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U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
LABORATORY TEST PROCEDURE
FOR
FMVSS 135
Light Vehicle Brake Systems



ENFORCEMENT
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OVSC LABORATORY TEST PROCEDURE NO. 135

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REVISION CONTROL LOG
 FOR OVSC LABORATORY TEST PROCEDURES
 TP-135-01 - LIGHT VEHICLE BRAKE SYSTEMS

Test Procedure		FMVSS 135-01		Description
Rev. No	DATE	AMMENDMENT	EFFECTIVE DATE	
00	10/29/97	60FR6411, 2/2/95	3/6/95	Original release, mandatory for PCs 9/1/00
01	12/02/05	60FR37844, 7/24/95	8/23/95	Minor changes to test conditions
		60FR44548, 8/28/95	8/28/95	Corrections to 7/24/95 final rule reg. text
		62FR46907, 9/5/97	10/20/97	Amendments for brake systems of electric vehicles
		62FR51064, 9/30/97	12/1/97	Standard extended to LTV's GVWR ≤ 3,500 kg, mandatory 9/1/2002
		65FR6327, 2/9/00	3/27/00	Minor changes to test conditions, vehicles with regenerative braking
		70FR37706, 6/30/05	6/30/05	Minor correction to S5.5.5(b)

1. PURPOSE AND APPLICATION

The Office of Vehicle Safety Compliance (OVSC) provides contractor laboratories with Laboratory Test Procedures as guidelines for obtaining compliance test data. The data are used to determine if a specific vehicle or item of motor vehicle equipment meets the minimum performance requirements of the subject Federal Motor Vehicle Safety Standard (FMVSS). The purpose of the OVSC Laboratory Test Procedures is to present a uniform testing and data recording format, and provide suggestions for the use of specific equipment and procedures. These Laboratory Test Procedures do not constitute an endorsement or recommendation for use of any product or method. If any contractor views any part of an OVSC Laboratory Test Procedure to be in conflict with a FMVSS or observes deficiencies in a Laboratory Test Procedure, the contractor is required to advise the Contracting Officer's Technical Representative (COTR) and resolve the discrepancy prior to the start of compliance testing.

The OVSC Laboratory Test Procedures are not intended to limit or restrain a contractor from developing or utilizing any testing techniques or equipment which will assist in procuring the required compliance test data. However, the application of any such testing technique or equipment is subject to prior approval of the COTR.

NOTE: The OVSC Laboratory Test Procedures, prepared for the limited purpose of use by independent laboratories under contract to conduct compliance tests for the OVSC, are not rules, regulations or NHTSA interpretations regarding the meaning of a FMVSS. The Laboratory Test Procedures are not intended to limit the requirements of the applicable FMVSS(s). In some cases, the OVSC Laboratory Test Procedures do not include all of the various FMVSS minimum performance requirements. Recognizing applicable test tolerances, the Laboratory Test Procedures may specify test conditions that are less severe than the minimum requirements of the standard. In addition, the Laboratory Test Procedures may be modified by the OVSC at any time without notice, and the COTR may direct or authorize contractors to deviate from these procedures, as long as the tests are performed in a manner consistent with the standard itself and within the scope of the contract. Laboratory Test Procedures may not be relied upon to create any right or benefit in any person. Therefore, compliance of a vehicle or item of motor vehicle equipment is not necessarily guaranteed if the manufacturer limits its certification tests to those described in the OVSC Laboratory Test Procedures.

2. GENERAL REQUIREMENTS

This standard applies to vehicles with a gross vehicle weight rating (GVWR) of 3500 kg (7716 lbs.) or less. Standard 135 specifies requirements for service brake and associated parking brake systems in order to insure safe braking performance under normal and emergency driving conditions.

The service brakes shall be capable of stopping each vehicle in a series of tests within specific distances, speeds, brake pedal forces, and/or decelerations. Vehicles shall be capable of stopping under partial failure of the service brake system, inoperative brake power assist unit or brake power unit, antilock failure, variable proportioning valve failure, and with the engine off. Braking capability during and after exposure to the high brake temperatures caused by prolonged or severe use is also evaluated. Tests are conducted to evaluate whether vehicles not equipped with antilock brakes, are front biased with lockup of both front wheels occurring simultaneously or at a lower deceleration rate than the rear wheels. Vehicles which are not front biased are additionally tested for adhesion utilization to ensure that the vehicles brake system is able to utilize the available adhesion at the tire-road interface. Additional requirements must be met for electric vehicles and for vehicles equipped with electrically actuated brakes.

Each vehicle shall be manufactured with a parking brake system which, when engaged, shall be capable of holding the vehicle stationary on a specified grade for a specified time.

Each vehicle shall have one or more brake system indicator lamps mounted in front of and in clear view of the driver. Indicator lamps shall be activated both when certain vehicle conditions occur and when the ignition switch is turned to a certain position as a check of lamp function.

Each vehicle shall have a specific brake fluid warning statement located on or near the brake fluid reservoir filler plug or cap.

Each vehicle shall be capable of completing all performance requirements without detachment or fracture of any component of the braking system and without any visible brake fluid or lubricant on the friction surface of the brake, or leakage at the master cylinder or brake power unit reservoir cover, seal, or filler openings.

