



Light Vehicle Brake Systems Performance - FMVSS 135

1 Scope

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. To evaluate hydraulic brake system performance consistent with the requirements of United States of America, Federal Safety Standards, Motor Vehicle Safety Standard Number (No.) 135, Light Vehicle Brake Systems. This standard specifies requirements for service brake and associated parking brake systems. The purpose of Federal Motor Vehicle Safety Standard (FMVSS) 135 is to ensure safe braking performance during normal and emergency conditions.

Note: This standard requires review whenever a new issue of the FMVSS 135 is enacted.

1.2 Foreword. This standard is used to demonstrate compliance with the United States government for brake performance requirements in FMVSS 135.

The test vehicle should represent as much of the vehicle family as possible. A process for selecting the test vehicle and test vehicle loading, Test Vehicle Definition Analysis, is in Appendix B of this procedure. To facilitate the selection of vehicle(s) and loading conditions to test, a table may be created with an entry for each combination of brake system, wheelbase, and weight limits. Two sample table formats are shown in Appendix B. The content varies slightly based on how the vehicle program handles mass data. Table B2 is applicable for vehicle programs (typically car programs) that track mass and calculate the weight placard for each vehicle by adding a defined passenger and payload configuration to the as built weight and distribution predicted from that vehicle's build content, resulting in a Gross Vehicle Weight Rating (GVWR) and distribution specific to that vehicle. The resulting GVWR weight is then used to calculate the corresponding Front and Rear Axle Weight Ratings that result in that distribution at GVWR. Table B3 is applicable for programs that use weight placards with Front and Rear Gross Axle Weight Ratings that total more than the Gross Vehicle Weight Rating, thus allowing a range of weight distributions at GVWR (typically truck programs). Figure B1 provides a visual representation of the logic used to define the required columns for Table B2 or Table B3. For vehicle programs that allow a range of GVWR mass distributions for a given vehicle, bounded by the vehicle's Gross Axle Weight Ratings, the calculations to determine the appropriate GVWR minimum percentage front weight test condition are illustrated in Table B1.

Following the test, an analysis of the applicability of the test results for a range of vehicle models may be requested. The process for this analysis, Vehicle Build Range Analysis for Brake System Certification, is in Appendix C of this standard.

This standard does not demonstrate compliance with the FMVSS 135 equipment and controls requirements, instrument cluster brake system warning indicator requirements, or master cylinder reservoir capacity and labeling requirements.

The responsible Lead System Engineer and Validation Engineer must certify that the brake system covered by this test meets all of the equipment and controls requirements of FMVSS 135 section S5, specifically S5.1 thru S5.3.2. Standard GMW15109 should be used.

The responsible Lead System Engineer and Validation Engineer must certify that the brake system covered by this report meets all of the reservoir volume and labeling requirements of FMVSS 135 section S5.4, specifically S5.4.1 thru S5.4.4. The reservoir volume must be determined either from engineering documentation based on drawings or layout studies or laboratory tests or from physical measurement. Standard GMW15110 should be used.

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The responsible Electrical Center personnel at the vehicle platform must certify that all released instrument clusters meet the brake system warning indicator requirements of FMVSS 135 section S5.5, specifically S5.5.1 thru S5.5.5. Limited information concerning the warning indicators for the specific vehicle tested are provided in the data sheets pack for this procedure. Additional validation (e.g., GMW16013) will be required from Electrical Center.

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 be considered correct and takes precedence. The content owner of this procedure should be notified of the discrepancies.

1.3 Applicability. Passenger cars and multi-purpose passenger vehicles, trucks and buses with a GVWR of 3500 kg or less.

2 References

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

2.1 External Standards/Specifications.

ASTM E1136-93	ASTM E1337-90	FMVSS 135	SAE J227a
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2.2 GM Standards/Specifications.

GMW15109	GMW15110	GMW16013
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2.3 Additional References.

GM Best Practice Brakes-64

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. For measuring the vehicle weight; at least, the mass (weight) at each axle and with 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 ASTM International (ASTM) ASTM E1136-93 standard reference test tire, in accordance with Method ASTM E1337-90 at a speed of 64.4 km/h (40 mph), without water delivery. The test road used shall have the PFC measured on a monthly basis 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. The facility should accommodate both lightly loaded and gross loaded conditions.

