Data should be digitally recorded.

4.3.2.4.2 Place vehicle on variable grade park brake ramp with vehicle facing up the grade.

4.3.2.4.3 Increase slope 1.0 % grade greater than the Stationary Grade from 4.3.2.2.5.

4.3.2.4.4 Apply brakes lightly (≤ 1000 kPa pressure). Make sure the brake light is on.

4.3.2.4.5 Shift gear selector to neutral.

4.3.2.4.6 Release the brake pedal slowly (≈ 10 N/s) until the brake light turns off and the pedal has been fully released. The vehicle will begin to roll. Allow vehicle to roll to the bottom of the ramp. Stop vehicle with < 1000 kPa pressure.

4.3.2.4.7 Remove vehicle from ramp. Drive around ramp turnaround area while gently applying the brakes < 1000 kPa pressure.

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4.3.2.4.8 Repeat 4.3.2.4.2 thru 4.3.2.4.7 until a total of 5 runs is completed.

4.3.2.5 Engine Drag Torque Tests.

4.3.2.5.1 Vehicle Facing Down Grade.

4.3.2.5.1.1 Data required are the documentation of the engine speed and the maximum grade. Engine speed should be monitored, but digital recording is not required.

4.3.2.5.1.2 Place vehicle on variable grade park brake slope with the front of the vehicle facing downward.

4.3.2.5.1.3 Shift to Reverse.

4.3.2.5.1.4 Increase slope in 0.5 % grade increments until vehicle begins to roll down the grade. Document the last grade at which the vehicle remained stationary. This is the Reverse Drive Torque Grade.

4.3.2.5.1.5 Remove vehicle from ramp. Drive around ramp turnaround area while gently applying the brakes (< 1000 kPa pressure).

4.3.2.5.1.6 Repeat 4.3.2.5.1.2 thru 4.3.2.5.1.5 until a total of 3 runs is completed.

4.3.2.5.2 Vehicle Facing Up Grade.

4.3.2.5.2.1 Data required are the documentation of the engine speed and the maximum grade. Engine speed should be monitored, but does not need to be recorded to a file.

4.3.2.5.2.2 Place vehicle on variable grade park brake slope with the front of the vehicle facing upward.

4.3.2.5.2.3 Shift to Drive.

4.3.2.5.2.4 Increase slope in 0.5 % grade increments until vehicle begins to roll. Document the last grade at which the vehicle remained stationary. This is the Forward Drive Torque Grade.

4.3.2.5.2.5 Remove vehicle from ramp. Drive around ramp turnaround area while gently applying the brakes (< 1000 kPa pressure).

4.3.2.5.2.6 Repeat 4.3.2.5.2.2 thru 4.3.2.5.2.5 until a total of 3 runs is completed.

4.3.2.6 Unintended Brake Light Activation Test.

4.3.2.6.1 Data required are brake line pressures, vehicle speed, brake light signal, and engine speed, pedal position (Controller Area Network (CAN) signal). Remove pedal force transducer on brake pedal and pedal travel transducer. Data should be digitally recorded.

4.3.2.6.2 Proceed to the MPG Belgian Blocks road and drive one lap at the posted speed 50 km/h. Do not apply brakes. If an unavoidable brake apply is made, note the apply in the test record. Run 2 additional laps of the Belgian Blocks for a total of 3 runs.

4.3.2.6.3 Proceed to the MPG Pot Holes course and drive vehicle on the potholes road course. Unless otherwise specified in the test request, run two separate passes on the "#1 Pot Hole" and two separate passes on the "#2 Pot Holes" at a vehicle speed of 16 km/h or less. Vehicle speed should be adjusted as needed to prevent vehicle damage. Reference GMW3238.

5 Data

5.1 Calculations. The specific calculation methodologies are outlined below based on switch type categories.

5.1.1 ZABS Switch.

5.1.1.1 Method of Analysis: Analysis-Only Evaluation.

5.1.1.1.1 Required data.

5.1.1.1.1.1 Apply system cut-in, and cut-out force variation testing using GMW14590 test procedure (6 random samples if possible), or equivalent supplier brake apply system cut-in and cut-out force variation test data.

5.1.1.1.1.2 ZABS switch activation and release force variation data (supplier). Production or strong surrogate variation data is required.

5.1.1.1.2 Statistical analysis needs to be performed on the above force data. The mean and standard deviation should then be input into the Montecarlo Simulation Spreadsheet, CG2462. Additional data, if available, can also be input into the spreadsheet for more accurate results. The results of the simulation are displayed within the spreadsheet.

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