3. SECURITY

The contractor shall provide appropriate security measures to protect the OVSC test vehicles and parts during the entire compliance testing program. The contractor is also financially responsible for any acts of theft and/or vandalism which occur during the storage of test vehicles. Security problems which arise shall be reported by telephone to the COTR and the Industrial Property Manager (IPM), Office of Contracts and Procurement (OCP), within 2 working days after the incident. A letter containing specific details of the security problem shall be sent to the IPM (with copy to the COTR) within 4 working days. The contractor shall protect and segregate all photographs and data that evolve from compliance testing. No information concerning the vehicle safety compliance testing program shall be released to anyone except the COTR, unless specifically authorized by the COTR or the COTR's Branch or Division Chief.

NO INDIVIDUALS, OTHER THAN CONTRACTOR PERSONNEL DIRECTLY INVOLVED IN THE COMPLIANCE TESTING PROGRAM, SHALL BE ALLOWED TO WITNESS ANY VEHICLE COMPLIANCE TEST UNLESS SPECIFICALLY AUTHORIZED BY THE COTR.

4. GOOD HOUSEKEEPING

Contractors shall maintain the entire vehicle compliance testing area, test fixtures and instrumentation in a neat, clean and painted condition with test instruments arranged in an orderly manner consistent with good test laboratory housekeeping practices.

5. TEST SCHEDULING AND MONITORING

The contractor shall submit a test schedule to the COTR prior to testing. Tests shall be completed as required in the contract. Scheduling shall be adjusted to permit sample motor vehicles to be tested to other FMVSS as may be required by the OVSC. All testing shall be coordinated to allow monitoring by the FMVSS No. 135 COTR.

6. TEST DATA DISPOSITION

The contractor shall make all vehicle preliminary compliance test data available to the COTR on location within 4 hours after the test. Final test data shall be furnished to the COTR within 5 working days. Additionally, the contractor shall analyze the preliminary test results as directed by the COTR. All backup data sheets, technical notes, etc., shall be either sent to the COTR or destroyed at the conclusion of each delivery order, purchase order, etc.

7. GOVERNMENT FURNISHED PROPERTY (GFP)

ACCEPTANCE OF TEST VEHICLES

The Contractor has the responsibility of accepting each test vehicle whether delivered by a new vehicle dealership or another vehicle transporter. In both instances, the contractor acts in the OVSC's behalf when signing an acceptance of the test vehicle delivery. When a vehicle is delivered, the contractor must check to verify the following:

- A. All options listed on the "window sticker" are present,
- B. Tires and wheels are new and the same as listed,
- C. There are no dents or other interior or exterior flaws,
- D. The vehicle has been properly prepared and is in running condition, and
- E. Owner's manual, warranty document, consumer information, and extra set of keys are present.

A Vehicle Condition form will be supplied to the contractor when the test vehicle is transferred from a new vehicle dealership or between test contracts. The contractor must complete a Vehicle Condition form for each vehicle and deliver it to the COTR with the Final Test Report or the report will not be accepted for payment.

NOTIFICATION OF COTR

The COTR must be notified within 24 hours after a vehicle has been delivered. In addition, if any discrepancy or damage is found at the time of delivery, a copy of the Vehicle Condition form shall be sent to the COTR immediately.

8. CALIBRATION OF TEST INSTRUMENTS

Before the contractor initiates the safety compliance test program, a test instrumentation calibration system shall be implemented and maintained in accordance with established calibration practices. The calibration system shall be set up and maintained as follows:

- A. Standards for calibrating the measuring and test equipment will be stored and used under appropriate environmental conditions to assure their accuracy and stability.
- B. All measuring instruments and standards shall be calibrated by the contractor, or a commercial facility, against a higher order standard at periodic intervals NOT TO EXCEED TWELVE (12) MONTHS! Records, showing the calibration traceability to the National Institute of Standards and Technology (NIST), shall be maintained for all measuring and test equipment.
- C. All measuring and test equipment and measuring standards will be labeled with the following information:
 - (1) Date of calibration
 - (2) Date of next scheduled calibration
 - (3) Name of the technician who calibrated the equipment
- D. A written calibration procedure shall be provided by the contractor which includes as a minimum the following information for all measurement and test equipment:
 - (1) Type of equipment, manufacturer, model number, etc.
 - (2) Measurement range
 - (3) Accuracy
 - (4) Calibration interval
 - (5) Type of standard used to calibrate the equipment (calibration traceability of the standard must be evident)
- E. Records of calibration for all test instrumentation shall be kept by the contractor in a manner which assures the maintenance of established calibration schedules. All such records shall be readily available for inspection when requested by the COTR. The calibration system will need the acceptance of the COTR before the test program commences. Further guidance is provided in the International Standard ISO 10012-1, "Quality Assurance Requirements for Measuring Equipment" and American National Standard ANSI/NCSL Z540-1, "Calibration Laboratories and Measuring and Test Equipment - General Requirements".
- F. Daily pre and post test Instrumentation calibration sheets or equivalent, as shown in section 19, are to be included in the final test report.