3.1.6 Variable Grade Ramp. A variable grade ramp capable of 30% grades is recommended for park brake evaluation.

3.2 Equipment.

3.2.1 The measurement of the following at time of test is required:

- a. Vehicle odometer mileage.
- b. Vehicle tire pressures.
- c. 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.

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3.2.3 Data acquisition and recording equipment that supports a minimum sample rate of 100 Hz on all channels is required. When using a system that can use multiple scan rates, the sample rate for all temperature channels is 10 Hz and the sample rate for all other channels is 100 Hz.

3.2.4 The following information 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 instrumentation required is detailed for each test segment.

3.2.4.1 As Received and Vehicle Build Floor Check.

- a. Service Brake Pedal Travel.
- b. Service Brake Pedal Force.
- c. Booster Vacuum or Boost Pressure.

3.2.4.2 Start of Test Floor Checks with Pressures.

- a. Service Brake Pedal Travel.
- b. Service Brake Pedal Force.
- c. Booster Vacuum or Boost Pressure.
- d. Brake Hydraulic Line Pressure at each corner.

3.2.4.3 Burnish.

- a. Brake pad/lining temperatures.

3.2.4.4 Adhesion Utilization.

- a. Service Brake Pedal Force.
- b. Booster Vacuum or Boost Pressure.
- c. Brake Hydraulic Line Pressure at each corner.
- d. Vehicle deceleration.
- e. Vehicle speed, including means to capture speed at time of brake application.
- f. Wheel Speed at each corner.
- g. Wheel Torque at each corner.
- h. Brake pad/lining temperatures.
- i. Ambient air temperature.

3.2.4.5 Park Brake.

- a. Park Brake Apply Force.
- b. Service Brake Pedal Force.
- c. Brake pad/lining temperatures.
- d. Ambient air temperature.

3.2.4.6 All Remaining Tests.

- a. Service Brake Pedal Force.
- b. Booster Vacuum or Boost Pressure.
- c. Brake Hydraulic Line Pressure at each corner.
- d. Vehicle deceleration.
- e. Vehicle speed, including means to capture speed at time of brake application.
- f. Wheel speed at each corner.
- g. Vehicle distance, including means to display stopping distance during testing.
- h. Brake pad/lining temperatures.
- i. Ambient air temperature.

3.2.4.7 Additional Instrumentation Requirements for Electric Vehicle (EV)s.

- a. Propulsion battery power consumption (for state of charge).

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3.2.4.8 Additional Instrumentation Requirements for Electrically Actuated Brakes.

- a. Current at each applicable corner.
- b. Voltage at each applicable corner.

3.2.5 All instrumentation and test equipment shall be calibrated as required. Record instrumentation identification and calibration dates in the test record unless the information is otherwise preserved in the testing laboratory records.

3.3 Test Vehicle/Test Piece.

3.3.1 Test vehicle selection should consider 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 which is representative of the extreme characteristics of the vehicle family. Pre-test analysis should be completed to select the appropriate vehicle for test.

3.3.2 A separate electrical group procedure is used to verify the brake indicator lamp (telltale) location, size, color and mechanization for each instrument cluster to be used with the brake system certified by this test.

3.3.3 New tires are required for installation at start of test on test wheels. An identical second set of new tires may be installed on the test torque wheels.

3.3.4 At the start of test, the brakes of the vehicle shall be in the same condition as when the vehicle is manufactured, i.e., new condition. Therefore, new brake parts are required for vehicle build at start of test.

3.4 Test Time.

Calendar time: 6 to 8 days (15 days for Electric Vehicles without Fast Charge)

Test hours: 40 to 48 hours (88 to 96 hours for Electric Vehicles without Fast Charge)

Coordination hours: 12 to 16 hours

3.5 Test Required Information.

3.5.1 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.

3.5.2 The test engineer should be familiar with terms and definitions from the regulatory standard. See 7.1 Glossary.

3.5.3 The following are available but are not attached.

3.5.3.1 A data sheets pack used to conduct the test and record results is currently in Excel Spreadsheet format with active, automatic macro routines. This data sheets pack is **required** to run the test.

