



Braking Systems of Motor Vehicles

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. The purpose of this standard is to evaluate the hydraulic braking system performance of motor vehicles to the requirements of Economic Commission Europe (ECE) Regulation Number 13.10, June 2005 (R13.10).

Note: This procedure requires review whenever a new revision of ECE R13.10 is enacted.

1.2 Foreword. This standard covers the road based brake performance. It does not evaluate compliance to the non-road-based brake system design requirements specified in the regulation.

1.3 Applicability. This standard covers the performance requirements of category M1 (passenger carrying) and N1 (goods carrying) vehicles with vacuum assisted hydraulic brake systems only. For other types of brake systems, refer to the ECE R13.10 regulation.

2 References

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

2.1 External Standards/Specifications.

ECE R13.10 FMVSS 135

2.2 GM Standards/Specifications.

None

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 A test surface having a coefficient of adhesion ≥ 0.8 for straight line stops and skid pad.

3.1.4 Test grades or hills of 12 % and 18 % grades. Test grades or hills of up to 15 % and up to 20 %, respectively, may be used.

3.1.5 Weighing scales, including ballast materials.

3.1.6 Wheel alignment machine.

3.1.7 For anti-lock brake system (ABS) tests: A test area having a level surface with a peak coefficient of adhesion of ≤ 0.3 (low- μ), large enough for the testing to be performed in safety. This surface should be preceded and followed by a level surface with a coefficient of adhesion of ≈ 0.8 (high- μ), which is of sufficient length on the approach side to enable the test speeds to be attained. For testing ABS category 1 and 2 devices, the low- μ surface must have a high- μ surface on at least one side to enable the split- μ tests to be performed.

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3.1.7.1 Optional: If a suitable surface with a peak coefficient of adhesion of ≤ 0.3 is not available, worn tires and a surface with a higher coefficient of adhesion up to 0.4 may be used at the discretion of the Test Officer. In this case the details must be recorded on the test report.

3.2 Equipment.

3.2.1 Stopwatch.

3.2.2 Torque wrench.

3.2.3 Tire pressure gauge.

3.2.4 Weather station capable of recording ambient temperature and pressure, humidity and wind velocity.

3.2.5 Appropriate data acquisition equipment Minimum sampling frequency per channel: 100 Hz.

3.2.6 One accelerometer (0 to 10) m/s².

3.2.7 One pedal force transducer (0 to 1500) N.

3.2.8 One pedal travel transducer (0 to 200) mm.

3.2.9 One vehicle speed and distance transducer (0 to 250) km/h. Speed and distance measurement shall be accurate to within 1 %.

3.2.10 Minimum 4 (four) thermocouples ((0 to +800) °C) to measure brake disc or drum surface temperature.

3.2.11 Optional: Eight pad temperature thermocouples ((0 to +800) °C), 4 (four) fluid temperature thermocouples ((0 to +250) °C), eight thermocouples for hoses, park brake backing plates, master cylinder and ambient temperature, as required.

3.2.12 Optional: 4 (four) brake line pressure transducers (0 to 150) bar.

3.2.13 Additional Equipment for ABS Tests:

3.2.13.1 Adjustable pressure regulating valves (allowing fine adjustment of output pressure) fitted in the line to each wheel.

3.2.13.2 A means of isolating axles so that each axle equipped with anti-lock can be braked independently of the other when the brake pedal is applied. The pressure regulating valves above may be used for this purpose if the output from the valves can be reduced to zero.

3.2.13.3 Suitable equipment to produce event markers showing the point of transition from the low to high- μ surfaces and vice versa.

3.3 Test Vehicle/Test Piece. In selection of the test vehicle, consideration shall be given to the following, which is to be representative of the worst case characteristics of the vehicle family under evaluation.

3.3.1 Laden Mass. The laden mass is the maximum gross vehicle mass (GVM) in the model range.

3.3.2 Unladen Mass. The unladen mass is the maximum front/rear ratio of mass in the model range.

3.3.3 Suspension. Use the worst case variant with regard to adhesion, mass distribution or control of load sensing devices.

3.3.4 Wheelbase. Use the minimum in range for dynamic tests but with piping to simulate maximum wheelbase for reaction time and depletion tests (if applicable).

3.3.5 Maximum Speed. Use the powertrain capable of achieving the initial speed of the 80 % maximum speed (v_{max}) Type-O test with engine connected and achieving acceleration for the Type-I fade test of fastest variant in range.

