



SURFACE VEHICLE RECOMMENDED PRACTICE

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FMVSS 105 Inertia Brake Dynamometer Test Procedure for Vehicles Above 4540 kg GVWR

RATIONALE

The current version of this recommended practice clarifies the scope related to tow vehicles and trailering applications. The technical content, the test conditions, and the test sequences from previous versions remain unchanged.

TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	Purpose.....	3
2.	REFERENCES.....	3
2.1	Applicable Documents.....	3
2.1.1	SAE Publications.....	3
2.1.2	NHTSA Publications.....	3
2.2	Related Publications.....	4
2.2.1	SAE Publications.....	4
2.2.2	Code of Federal Regulations (CFR) Publications.....	4
2.2.3	ISO Publications.....	4
2.2.4	NHTSA Publications.....	4
2.2.5	NIST Publications.....	4
3.	DEFINITIONS.....	4
4.	TEST CYCLES.....	8
4.1	Dynamic Brake Application.....	8
4.1.1	Time t_0	8
4.1.2	Time t_1	8
4.1.3	Time t_2	8
4.1.4	Time t_3	9
4.1.5	Time t_4	9
5.	TEST EQUIPMENT.....	9
6.	TEST CONDITIONS.....	9
7.	TEST PARTS PREPARATION AND TEST SETUP.....	13

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8.	TEST PROCEDURES.....	13
8.1	Optional or Alternative Sections.....	13
8.2	Development Test Sequence.....	14
8.3	In-Wheel Parking Brake Section (Optional Section).....	14
8.4	Water Soak Section (Optional Section)	14
8.5	FMVSS Test Sequence.....	16
9.	TEST REPORT	17
9.1	Test Conditions	17
9.2	Graphs	17
9.3	Tabular Data	18
9.4	Initial Cooling Air Temperature and Humidity (When Available) for Each Section of the Test.....	18
9.5	Other Measurements and Report Items.....	18
10.	NOTES	18
10.1	Revision Indicator.....	18
APPENDIX A	EXPLANATORY NOTES	19
Figure 1	Typical brake application time stamps	8
Figure 2	Cooling airflow direction relative to caliper position	10
Figure 3	Plug-type thermocouple	10
Figure 4A	Control (primary) thermocouple at centerline, with secondary thermocouple on the trailing side	11
Figure 4B	Depth for control (primary) thermocouple	11
Figure 4	Brake pad thermocouple installation for non-grooved, non-split pads.....	11
Figure 5	Brake shoe thermocouple installation	11
Figure 6	Brake shoe and brake drum thermocouple axial location.....	12
Figure 7	Brake disc thermocouple installation	12
Table 1	Development test sequence	15
Table 2	FMVSS test sequence	16

1. SCOPE

This SAE Recommended Practice is derived from the FMVSS 105 vehicle test and applies to two-axle multipurpose passenger vehicles, trucks, and buses with a GVWR above 4540 kg (10000 pounds) equipped with hydraulic service brakes. There are two main test sequences: the Development Test Sequence for generic test conditions when not all information is available or when an assessment of brake output at different inputs is required, and the FMVSS Test Sequence when vehicle parameters for brake pressure as a function of brake pedal input force and vehicle-specific loading and brake distribution are available. The test sequences are derived from the Federal Motor Vehicle Safety Standard 105 (and 121 for optional sections) as single-ended inertia-dynamometer test procedures when using the appropriate brake hardware and test parameters. This recommended practice provides Original Equipment Manufacturers (OEMs), brake and component manufacturers, and aftermarket suppliers with results related to brake output, friction material effectiveness, and corner performance in a laboratory-controlled test environment.

The test sequences include dynamic conditions (braking speeds, temperature, and braking history as outlined in FMVSS 105), inertia loads equivalent to the vehicle's LLVW and GVWR, and fully operational, partial failure, and failed system conditions. All applicable sections of FMVSS 105 are included. Optional sections include parking brake output, water recovery, TP-121D dynamometer retardation, and 32 km/h (20 mph) stops to simulate Federal Motor Carrier Safety Administration (FMCSA) requirements.