3.5.3.2 Data Processing software is available. Instructions for the software are available.

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 sheet named Data Sheet in the test data pack. The insertion of these data in the data pack will allow the headers on the test instruction sheets to be completed.

4.1.2 The test weights and weight distributions should be determined and recorded in the data sheets pack. Use pre-test 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 shall be any temperature between -20 °C and 40 °C for all test sections except the thermal 4.3.33 thru 4.3.37 which will be restricted to ambient temperatures between -10 °C to 40 °C.

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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 Adhesion Utilization and Failed Antilock Brake System (ABS) Tests. For systems with ABS and Electronic Brake Force Distribution (EBD), both systems are to be failed completely when failed ABS is specified.

4.2.2.2 Adjustable Brake Pedal Assembly. If vehicle is equipped with an adjustable brake pedal assembly, the pedals should be adjusted to the position with the lowest pedal ratio. This pedal position shall be used for all test sections. The lowest pedal ratio shall be determined by comparing pressures generated during no-power floor checks.

4.2.2.3 Adjustments and Repairs. These requirements must be met without replacing any brake system parts or making any adjustments to the brake system except as specified. Where brake adjustments are specified, adjust the brakes, including the parking brakes, in accordance with the manufacturer's recommendation. No brake adjustments are allowed during or between subsequent tests in the test sequence.

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

4.2.2.5 Automatic Brake Adjusters. Automatic brake adjusters are operational throughout the entire test sequence. They may be adjusted either manually or by other means, as recommended by the manufacturer, only prior to the beginning of the road test sequence.

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

4.2.2.7 Brake Control. All service brake system performance requirements, including the partial system requirements, must be met solely by use of the service brake control.

4.2.2.8 Brake Control Application. A vehicle must be able to meet the requirements of this specification with the brakes applied manually by an expert driver.

4.2.2.9 Brake Control Applied Force (Pedal Force). Unless otherwise specified, the force applied to a brake control shall be not less than 65 N and shall be less than or equal to 500 N.

4.2.2.10 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.

4.2.2.11 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 per brake. For brake drum shoe, recess the thermocouple 1.0 mm under the surface. For disc brake pad, recess the thermocouple 2.0 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.

4.2.2.12 Brake Torque Measurement for the Adhesion Utilization Test. 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.

4.2.2.13 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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4.2.2.14 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. 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.

4.2.2.15 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 worst case distribution as possible without the use of extreme measures and the total weight does not exceed the GVWR. Both minimum percent front and maximum percent front GVWR mass distributions must be known. The test data sheets pack specifies the mass distribution used for each GVWR test.

4.2.2.16 Initial Brake Temperature (IBT). Unless otherwise specified, the initial brake temperature is to be $\geq 65^{\circ}\text{C}$ and $\leq 100^{\circ}\text{C}$. If the lower limit of the specified IBT for the first stop in a test sequence (other than a parking brake grade holding test) has not been reached, 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/s^2 .

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

4.2.2.17.1 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.

4.2.2.17.2 Close the throttle and coast in gear.

4.2.2.17.3 When the test speed is reached apply the brakes.

4.2.2.17.4 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.

4.2.2.17.5 Procedures in drive gear which call for disabling EV regenerative braking (regen). Because it is not part of the service, brake system may be run in neutral instead if this automatically disables the regen.

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

4.2.2.18.1 Exceed the test speed by 6 km/h to 12 km/h.

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

4.2.2.18.3 Shift to neutral.

4.2.2.18.4 When the test speed is reached, apply the brakes.

4.2.2.18.5 For tests conducted "in neutral" the operator of an EV with no "neutral" position (or other means such as a clutch for disconnecting the drive train from the propulsion motor(s)) does not apply any electromotive force to the propulsion motor(s). Any electromotive force that is applied to the propulsion motor(s) automatically remains in effect unless otherwise specified by the test procedure.

4.2.2.19 Lining Preparation. At the beginning of preparation for the road tests, the brakes of the vehicle are in the same condition as when the vehicle was manufactured. No burnishing or other special preparation is allowed, unless all vehicles sold to the public are similarly prepared as a part of the manufacturing process.