3.3.6 Engine. Use the engine which contributes the least engine braking effect. If this is not compatible with the speed and acceleration requirements, an additional vehicle may be required.

3.3.7 Gearbox. Use either the manual or automatic gearbox, whichever contributes the least engine braking effect.

3.3.8 Overall Transmission Ratio. Use the transmission ratio which contributes the minimum engine braking effect at the critical speeds for the Type-O and Type-I tests. If this is not compatible with the speed and acceleration requirements, an additional vehicle may be required.

3.3.9 Foundation Brakes and Brake Transmission Components. All variants are to be tested. Where alternative makes of valves are used, static tests on all variants may be the only required testing.

3.3.10 Tires. Use tires with the maximum rolling radius and minimum adhesion performance.

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3.3.11 Wheels. Use steel wheels where alloys of the same size are available.

3.3.12 Body Style. Use body style options giving the worst case brake cooling package for the model range.

3.4 Test Time.

Calendar time: 5 to 7 days

Test hours: (24 to 48) h

Coordination hours: (8 to 16) h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. One operator experienced and trained in regulatory brake testing.

4 Procedure

4.1 Preparation.

4.1.1 Test Vehicle Preparation.

4.1.1.1 Fit tow bar to vehicle, if requested.

4.1.1.2 Install worst case front spoiler for brake cooling. Blank off the bumper fascia cooling ducts, if requested.

4.1.1.3 Install side skirts, if requested.

4.1.1.4 Blank off the cooling holes in wheel trims/alloy wheels, if requested.

4.1.1.5 Close off functional louvers or cooling ducts, if requested.

4.1.1.6 Perform powertrain break-in procedure, if required.

4.1.1.7 Ensure vehicle is equipped with fire extinguisher, if required.

4.1.2 Brakes Preparation.

4.1.2.1 The vehicle must be fitted with a new brake system as specified by the brake engineer.

4.1.2.2 Install thermocouples in requested location in brake pads where required. Recommended installation procedure is as per FMVSS 135.

4.1.2.3 Install new discs/drums, pads/lining and calipers/cylinders as per work instruction.

4.1.2.4 Install thermocouples for brake discs or drums, where fitted.

4.1.2.5 Install brake fluid temperature thermocouples in the bleeder screws in contact with the brake fluid where required.

4.1.2.6 Using new brake fluid, fully flush and fill the brake system, then bleed hydraulic circuit. Check bleeders for leaks after stationary brake applies.

4.1.2.7 Fit master cylinder and ambient temperature thermocouples where required.

4.1.3 Instrumentation.

4.1.3.1 Install data acquisition system securely in the test vehicle.

4.1.3.2 Connect all thermocouples to data acquisition system.

4.1.3.3 Check calibration of transducers. Document calibration and instrument identification in the test record unless otherwise preserved by the test facility.

4.1.3.4 Ensure all instrumentation is working correctly by performing an instrumentation check.

4.1.4 Test Preparation.

4.1.4.1 Check and document vehicle details in the test record.

4.1.4.2 Check and adjust vehicle service items as requested. Adjust tire pressures according to prescribed test mass and speed condition.

4.1.4.3 Measure maximum speed of vehicle if required. Use the following method.

4.1.4.3.1 Load vehicle to GVM (Laden).

4.1.4.3.2 Accelerate to the maximum speed obtainable and hold. Make four separate times versus distance measurements. Calculate the vehicle speed from each measurement. Average of four speeds, and report this average in the test record.

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4.1.4.4 Ballast the vehicle's front and rear axles to laden mass as specified by test originator prior to burnish sequence. Document the distribution and position of ballast in the test record.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Ambient Temperature: (0 to +40) °C.

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

4.2.1.2.1 For wind speeds ≤ 5 m/s run stops in either direction.

4.2.1.2.2 For wind speeds of (6 to 14) m/s parallel to the road, run stops with the wind direction.

4.2.1.2.3 For crosswinds at speeds of (6 to 14) m/s, run stops in either direction.

4.2.1.2.4 Do not run if wind speed exceeds 14 m/s.

4.2.1.3 Fade test sections should be run with a wind speed of ≤ 5 m/s. Occasional gusting above this limit is permitted.

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 Fill the fuel tank to the level appropriate to the required vehicle test mass prior to all test sequences, and every 100 km during burnish sequence.

4.2.2.2 All vehicle openings (except flow through ventilation system) are to be closed during all decelerations.

4.2.2.3 Although there is no specific order in which tests are to be conducted, the Type-I Fade test should be left until all other dynamic testing has been completed.