9. PHOTOGRAPHIC DOCUMENTATION

Photographs shall be black and white or color, 8 x 10 inches, and legible. A tag, label or placard identifying the test vehicle model as well as the NHTSA number, if applicable, shall appear in each photograph and be legible. The test vehicle shall show the compliance test date. Each photograph shall be labeled as to subject matter. As a minimum the following photographs shall be included:

- A. 3/4 frontal view from left side of vehicle (at GVWR)
- B. 3/4 rear view from right side of vehicle (at GVWR)
- C. Vehicle's certification label
- D. Vehicle's tire information label (if not part of certification label)
- E. Thermocouple installation of left front and right rear (with wheels and or drums removed)
- F. Test instrumentation in vehicle
- G. Test track dimensioned layout (may be a scaled drawing).
- H. Photos of all test instrumentation used in conducting this test with full description; may be a composite photo taken with instrumentation removed from vehicle.
- I. Torque wheels installed (if applicable)
- J. Vehicle being weighed and location(s) of ballast in vehicle.
- K. Brake system indicator lamps, when activated under the condition(s) specified in test procedure section 14.
- L. Brake fluid reservoir label as defined in test procedure section 14.
- M. Close up of any failures.

10. DEFINITIONS (S4)

NOTE: Parenthetical references, as shown above (S4), relate to sections in FMVSS 135 as revised February 9, 2000.

NOTE: Text in Italics pertains to electric vehicles, electrically-actuated service brakes, electrically transmitted brake signal, and/or RBS.

ADHESION UTILIZATION CURVES

Curves showing, for specified load conditions, the adhesion utilized by each axle of a vehicle plotted against the braking ratio of the vehicle.

ANTILOCK BRAKE SYSTEM or ABS

A portion of a service brake system that automatically controls the degree of rotational wheel slip during braking by:

- A. Sensing the rate of angular rotation of the wheels;
- B. Transmitting signals regarding the rate of wheel angular rotation to one or more controlling devices which interpret those signals and generate responsive controlling output signals; and
- C. Transmitting those controlling signals to one or more modulator devices which adjust brake actuating forces in response to those signals.

AVERAGE PEDAL FORCE (not defined in standard)

Average value taken from the initiation of the pedal force until completion of the stop. (60 FR 6434, Feb. 2, 1995, page 6431)

Initiation of the pedal force is the point at which brake application can be detected and data acquisition begun without false triggering, e.g. 5 - 10 Newtons (1 - 2 Lbs.)

AVERAGE DECELERATION (not defined in standard -see above)

Average value taken from the initiation of the pedal force until completion of the stop.

NOTE: The recorded deceleration is acquired from the moment the service brake pedal is moved until the vehicle reaches zero speed. Therefore, the time needed to achieve the target deceleration (rise time) and the time the vehicle goes from the target deceleration to zero (fall

time) will be included in the average deceleration calculation. Hence the recorded average deceleration values will be slightly less than the required/target values even if the driver maintains the correct deceleration for the majority of the stop.

BACKUP SYSTEM

A portion of a service brake system, such as a pump, that automatically supplies energy in the event of a primary brake power source failure.

BRAKE FACTOR

The slope of the linear least squares regression equation best representing the measured torque output of a brake as a function of the measured applied line pressure during a given brake application for which no wheel lockup occurs.

BRAKE HOLD-OFF PRESSURE

The maximum applied line pressure for which no brake torque is developed, as predicted by the pressure axis intercept of the linear least squares regression equation best representing the measured torque output of a brake as a function of the measured applied line pressure during a given brake application.

BRAKE POWER ASSIST UNIT

A device installed in a hydraulic brake system that reduces the amount of muscular force that a driver must apply to actuate the system, and that, if inoperative, does not prevent the driver from braking the vehicle by a continued application of muscular force on the service brake control.

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 driver action consisting only of modulating the energy application level.

BRAKING RATIO

The deceleration of the vehicle divided by the gravitational acceleration constant.

ELECTRIC VEHICLE (EV)

A motor vehicle that is powered by an electric motor drawing current from rechargeable storage batteries, fuel cells, or other portable sources of

electrical current, and which may include a non-electrical source of power designed to charge batteries and components thereof.

ELECTRICALLY-ACTUATED SERVICE BRAKES

Service brakes that utilize electrical energy to actuate the foundation brakes.

FUNCTIONAL FAILURE

A failure of a component (either electrical or mechanical in nature) which renders the system totally or partially inoperative yet the structural integrity of the system is maintained.

HYDRAULIC BRAKE SYSTEM

A system that uses hydraulic fluid as a medium for transmitting force from a service brake control to the service brake and that may incorporate a brake power assist unit, or a brake power unit.

INITIAL BRAKE TEMPERATURE (IBT)

The average temperature of the service brakes on the hottest axle of the vehicle 0.32 km (0.2 miles) before any brake application.

LIGHTLY LOADED VEHICLE WEIGHT (LLVW)

Unloaded vehicle weight plus the weight of a mass of 180 kg (396 pounds), including driver and instrument.

MAXIMUM SPEED (Vmax)

The highest speed attainable by accelerating at a maximum rate from a standing start for a distance of 3.2 km (2 miles) on a level surface, with the vehicle at its lightly loaded weight, and if an EV, with the propulsion batteries at a state of charge of not less than 95 percent at the beginning of the run.

MINIMUM PEDAL FORCE (not defined in standard)

When a minimum pedal force is specified, e.g. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs), after the ramp up of the pedal force past the minimum specified value, the stop must be completed without the pedal force going lower than this minimum value except when the vehicle velocity approaches zero at the termination of the stop.

OBJECTIVE BRAKE FACTOR

The arithmetic average of all the brake factors measured over the twenty brake applications defined in S7.4, for all wheel positions having a given brake configuration.