4.2.2.20 Lightly Loaded Vehicle Weight Loading. For the tests at LLVW, the vehicle is loaded to the worst case 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. Both minimum percent front and maximum percent front LLVW mass distributions must be known. The test data sheets pack specifies the mass distribution used for each LLVW test.

4.2.2.21 Regenerative Brake System (RBS).

4.2.2.21.1 For an EV equipped with an RBS that is part of the service brake system, the RBS is operational during the burnish and all tests, except for the test of a failed RBS

4.2.2.21.2 For an EV equipped with an RBS that is not part of the service brake system, the RBS is operational and set to produce the maximum regenerative braking effect during the burnish, and is disabled during the test procedures. If the vehicle is equipped with a neutral gear that automatically disables the RBS, the test procedures which are designated to be conducted in gear may be conducted in neutral.

4.2.2.22 State of Charge of Batteries for EVs. Unless otherwise specified, fully charge the propulsion batteries prior to each test sequence listed in Table 1. If vehicle labeling and the owner's manual lack

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instructions, charge the batteries to 95% or greater state of charge to meet this requirement. Except for the burnish, no further charging of any propulsion battery occurs during any of the performance tests in the test sequence listed in Table 1.

4.2.2.22.1 The state of charge of the propulsion batteries is determined in accordance with SAE International (SAE) Recommended Practice SAE J227a (incorporated by reference, see § 571.5). The applicable sections of J227a are 3.2.1 thru 3.2.4, 3.3.1 thru 3.3.2.2, 3.4.1 and 3.4.2, 4.2.1, 5.2, 5.2.1 and 5.3.

4.2.2.23 State of Charge of Batteries for Electrically-Actuated Service Brakes. A vehicle equipped with electrically-actuated service brakes shall undergo an additional test series with depleted batteries. Each battery providing power to the electrically-actuated service brakes, shall be in a depleted state of charge for conditions (a), (b), or (c) of this paragraph as appropriate.

- a. For an EV equipped with electrically-actuated service brakes deriving power from the propulsion batteries and with automatic shut-down capability of the propulsion motor(s), the propulsion batteries are at not more than 5% above the EV actual automatic shut-down critical value. The critical value is determined by measuring the state-of-charge of each propulsion battery at the instant that automatic shut-down occurs.
- b. For an EV equipped with electrically-actuated service brakes deriving power from the propulsion batteries and with no automatic shut-down capability of the propulsion motor(s), the propulsion batteries are at an average of not more than 5% above the actual state of charge at which the required brake failure warning signal is illuminated.
- c. For a vehicle which has one or more auxiliary batteries that provides electrical energy to operate the electrically-actuated service brakes, each auxiliary battery is at not more than 5% above the actual state of charge at which the required brake failure warning signal is illuminated.

4.2.2.24 Stopping Distance. Braking performance is determined by measuring the stopping distance from a given initial speed. Unless otherwise specified, the vehicle is stopped in the shortest distance achievable (best effort) on all stops. Where more than one stop is required for a given set of test conditions, a vehicle is deemed to comply with the corresponding stopping distance requirements if at least one of the stops is made within the prescribed distance.

4.2.2.25 Stopping Distance Data Corrections.

4.2.2.25.1 Initial Speed Correction. Stopping distances reported on the Data Sheets are to be corrected for initial stopping speed using the following equation, 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 (meters)
 S_m = Measured stopping distance (meters)
 V_r = Requested initial speed (kilometers per hour)
 V_a = Actual initial speed (kilometers per hour)

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4.2.2.25.2 Peak Friction Coefficient Correction. After correcting to desired initial speed, adjust corrected distance to Peak Friction Coefficient (PFC) using the following equation.

$$S = \left[\left(\frac{PFC_{act.}}{PFC_{spec.}} \right) (S_c - 0.1V_c) \right] + 0.1V_c$$

Where:

S = Stopping distance (meters) adjusted to measured PFC

PFC_{act.} = Measured PFC of the test road surface (actual)

PFC_{spec.} = PFC specified in Standard (0.9)

S_c = initial speed corrected stopping distance (meters)

V_c = corrected test speed (kilometers per hour)

4.2.2.26 Stopping Distance Equations. In the stopping distance equations given for each applicable test (such as $S \leq 0.10V + 0.0060V^2$), S is the maximum stopping distance in meters, and velocity (V) is the test speed in kilometers per hour.