4.2.2.4 The minimum specified performance limits for each of the dynamic tests must be met for both stopping distance and mean fully developed deceleration (MFDD).

4.2.2.5 If the maximum design speed of the test vehicle is lower than the prescribed test speed, the test shall be performed at the vehicle's maximum speed.

4.2.2.6 Maximum allowable pedal force to achieve prescribed performance must not exceed the maximum force allowed for the vehicle category. Consideration should be given to instrument uncertainty.

4.2.2.7 Test road surface to have a good coefficient of adhesion (dry road).

4.2.2.8 At the start of the tests, the tires must be cold and at the appropriate pressure to suit the prescribed test mass condition.

4.2.2.9 The prescribed performance must be obtained without wheel locking at speeds above 15 km/h, without deviation of the vehicle from a 3.5 m wide lane, and without abnormal vibrations.

4.2.2.9.1 If any instability occurs during the braking event, note same in the test record.

4.2.2.9.2 The vehicle is to be aligned in the center of the lane at the start of each brake application.

4.2.2.9.3 Steering correction is permitted provided it does not involve significant effort or any sudden steering reaction.

4.2.2.10 When conducting a Type-O test with engine disconnected, accelerate the vehicle to at least 5 km/h above the prescribed test speed. Shift the transmission into neutral, coast down to the prescribed initial speed and apply the brakes. The actual speed at the point of brake application must not be less than 98% of the prescribed test speed.

4.2.2.11 When conducting a Type-O test with engine connected, accelerate the vehicle to at least 5 km/h above the prescribed test speed using the highest appropriate gear for the speed. Release the accelerator and, with the gear still engaged, coast down to the prescribed initial speed and apply the brakes. The clutch may be disengaged at the end of the stop to prevent stalling. The actual speed at the point of brake application must not be less than 98% of the prescribed test speed.

4.2.2.12 The temperature of the service brakes shall be at the required initial brake temperature (IBT) prior to any brake application, unless specified otherwise. (See paragraph 7.1 for details.) To heat the brakes to initial brake temperature, make up to ten snubs from (60 to 15) km/h at a maximum deceleration of 3 m/s².

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4.2.2.13 Unless otherwise specified, each test may comprise up to six stops, including any stops needed for familiarization. Perform only as many effectiveness stops as necessary, within the allowable number, until the maximum braking performance that the vehicle can achieve without wheel lock is obtained.

4.3 Instructions.

4.3.1 Static Brake System Tests.

Note: Conduct all static tests with cold brakes.

4.3.1.1 Warning Signal–Pressure Differential Check. This test is applicable to vehicles without a low master cylinder fluid level warning light.

4.3.1.1.1 Connect a pressure gauge/transducer to both of the master cylinder outlet ports.

4.3.1.1.2 Start the engine and apply a sustained pedal effort to the brake system of 100 N.

4.3.1.1.3 Slowly open one bleed nipple to provide a slow drop in line pressure in the circuit being failed.

4.3.1.1.4 Monitor the Brake Failure Indication Lamp and the line pressures.

4.3.1.1.5 On activation of the Brake Failure Indication Lamp, record line pressures for both the active and failed circuit. Stop engine and restore braking system to normal function.

4.3.1.1.6 Repeat this procedure on the other circuit.

4.3.1.1.7 Regulatory limit is ≤ 15.5 bar.

4.3.1.2 Brake Line Pressure versus Pedal Force (Optional). Perform this test if requested by engineer.

4.3.1.2.1 Connect a pressure gauge/transducer to both of the master cylinder outlet ports and after any load proportioning valve. Vehicle should be in unladen condition.

4.3.1.2.2 Fit a force transducer to the brake pedal, centrally located on the pedal pad with the line of action coincident with the line of travel of the pedal.

4.3.1.2.3 Conduct this test both with and without power assistance.

4.3.1.2.4 Apply a progressively increasing effort to the brake pedal, up to 600 N.

4.3.1.2.5 Conduct power assisted tests with engine idling at operating temperature. Allow approximately two minutes from start up to stabilize booster vacuum.

4.3.1.3 Brake Pedal Travel versus Pedal Force (Optional). Perform this test if requested by engineer.

4.3.1.3.1 Fit a force transducer and a distance transducer to the brake pedal. Measurements made are to be in relation to the center of the brake pad with the line of action coincident with the line of travel of the pedal.