PEAK FRICTION COEFFICIENT (PFC)

The ratio of the maximum value of braking test wheel longitudinal force to the simultaneous vertical force occurring prior to wheel lockup, as the braking torque is progressively increased.

PRESSURE COMPONENT

A brake system component that contains the brake system fluid and controls or senses the fluid pressure.

REGENERATIVE BRAKING SYSTEM (RBS)

An electrical energy system that is installed in an EV for recovering or dissipating kinetic energy, and which uses the propulsion motor(s) as a retarder for partial braking of the EV while returning electrical energy to the propulsion batteries or dissipating electrical energy.

SNUB

The braking deceleration of a vehicle from a higher reference speed to a lower reference speed that is greater than zero.

SPLIT SERVICE BRAKE SYSTEM

A brake system consisting of two or more subsystems actuated by a single control, designed so that a single failure in any subsystem (such as a leakage-type failure of a pressure component of a hydraulic subsystem except structural failure of a housing that is common to two or more subsystems, or an electrical failure in an electric subsystem) does not impair the operation of any other subsystem.

STOPPING DISTANCE

The distance traveled by a vehicle from the point of application of force to the brake control to the point at which the vehicle reaches a full stop.

VARIABLE BRAKE PROPORTIONING SYSTEM

A system that has one or more proportioning devices which automatically

change the brake pressure ratio between any two or more wheels to compensate for changes in wheel loading due to static load changes and/or dynamic weight transfer, or due to deceleration.

WHEEL LOCKUP

100 percent wheel slip.

11. TEST EQUIPMENT AND REFERENCES

The following test equipment or equivalent shall be used:

A. Fifth wheel (optical or contact) to measure vehicle velocity, 150 fps (164 km/h) range with accuracy of ± 0.7 fps (.77 km/h) at 88 fps (97 km/h), maximum non-linearity of ± 1.5 fps (1.6 km/h) over the range and visual output resolution of 0.15 fps (.16 km/h).

B. 140-tooth gear magnetic pickup or equivalent to measure stopping distance, 10^5 feet (30480 meters) range with accuracy of + 10 feet (3.0m) in 1,000 feet (305m), maximum non-linearity of ± 20 feet ((6.1m), per 2,000 feet (610 m) increment, and visual output resolution of 0.1 foot (.030m).

C. Two load cells to measure normal pedal force on service brake and parking brake, (perpendicular to pedal face), 300 pound (1334N) range with accuracy of ± 1.5 pounds (6.7N) at 150 pounds (667N), maximum non-linearity of + 3 pounds (13.3N) over the range, and visual output resolution of 1.5 pounds (6.7N).

D. Iron-constantan thermocouple, plug type. Maximum wire resistance variation $\pm 10\%$ pyrometer calibrated value for non-compensated pyrometers.

NOTE: See Section 13, General Test Conditions (Vehicle Condition) for Thermocouple installation.

E. Friction material temperature instrumentation (pyrometer) to measure brake lining temperatures, 1,200°F (649C) range with $\pm 10^\circ\text{F}$ (5.6C) accuracy at 300°F (149C), maximum non-linearity of $\pm 20^\circ\text{F}$ (11.1C) over the range and visual output resolution of 5°F (2.8C).

F. Decelerometer to measure vehicle deceleration rate, 1G range with ± 0.5 fpsps (.15mpsps) accuracy at 32.2 fpsps (9.8mpsps), maximum non-linearity of ± 0.5 fpsps (.15mpsps) over the range, and visual output resolution of 0.5 fpsps (.15mpsps).

G. Ambient temperature gauge to record ambient test temperatures, 32°F (0C) to 100°F (37.8C) range with $\pm 0.5^\circ\text{F}$ (.28C) accuracy at 70°F (21.1C), maximum non-linearity $\pm 1.0^\circ\text{F}$ (.56C) over the range, and visual output resolution of 1°F (.56C).

H. Stopwatch to measure elapsed time during certain tests, 15 minute range with accuracy ± 0.5 second in 60 seconds, maximum non-linearity of 1.5 seconds over the range, and visual output resolution of 0.1 second.

I. Anemometer to measure wind velocity. Twenty-five (25) mph (40km/h) range with ± 1 mph (1.6km/h) accuracy at 15 mph (24km/h), maximum non-linearity of ± 2 mph (3.2km/h) over the range and visual output resolution of 1 mph (1.6km/h).

J. Ballast to simulate passenger, cargo, etc. Ballast with a density of 50 to 450 lb/ft³ (801 to 7208 kg/m³) is used in the seating area of all vehicles, as well as the cargo areas of vehicles.

K. Wheel lockup detector providing an electrical indication of wheel rotation (or wheel lockup) to a continuous recorder or digital data recorder with data acquisition software. The lockup detector system must provide a visual indication for wheels that lockup above 9.3 mph (15km/h), + 1 mph (1.6km/h), - 0 mph (for 0.1 seconds or longer) and remain on until the system is reset.

The reset circuitry must have the capability of resetting the visual indicators while the vehicle speed is above 9.3 mph (15km/h). The system must also have the capability of recording, either on a strip chart or digital acquisition graph, any combination of wheel lockup, and show which wheel or wheels locked up at speeds above 9.3 mph (15km/h).