This recommended practice does not evaluate or quantify other brake system characteristics such as wear, noise, judder, ABS performance, or braking under extreme temperatures or speeds. Minimum performance requirements are not part of this recommended practice. Consistency and margin of pass/fail of the minimum requirements related to stopping distance or equivalent deceleration levels of the FMVSS 105 vehicle test can be assessed as part of the project in coordination with the test requestor when using the appropriate vehicle information and vehicle dynamics modeling. Nevertheless, this procedure and its results do not replace the vehicle-level test to demonstrate compliance with FMVSS (105 for hydraulic brake systems or 121 for air-over-hydraulic brake systems) or other mandatory regulations (like ECE R13 or equivalents).

Towing and trailering applications are not part of this document and require a separate assessment per SAE J2807.

1.1 Purpose

The purpose of this procedure is to assess the performance of a brake corner assembly during conditions that correspond to the FMVSS 105 vehicle test procedure for applications above 4540 kg (10000 pounds) of GVWR.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2784 FMVSS Inertia Dynamometer Test Procedure for Vehicles Below 4540 kg GVWR

SAE J2807 Performance Requirements for Determining Tow-Vehicle Gross Combination Weight Rating and Trailer Weight Rating

2.1.2 NHTSA Publications

Available from National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-888-327-4236, <https://www.nhtsa.gov/>.

TP-121D-01 May 9, 1990, NHTSA - Office of Vehicle Safety Compliance (OVSC) Laboratory Test Procedure for FMVSS 121D Air Brake Systems - Dynamometer

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2115 Air Brake Performance and Wear Test Code, Commercial Vehicle Inertia Dynamometer

2.2.2 Code of Federal Regulations (CFR) Publications

Available from United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

393.52 Federal Motor Carrier Safety Regulations Handbook (FMCSR) - Brake Performance, Code of Federal Regulations Title 49, Subchapter B, Part 393, Subpart C

2.2.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 611:2003 Road Vehicles - Braking of Automotive Vehicles and Their Trailers – Vocabulary

2.2.4 NHTSA Publications

Available from National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE, Washington, DC 20590, Tel: 1-888-327-4236, <https://www.nhtsa.gov/>.

571.105 Standard No. 105 - Hydraulic and Electric Brake Systems

TP-105-03 July 1, 2005, NHTSA - OVSC Laboratory Test Procedure for FMVSS 105 Hydraulic and Electric Brake Systems

2.2.5 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST-SP811 2008 Guide for the Use of the International System of Units (SI)

3. DEFINITIONS

3.1 AIR-OVER-HYDRAULIC BRAKES

Brake system that supplies air to an air-hydraulic intensifier to supply pressurized brake fluid to the foundation brake. This system is more common on front disc brakes. The basic system uses an air actuator that applies load onto a hydraulic master cylinder.

3.2 AIR-OVER-HYDRAULIC INTENSIFIER RATIO

On an air-over-hydraulic brake system, the ratio is the actuator area on the air supply side to the master cylinder area on the hydraulic output side. The air-over-hydraulic intensifier ratio varies from 13.5:1 to 23.5:1.

3.3 APPARENT FRICTION FOR DISC BRAKES

Coefficient of friction or disc brake effectiveness. Per Equation 1:

$$\mu = \frac{k_1 \cdot T}{2 \cdot (p - p_{threshold}) \cdot A_p \cdot r_{eff} \cdot \eta} \quad (\text{Eq. 1})$$

where:

μ = apparent friction for disc brakes [unitless]

k_1 = unit conversion factor; $k_1 = 1 \times 10^6$ for SI units, and $k_1 = 12$ for English units

T = output torque [N·m], [lb-ft]

p = brake pressure [kPa], [psi]

$p_{threshold}$ = minimum pressure required to start developing braking torque [kPa], [psi]