4.3.1.3.2 Conduct this test both with and without power assistance.

4.3.1.3.3 Apply a progressively increasing effort to the brake pedal, up to 600 N.

4.3.1.3.4 For non power assisted test, evacuate booster completely by cycling brake pedal ten times.

4.3.1.3.5 Conduct power assisted tests with engine idling at operating temperature. Allow approximately two minutes from start up to stabilize booster vacuum.

4.3.2 Dynamic Brake System Tests.

4.3.2.1 Suggested Dynamic Brake Sequence. The suggested test sequence for the dynamic testing is shown in Table 1. The instructions for the testing are in the listed Appendices. Perform the tests following the instructions. Any deviations from the suggested test sequence should be noted in the test record. Testing for the Residual Braking System is covered by the Secondary Braking System testing.

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Table 1: Brake Testing Sequence

Testing Order		Appendix/Sequence
Vehicle Loaded To LADEN Mass:		
1	Instrumentation Check	A Sequence 1
2	Burnish	A Sequence 2 (Sequence 3 if requested)
3	Wheel Lock Sequence (Non-ABS Only)	B
Vehicle Loaded To UNLADEN Mass:		
4	Wheel Lock Sequence (Non-ABS Only)	B
5	ABS Performance Tests	D
6	Torque Wheel Test (Required If Vehicle Failed Wheel Lock Sequence)	C
Vehicle Loaded To LADEN Mass:		
7	Torque Wheel Test (Required If Vehicle Failed Wheel Lock Sequence)	C
8	Type-O Test, Engine Disconnected, Service Brake System	A Sequence 4
9	Type-O Test, Engine Connected, Service Brake System	A Sequence 5
10	Type-O Test, Engine Connected, Check Vehicle Behavior	A Sequence 6
11	Type-O Test, Engine Disconnected, Secondary Braking System, No Boost	A Sequence 7c
12	Type-O Test, Engine Disconnected, Failed ABS	A Sequence 7d
13	Type-O Test, Engine Disconnected, Failed Proportioning	A Sequence 7e
14	Type-O Test, Disconnected, Engine Off, If No Non-Return Valve In Servo System	A Sequence 8a,b
15	Type-O Test, Engine Disconnected, Secondary Braking System, Circuit Failures	A Sequence 7a,b
Vehicle Loaded To UNLADEN Mass:		
16	Type-O Test, Engine Disconnected, Secondary Braking System, Circuit Failures	A Sequence 7a,b
17	Type-O Test, Engine Disconnected, Service Brake System	A Sequence 4
18	Type-O Test, Engine Connected, Service Brake System	A Sequence 5
19	Type-O Test, Engine Connected, Check Vehicle Behavior	A Sequence 6
20	Type-O Test, Engine Disconnected, Secondary Braking System, No Boost	A Sequence 7c
21	Type-O Test, Engine Disconnected, Failed ABS	A Sequence 7d

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Testing Order		Appendix/Sequence
22	Type-O Test, Engine Disconnected, Failed Proportioning	A Sequence 7e
23	Type-O Test, Disconnected, Engine Off, If No Non-Return Valve In Servo System	A Sequence 8a,b
Vehicle Loaded To LADEN Mass:		
24	Park Brake – Vehicle Only	A Sequence 9
25	Park Brake – Vehicle And Trailer	A Sequence 10
26	Park Brake – Vehicle In Motion	A Sequence 11
27	Type-I Heating Procedure	A Sequence 12
28	Type-O Hot Performance	A Sequence 13

4.3.3 Final Inspection.

4.3.3.1 The vehicle passes the test if all the performance requirements are met without a component failure.

4.3.3.2 Allow the brakes to cool and ensure there is no binding or rubbing of the brakes.

4.3.3.3 Check lining surface area of any single friction element is reduced by no more than 10% as a result of tear-out or detachment.

4.3.3.4 Check that there is no detachment or malfunction of any mechanical component of the braking system.

4.3.3.5 Check that there is no visible evidence of brake fluid on brake friction surfaces, at wheel cylinders, or at fluid line junction.

4.3.3.6 Document the appearance of friction surfaces and the degree of burnish of park brake linings.

4.3.3.7 Photograph brake linings.

4.3.3.8 Photograph test vehicle (frontal and side view).

5 Data

5.1 Calculations. See test instruction sections in Appendices A thru D for any required calculations.

5.2 Interpretation of Results.

5.2.1 Results from this testing should be compared to the requirements in the applicable regulatory standards.

5.2.2 Compliance to the regulation shall be demonstrated in both the laden and unladen vehicle loading conditions.

5.2.3 Both the prescribed stopping distance and the prescribed mean fully developed deceleration for the relevant vehicle category must be met, but it may not be necessary to actually measure both parameters.