4.2.2.27 Test Speeds.

4.2.2.27.1. If a non-EV is incapable of attaining the specified normal test speed, it is tested at a speed that is a multiple of 5 km/h that is 4 km/h to 8 km/h less than its maximum speed and its performance must be within a stopping distance given by the equation provided for the specific requirement.

4.2.2.27.2. If an EV is incapable of attaining the specified test speed due to depleted propulsion batteries, such that the vehicle reaches automatic shut-down, will not accelerate, or the low state of charge brake warning lamp is illuminated, the vehicle is to be accelerated to brake test speed by auxiliary means.

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

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

4.2.2.30 Variable Brake Proportioning Valve. If a car is equipped with a variable brake proportioning system, the proportioning valve is fully operational for all tests except the test for failed variable brake proportioning system.

4.2.2.31 Vehicle Position and Steering.

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

4.2.2.31.2 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.

4.2.2.32 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. Each vehicle shall meet all the requirements when tested according to the conditions and procedures and in the sequence specified in Table 1. For reference, the paragraph numbers for the test instruction and the corresponding FMVSS 135 performance requirement are listed in the table.

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Table 1: Vehicle Test Sequence

	Instruction	FMVSS 135 Requirement
As Received floor checks.	4.3.3	N/A
Vehicles build floor checks.	4.3.12.1	N/A
Start of test floor checks.	4.3.12.3	N/A
Center of Gravity heights.	4.3.13	N/A
Vehicle loaded to GVWR:		
Burnish.	4.3.14	N/A
Vehicle loaded to LLVW:		
Vehicle maximum speed.	4.3.15	N/A
Adhesion utilization.	4.3.17	7.4.5
Vehicle loaded to GVWR:		
Adhesion utilization.	4.3.17	7.4.5
Cold effectiveness.	4.3.19	7.5.3
High speed effectiveness.	4.3.20	7.6.3
Stops with engine off.	4.3.21	7.7.4
Vehicle loaded to LLVW:		
Cold effectiveness.	4.3.22	7.5.3
High speed effectiveness.	4.3.23	7.6.3
Failed antilock.	4.3.24	7.8.3
Failed brake proportioning.	4.3.25	7.9.3
Fluid Sensor check.	4.3.26	N/A
Partial failure.	4.3.27	7.10.4
Vehicle loaded to GVWR:		
Partial failure.	4.3.28	7.10.4
Failed antilock.	4.3.29	7.8.3
Failed brake proportioning.	4.3.30	7.9.3
Power brake unit failure.	4.3.31	7.11.4
Parking brake.	4.3.32	7.12.3
Baseline stops.	4.3.33	N/A
Heating snubs.	4.3.34	N/A
Hot performance.	4.3.35	7.14.4
Brake cooling.	4.3.36	N/A
Recovery performance.	4.3.37	7.16.4
End of test floor checks.	4.3.38	N/A
Final inspection.	4.3.39	5.6

4.3.1 The data sheets pack shall be used when running this standard. The data sheets pack contains information sheets, test instructions, and data sheets. The data sheets are required to report the test results and all information should be completed as the performance tests are completed.

4.3.2 Install plug-type thermocouples in test linings and/or pads according to 4.2.2.11.

4.3.3 If an as-received floor check is requested, perform the floor check according to the instructions in the data sheets pack. Do not install any additional instrumentation. Do not break into the vehicle hydraulic system.

4.3.4 Install new brake drums and/or rotors, return and hold-down springs, and thermocouple friction material. Set brake clearances to manufacturer's specification. Check that automatic brake adjusters are operational. Install new park brake cables and new park brake friction material if separate from the service brake friction material. Adjust parking brake to manufacturer's specification. Any deviations from these specified installations must be noted and approved by the Test Engineer, the Lead System Engineer, or the Validation Engineer.