A_p = total piston area acting on one side of the caliper for disc brakes [mm²], [in²]

r_{eff} = radial distance from centerline of the piston to the axis of rotation for disc brakes; unless other dimensions are provided by the requestor [mm], [inch]

η = brake efficiency/100 [unitless]

3.4 DRUM BRAKE EFFECTIVENESS (C*)

Drum brake factor or drum brake effectiveness. Per Equation 2:

$$C^* = \frac{k_1 \cdot T}{(p - p_{threshold}) \cdot A_p \cdot r_{eff} \cdot \eta} \quad (\text{Eq. 2})$$

where:

C^* = effectiveness for drum brakes [unitless]

k_1 = unit conversion factor; $k_1 = 1 \times 10^6$ for SI units, and $k_1 = 12$ for English units

T = output torque [N·m], [lb-ft]

p = brake pressure [kPa], [psi]

$p_{threshold}$ = minimum pressure required to start developing braking torque [kPa], [psi]

A_p = total wheel cylinder area for drum brakes [mm²], [in²]

r_{eff} = internal drum diameter divided by 2 for drum brakes; unless other dimensions are provided by the requestor [mm], [inch]

η = brake efficiency/100 [unitless]

3.5 BRAKE CORNER

Brake assembly. Assembly of the foundation brake including friction material, brake assembly with mounting hardware, brake rotor or drum, and wheel hub assembly, excluding wheel and tire.

3.6 BRAKE POWER ASSIST UNIT

A device installed in a hydraulic brake system to reduce the driver effort required to actuate the system and that, if inoperative, does not prevent the driver from braking the vehicle by a continued application of pedal force on the service brake control.

3.7 BRAKE POWER UNIT

A device installed in a brake system that provides the energy required to actuate the brakes, either directly or indirectly, through an auxiliary device, with the driver action consisting only of modulating the energy application level.

3.8 BRAKE RETARDATION FORCE

Force at the contact surface between the wheel and the ground produced by the effect of the braking system, which opposes the speed or the tendency to movement of the vehicle.

3.9 BRAKING FORCE DISTRIBUTION

Ratio between the braking force of each axle and the total braking force for the vehicle, expressed as a percentage for each axle (e.g., 50% front, 50% rear). The braking force distribution between front and rear axles is a function of brake input force and tire-to-road adhesion utilization.

3.10 BREAKAWAY TORQUE

Torque required to initiate disc (or drum) rotation after input force (or pressure) is applied to the parking brake. [N·m], [lbf·ft]

3.11 DECELERATION-CONTROLLED BRAKE APPLICATION

Inertia-dynamometer control algorithm that adjusts the real-time brake pressure to maintain a constant torque output calculated from the instantaneous deceleration specified in the test procedure.

3.12 GROSS AXLE WEIGHT RATING (GAWR)

Maximum axle sprung weight declared by the manufacturer. When multiple axle component ratings are available instead of a unique value for the axle, use the highest rating declared. [kgf], [lbf]

3.13 GROSS VEHICLE WEIGHT RATING (GVWR)

Maximum vehicle weight declared by the manufacturer. [kgf], [lbf]

3.14 INITIAL BRAKE TEMPERATURE (IBT)

Temperature of the most heavily loaded pad (or shoe) at 0.32 km (0.2 mile) before the start of the service brake application. [°C], [°F]

3.15 LIGHTLY LOADED VEHICLE WEIGHT (LLVW)

Unloaded vehicle weight plus 227 kg (500 pounds) (including driver and test instrumentation). [kg], [lb]

3.16 PRESSURE-CONTROLLED BRAKE APPLICATION

Inertia-dynamometer control algorithm that maintains a constant input pressure to the brake irrespective of the torque output.

3.17 PRESSURE LEVEL AT 667 N (150 LBF); FULLY OPERATIONAL - P_{667 N Operational}

Brake system pressure at the front or rear corner with 667 N (150 lbf) of pedal force applied with the brake system and power assist unit (including rear brake proportioning) fully operational. [kPa], [lbf]