L. A continuous recorder, i.e., an oscillograph or computer utilizing a digital data acquisition system, to make a permanent, supplemental record of service brake pedal force, parking brake force, deceleration, lockup, distance and speed versus time, with the same accuracies as the above direct reading instrumentation or as otherwise indicated.

M. Manufacturer's shop manual.

N. Mechanical Brake Pedal Actuator (optional – consult with COTR)

O. Torque wheels at each wheel position (if torque wheel test is conducted), including slip ring assemblies and wheel speed indicators to permit wheel lock to be detected. (S6.4.3)

P. Pressure transducers to measure hydraulic pressure in each hydraulic circuit (if torque wheel tests are conducted). On hydraulically proportioned circuits, the pressure transducer shall be downstream of the operative proportioning valve. (S6.4.2)

Q. *Voltage meter to measure battery capacity for electric vehicles or brakes utilizing battery power for brake actuation.*

12. PRETEST REQUIREMENTS

Prior to conducting any compliance tests, contractors are required to submit a detailed in-house compliance test procedure to the COTR which includes a step-by-step description of the methodology to be used and a detailed check-off list.

The contractor's test procedure shall contain a complete listing of test equipment actually used. The list of test equipment shall include instrument accuracy and calibration due dates. The contractor shall conspicuously identify revisions to its in-house procedures and ensure that obsolete documents are not used.

There shall be no contradiction between the OVSC Laboratory Test Procedure and the contractor's in-house test procedure. Written approval must be obtained from the COTR before initiating the compliance test program so that all parties are in agreement.

TEST DATA LOSS

A compliance test is not to be conducted unless all of the various test conditions specified in the applicable OVSC Laboratory Test Procedure have been met. Failure of a contractor to obtain the required test data and to maintain acceptable limits on test parameters in the manner outlined in the applicable OVSC Laboratory Test Procedure may require a retest at the expense of the contractor. The retest costs will include the cost of the replacement vehicle (with the same equipment as the original vehicle) or item of motor vehicle equipment and all costs associated with conducting the retest. The original test specimen (vehicle or equipment item) used for the invalid test shall remain the property of OVSC, and the retest specimen shall remain the property of the contractor. If there is a test failure, the contractor shall retain the retest specimen for a period not exceeding 180 days. If there is no test failure, the Contractor may dispose of the test specimen upon notification from the COTR that the final test report has been accepted.

The Contracting Officer of NHTSA is the only official authorized to notify the contractor that a retest is required. The retest shall be completed within two (2) weeks after receipt of notification by the Contracting Officer that a retest is required. If a retest is conducted, no test report is required for the original test.

13. GENERAL TEST CONDITIONS (S6)

Each vehicle must be performance tested (Section 14) under the following general test conditions unless otherwise specified: (where a range of conditions is specified, the vehicle must meet the requirements at all points within the range)

GENERAL

The test track shall be under exclusive control of the contractor at time of test. Use of public roads is prohibited for performance testing.

Travel to and from the test track shall be minimal and entail only moderate braking. Dusty or muddy road surfaces shall be avoided.

NOTE: Parenthetical references which follow relate to sections in FMVSS 135 as revised February 9, 2000.

AMBIENT CONDITIONS (S6.1)**A. Ambient temperature (S6.1.1) —**

The ambient temperature is any temperature between 0° C (32 °F) and 40°C (104°F).

B. Wind speed (S6.1.2) —

The wind speed is not greater than 5 m/s (11.2 mph).

ROAD TEST SURFACE (S6.2)**C. Pavement friction (S6.2.1) —**

Unless otherwise specified, the road test surface produces a peak friction coefficient (PFC) of 0.9 when measured using an American Society for Testing and Materials (ASTM) E1136 standard reference test tire, in accordance with ASTM Method E 1337-90, at a speed of 64.4 km/h (40 mph), without water delivery.

D. Gradient (S6.2.2) —

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.

E. Lane width (S6.2.3) —

Road tests are conducted on a test lane 3.5 m (11.5 ft) wide.

VEHICLE CONDITIONS (S6.3)

F. Vehicle weight (S6.3.1) —

For tests at GVWR, the vehicle is loaded to its GVWR such that the weight on each axle as measured at the tire-ground interface is in proportion to its GAWR, with the fuel tank filled to 100% of capacity. However, if the weight on any axle of a vehicle at LLVW exceeds the axle's proportional share of the GVWR, the load required to reach GVWR is placed so that the weight on that axle remains the same as at LLVW.

For tests at LLVW, the vehicle is loaded to its LLVW such that the added weight is distributed in the front passenger seat area.

G. Fuel tank loading (S6.3.2) —

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.

H. Brake Lining preparation (S6.3.3) —

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.

I. Adjustments and repairs (S6.3.4) —

Replacement of any brake system parts or making any adjustments to the brake system except as specified in this standard is prohibited. Where brake adjustments are specified (S7.1.3 - burnish), 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.

J. Automatic brake adjusters (S6.3.5) —

Automatic 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.

K. Antilock brake system (ABS) (S6.3.6) —

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

L. **Variable** brake proportioning valve (S6.3.7) —

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.

M. Tire inflation pressure (S6.3.8) —

Tires are inflated to the pressure recommended by the vehicle manufacturer for the GVWR of the vehicle.

N. Engine (S6.3.9) —

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.