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

4.3.6 Prepare torque wheels for the vehicle. Mount new tires on the torque wheels (if using a second set of identical tires). When appropriate, install these wheel/tire units.

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

4.3.8 Check all vehicle fluid levels (oil, coolant, etc.) and fill to maximum recommended capacity.

4.3.9 If applicable, check and reset, if necessary, the engine idle and engine governed speed to manufacturer's specification.

4.3.10 Check and adjust, if necessary, the transmission control devices as required for proper operation.

4.3.11 Fill fuel tank to 100% capacity. Monitor fuel tank throughout test maintaining at least 75% capacity.

4.3.12 Build and Start of Test Floor Checks.

4.3.12.1 Install instrumentation for vehicle build floor check. Do not install any additional instrumentation. Do not break into the vehicle hydraulic system. Perform a static floor check on the test vehicle to establish the service brake pedal force and pedal travel relationship. The floor check shall include one run with booster assist (with power) and one run without booster assist (no-power).

4.3.12.2 Complete the installation of required instrumentation and installation of split-system valves. Install the vehicle wheels. Torque wheels are not installed until the Adhesion Utilization test (4.3.17).

4.3.12.3 After instrumentation, perform a static floor check with line pressures. The floor check shall include one run with booster assist (with power) and one run without booster assist (no-power).

4.3.12.3.1 If the vehicle is equipped with an adjustable brake pedal assembly, perform a static floor check (with line pressures) in the without booster assist (no-power) condition with the pedals adjusted (1) full forward, (2) full rearward, and (3) at the approximate midpoint of the travel. Determine the pedal position that results in the lowest front line pressure at 500 N pedal forces. Use this pedal position for all testing.

4.3.12.4 For vehicles not equipped with a variable brake proportioning system, use the static floor check with line pressures to determine the front versus rear brake pressure relationship over the entire range of line pressures. EBD or Dynamic Rear Proportioning (DRP) is **not** considered a variable brake proportioning system. If the test vehicle is equipped with a variable brake proportioning system, review FMVSS 135 section S7.4.3(j).

4.3.13 Center of Gravity Height Measurement. The CG height needs to be accurately measured for both GVWR and LLVW. The loading conditions that must be measured are the GVWR with minimum percent front loading and the LLVW with maximum percent front loading. Measurement at the other loading conditions is optional. These measurements shall be made before the start of the road test segments if at all possible. If the CG measurement facility is not available at the start of the testing, the measurements may be made at the end of test. In that case, an estimate of the CG height shall be used for the required Adhesion Utilization calculations during the test. At the end of test, when measured CG heights are available, additional analysis of the data will be required.

4.3.14 Burnish.

4.3.14.1 The road test surface conditions specified in 3.1.4 do not apply to the burnish schedule. Use any appropriate road system for the burnish.

4.3.14.2 Any pretest instrumentation checks are conducted as part of the burnish procedure, including any necessary rechecks after any instrumentation repair, replacement or adjustment. Instrumentation check test conditions must be in accordance with the burnish test procedure.

4.3.14.3 Setup data acquisition system to record the data channels requested.

4.3.14.4 For an EV, fully charge the propulsion batteries. If vehicle labeling and the owner's manual lack instructions, charge the batteries to 95% or greater state of charge to meet this requirement. Throughout the burnish, fully recharge after every 40 stops or when 80 km/h cannot be attained, whichever occurs first.

4.3.14.5 For an EV having a manual control for setting of regenerative braking, the manual control, at the beginning of the burnish procedure, is set to provide maximum regenerative braking throughout the burnish.

4.3.14.6 Ballast to the specified GVWR and mass distribution for this test segment. Establish an IBT ≤ 100 °C then make 200 stops in normal driving gear from 80 km/h to 0 km/h with a constant deceleration rate of 3.0 m/s². Maximum pedal force limit does not apply. Adjust pedal force as needed to maintain constant deceleration. After each stop use a moderate acceleration to a speed of 80 km/h and maintain that speed until making the next stop. The interval from the start of one service brake application to the start of the next is either the time necessary to reduce the IBT to 100 °C or less, or the distance of 2 km, whichever occurs first.

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