5.3 Test Documentation. Publish the test results and all test information in an engineering report following corporate guidelines.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Class M1: Vehicles used for the carriage of passengers and comprising not more than eight seats in addition to the driver's seat.

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Class N1: Vehicles used for the carriage of goods and having a maximum mass not exceeding 3500 kg.

Gross Combination Mass: The value specified by the manufacturer as being the maximum loaded mass allowable of a vehicle and trailer combination.

Initial Brake Temperature: The brakes must be cold, unless otherwise specifies. A brake is deemed to be cold when the temperature measured on the disc or the outside of the drum is to be below 100°C prior to brake application.

Initial Vehicle Speed (v_o): The speed at the moment when the driver begins to actuate the control of the braking system. The method of triggering the moment of brake actuation is defined under Stopping Distance. The initial speed shall be $\geq 98\%$ of the prescribed speed for the test in question.

Laden Test Mass: The maximum mass stated by the manufacturer to be technically permissible (i.e. maximum permissible at GVM). Where provision is made for several arrangements of the load on the axles, the distribution must be such that the load on each axle is proportioned according to the maximum permissible load for each axle, e.g., the maximum front test mass equals the quotient of the maximum front axle rating divided by the sum of the maximum front axle rating and the maximum rear axle rating times the GVM.

Maximum Speed ($v_{\max}$): Highest speed attainable by accelerating at maximum rate from a standing start for 3.2 km on a level surface (using the fastest powertrain in vehicle family).

Maximum Top Speed: $v_{\max}$ of fastest powertrain in vehicle family.

Mean Fully Developed Deceleration: The deceleration averaged with respect to distance over the interval v_b to v_e , according to the following formula:

$$MFDD = \frac{v_b^2 - v_e^2}{25.92(s_e - s_b)} \left[m/s^2 \right]$$

Where:

v_o = initial vehicle speed in km/h (see below)

v_b = vehicle speed at $0.8 v_o$ in km/h

v_e = vehicle speed at $0.1 v_o$ in km/h

s_b = distance traveled between v_o and v_b in m (meters)

s_e = distance traveled between v_o and v_e in m

Minimum Top Speed: $v_{\max}$ of slowest powertrain in vehicle family.

Stopping Distance: The stopping distance is the distance, covered by the vehicle from the moment the driver begins to actuate the control of the braking system, until the moment when the vehicle stops. The moment of brake actuation is triggered by either:

- When the center of the brake pedal pad moves no more than 3 mm from its fully released position;

Or:

- At the point of application of 20 N pedal force to the brake control.

Trailer Mass: The maximum permissible mass of a trailer to be connected to the vehicle specified by the manufacturer.

Unladen Test Mass: Base curb mass of the vehicle with all standard equipment, including all lubricants and fluids necessary to operate the vehicle, at least 75% fuel capacity, plus:

- A minimum of 75 kg (driver only) to a maximum of 150 kg (driver plus passenger) additional loading in the front seat position for driver plus instrumentation (determined by worst case front/rear ratio),
- The sum of all heavy regular production options which contribute to the above mass to give a higher front/rear axle mass distribution.

Note: The Unladen Test Mass distribution of the test vehicle is to represent the worst case (maximum) ratio front/rear mass distribution for the model range. It is not necessary to reduce the mass of the unladen vehicle to the worst case in the range as long as the percentage distribution of the mass is the worst case condition. It is permissible to ballast the front and reduce the rear axle mass to achieve this on the test vehicle.

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Wheel Lock Up: A locked wheel is defined as a wheel that has zero rotational velocity.

7.2 Acronyms, Abbreviations, and Symbols.

ABS	Anti-lock Brake System
EBD	Electronic Brake Distribution
ECE	Economic Commission Europe
FMVSS	Federal Motor Vehicle Safety Standard (USA)
GVM	Gross Vehicle Mass
IBT	Initial Brake Temperature
MFDD	Mean Fully Developed Deceleration
$v_{\max}$	Vehicle maximum speed
WOT	Wide Open Throttle

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW15313

9 Release and Revisions

This standard was originated in April 2006. It was first approved by Global Chassis Brake Team in May 2008. It was first published in May 2008.

Issue	Publication Date	Description (Organization)
1	MAY 2008	Initial publication.
2	OCT 2013	Five Year Refresh 2013 (Chassis Brake GSSLT)

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