O. Vehicle openings (S6.3.10) —

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

P. *State of Charge of Batteries for EV's* (S6.3.11) —

The state of charge of the propulsion batteries is determined in accordance with SAE Recommended Practice J227a, Electric Vehicle Test Procedure, February 1976. The applicable sections of J227a are 3.2.1 through 3.2.4, 3.3.1 through 3.3.2.2, 3.4.1 and 3.4.2, 4.2.1, 5.2, 5.2.1, and 5.3. (S6.3.11.1)

At the beginning of the burnish procedure (S7.1 of the standard), in the test sequence, each propulsion battery is at the MAXIMUM STATE OF CHARGE recommended by the manufacturer, as stated in the vehicle operator's manual or on a label that is permanently attached to the vehicle, or, if the manufacturer has made no recommendation, not less than 95 percent. During the 200-stop burnish procedure, the propulsion batteries are restored to the maximum state of charge determined as above, after each

increment of 40 burnish stops until the burnish procedure is complete. The batteries may be charged at a more frequent interval during a particular 40-stop increment only if the EV is incapable of achieving the initial burnish test speed during that increment. During the burnish procedure, the propulsion batteries may be charged by external means or replaced by batteries that are at a state of charge of not less than 95 percent. For an EV having a MANUAL control for setting the level of regenerative braking, the manual control, at the beginning of the burnish procedure, is set to provide MAXIMUM regenerative braking throughout the burnish. (S6.3.11.2)

At the beginning of each performance test in the test sequence (S7.2 through S7.17 of this standard), unless otherwise specified, an EV's propulsion batteries are at the state of charge recommended by the manufacturer, as stated in the vehicle operator's manual or on a label that is permanently attached to the vehicle, or, if the manufacturer has made no recommendation, at a state of charge of not less than 95 percent. No further charging of any propulsion battery occurs during any of the performance tests in the test sequence of this standard. If the propulsion batteries are depleted during a test sequence such that the vehicle reaches automatic shut-down, will not accelerate, or the low state of charge warning lamp is illuminated, the vehicle is to be accelerated to brake test speed by auxiliary means. If a battery is replaced rather than recharged, the replacement battery shall be charged and measured for state of charge in accordance with these procedures. (S6.3.11.3)

Q. *Electric Vehicles (S6.3.13)*

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

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. (S6.3.13.1)

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.
(S6.3.13.2)

R. Thermocouples — Brake Temperature Measurement (S6.4.1) —

Install plug-type thermocouples in the approximate center of the facing length and width of the most heavily loaded shoe or disc pad, one per brake, as shown in Figure 1. 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") to 6 mm (0.24") of the groove and as close to the center as possible. In all cases, install thermocouples with minimum disassembly or adjustment of the brakes. If original adjustment is disturbed, it should be reset to the manufacturer's specification. Inspect friction material and drum or disc for any abnormalities or wear, and photograph if present. Non-service brake frictional surfaces shall have thermocouples installed in addition to service brakes.

S. Brake line pressure measurement for the torque wheel test (S6.4.2)

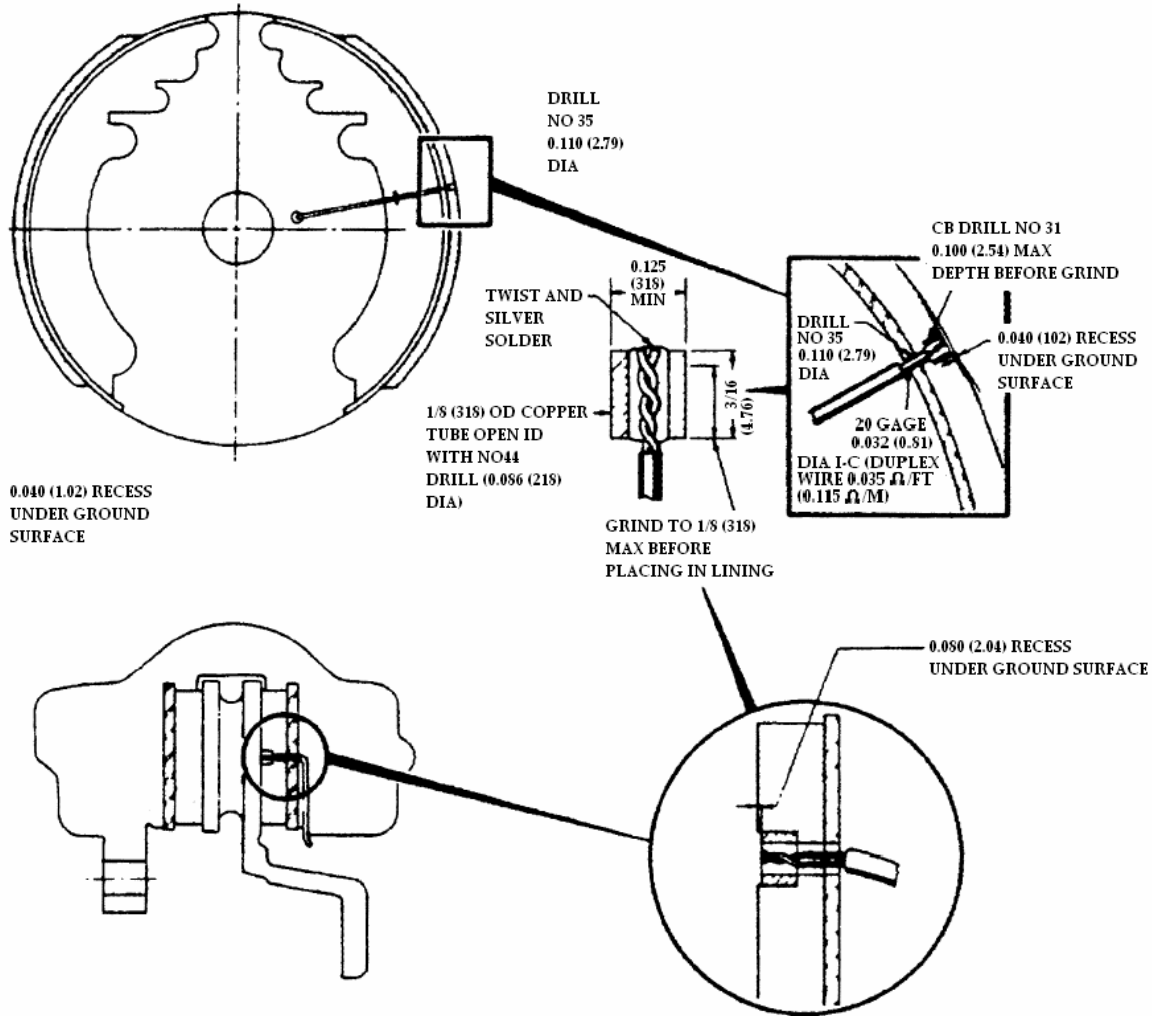
If applicable, the vehicle shall be fitted with pressure transducers in each hydraulic circuit. On hydraulically proportioned circuits, the pressure transducer shall be downstream of the operative proportioning valve.

T. Brake torque measurement for the torque wheel test (S6.4.3)

If applicable, 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.

U. Brake Fluid —

Check brake fluid reservoirs for proper amount of fluid. Note and correct any deficiency in amount or condition of fluid.



DIMENSIONS ARE IN (mm)

Figure 1-Typical Plug-Type Thermocouple Installations

MISCELLANEOUS

Verify the calibration of all instrumentation at the start and end of each test day using a written procedure approved for the instrumentation. If failure is indicated on any test, immediately recheck the calibration of all instrumentation after the COTR has been notified. Document results for inclusion in final report (see Sample Daily Calibration Sheet — Section 19 Forms).

PROCEDURAL TEST CONDITIONS (S6.5)

Brake control (S6.5.1) —

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

Test speeds (S6.5.2) —

If a vehicle is incapable of attaining the specified normal test speed, it is tested at a speed that is a multiple of 5 km/h (3.1 mph) that is 4 to 8 km/h (2.5 to 5.0 mph) less than its maximum speed and its performance must be within a stopping distance given by the formula provided for the specific requirement.

The vehicle speed shall be within +0 mph and approximately -1 mph (1.6 km/h) of the required speed for the test stops.

Stopping distance (S6.5.3) —

The braking performance of a vehicle 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.

In the stopping distance formulas given for each applicable test (such as $S \leq 0.10V + 0.0060V^2$, S is the maximum stopping distance in meters, and V is the test speed in km/h.

NOTE: The exact target speeds specified for each test will, in most cases, not be achievable. As a result, all actual stopping distances are to be adjusted to represent the distances that would have been obtained had the exact test speed been achieved. These corrected distances are calculated using the Society of Automotive Engineers, Inc., “Stopping Distance Test Procedure – SAE J299”, where the following expression is derived:

Corrected stopping distance =
 $[(\text{Target initial speed})^2 / (\text{Actual initial test speed})^2] \times \text{Actual stopping distance}$

Vehicle position and attitude (S6.5.4) —

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

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 $\pm 15^\circ$ from the center line of the test lane at any time during any stop.

Transmission selector control (S6.5.5) —

For tests in neutral, a stop or snub is made in accordance with the following procedures:

- A. Exceed the test speed by 6 to 12 km/h (3.7 to 7.5 mph);
- B. Close the throttle and coast in gear to approximately 3 km/h (1.9 mph) above the test speed;
- C. Shift to neutral; and
- D. When the test speed is reached, apply the brakes.

For tests in gear, a stop or snub is made in accordance with the following procedures:

- A. 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 to 12 km/h (3.7 to 7.5 mph);
- B. Close the throttle and coast in gear; and

- C. When the test speed is reached apply the brakes.
- D. 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 (18.6 mph).

Initial brake temperature (IBT) (S6.5.6) —

If the lower limit of the specified IBT for the 1st 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 (31.1 mph), at a deceleration rate not greater than 3 m/s^2 (9.8 fps^2).

14. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE TEST EXECUTION (S7)

Vehicles are tested per general and procedural conditions described in section 13 and according to the following test sequence: (THIS SEQUENCE CANNOT BE ALTERED UNLESS AUTHORIZED BY NHTSA)

Testing Order	Test	Test Procedure Section	FMVSS 135 Section
Initial	Speed Determination @LLVW	14	S4
Vehicle loaded to GVWR :			
1	Burnish/ Instrumentation Check	14.1	S7.1
2	Wheel Lock Sequence	14.2	S7.2
Vehicle Loaded to LLVW :			
3	Wheel Lock Sequence	14.3	S7.2
4	ABS Performance	14.4	S7.3
5	Torque Wheel	14.5	S7.4
Vehicle Loaded to GVWR :			
6	Torque Wheel	14.6	S7.4
7	Cold Effectiveness	14.7	S7.5
8	High Speed Effectiveness	14.8	S7.6
9	Stops with Engine Off	14.9	S7.7
Vehicle Loaded to LLVW :			
10	Cold Effectiveness	14.10	S7.5

(Table continued on next page)

14. **ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE
TEST EXECUTION (S7)....Continued**

Testing Order	Test	Test Procedure Section	FMVSS 135 Section
11	High Speed Effectiveness	14.11	S7.6
12	Failed Antilock	14.12	S7.8
13	Failed Proportioning Valve	14.13	S7.9
14	Failed Hydraulic circuit 1&2 & <i>Failed electric brake signal</i> & <i>Failed EV RBS</i>	14.14	S7.10
Vehicle Loaded to GVWR			
15	Failed Hydraulic Circuit 1& 2 & <i>Failed electric brake signal</i> & <i>Failed EV RBS</i>	14.15	S7.10
16	Failed Antilock	14.16	S7.8
17	Failed Proportioning Valve	14.17	S7.9
18	Power Brake Unit Failure & <i>Single Failure in Electrically Actuated Service Brakes</i> <i>Additional Test for Electrically- Actuated Service Brakes</i>	14.18	S7.11
		14.18A	S6.3.12
19	Parking Brake – Static	14.19	S7.12
20	Heating Snubs	14.20	S7.13
21	Hot Performance	14.21	S7.14
22	Brake Cooling	14.22	S7.15
23	Recovery Performance	14.23	S7.16
24	Final Inspection-system integrity Equipment Requirements - reservoir/indicators	14.24	S7.17 & S5

Prepare vehicle for testing according to test procedure sections 11,12, and 13.
Complete Data Sheet 1 for vehicle information.
Determine vehicle weight and load conditions and complete Data Sheet 3.
Data Sheet 2, a testing summary sheet, is completed after testing is concluded.

SPEED DETERMINATION (Max. Speed) —
(Record results on Data Sheet 4)

Prior to test initiation, determine the speed which the vehicle will attain on a level surface at LLVW in a distance of 3.2 km (two miles) from a standing start.

14.1 BURNISH (S7.1)
(Record results on Data Sheet 5)

14.1.1 General Information (S7.1.1)

Burnish procedures serve as a conditioning to permit the braking system to achieve its full capability.

Pretest Instrumentation and calibration checks are to be conducted as part of the burnish procedure, including any necessary rechecks after instrumentation repair, replacement or adjustment.

14.1.2 Vehicle conditions (S7.1.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In gear.

14.1.3 Test Conditions and Procedures (S7.1.3)

NOTE: The road test surface conditions specified in Section 13 (S6.2), do not apply to the burnish procedure.

- A. IBT: $\leq 100^{\circ}\text{C}$ (212°F).
- B. Test Speed: 80 km/h (49.7 mph).
- C. Pedal Force: Adjust as necessary to maintain specified constant deceleration rate.
- D. Deceleration Rate: Maintain a constant deceleration rate of 3.0 m/s^2 (9.8 fps^2).
- E. Wheel Lockup: No lockup of any wheel allowed for longer than 0.1 seconds at speeds greater than 15 km/h (9.3 mph).
- F. Number of Runs: 200 stops.
- G. Interval Between Runs: 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 (212°F) or less, or the distance of 2 km (1.24 miles), whichever occurs first.

- H. Accelerate to 80 km/h (49.7 mph) after each stop and maintain that speed until making the next stop.
- I. After burnishing, adjust the brakes in accordance with the vehicle manufacturer's recommendations (S6.3.4),

14.2 WHEEL LOCKUP SEQUENCE (S7.2) (Record Results on Data Sheet 6)

14.2.1 General Information (S7.2.1)

- A. The purpose of this test is to ensure that lockup of both front wheels occurs either simultaneously with, or at a lower deceleration rate than, the lockup of both rear wheels, when tested on road surfaces affording adhesion such that wheel lockup of the first axle occurs at a braking ratio of between 0.15 and 0.80, inclusive.
- B. This test is for vehicles WITHOUT antilock brake systems.
- C. This wheel lock sequence test is to be used as a screening test to evaluate a vehicle's axle lockup sequence and to determine whether the torque wheel test in 14.5 (S7.4) must be conducted.
- D. For this test, a simultaneous lockup of the front and rear wheels refers to the conditions when the time interval between the first occurrence of lockup of the last (second) wheel on the rear axle and the first occurrence of lockup of the last (second) wheel on the front axle is ≤ 0.1 second for vehicle speeds > 15 km/h (9.3 mph).
- E. A front or rear axle lockup is defined as the point in time when the last (second) wheel on an axle locks up.
- F. Vehicles that lock their front axle simultaneously or at lower deceleration rates than their rear axle need not be tested to the torque wheel procedure.
- G. Vehicles which lock their rear axle at deceleration rates lower than the front axle shall also be tested in accordance with the torque wheel procedure in S7.4.
- H. Any determination of noncompliance for failing adhesion utilization requirements shall be based on torque wheel test results.

14.2.2 Vehicle Conditions (S7.2.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In neutral.

14.2.3 Test Conditions and Procedures (S7.2.3)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F).
- B. Test Speed: 65 km/h (40.4 mph) for a braking ratio ≤ 0.50 ; 100 km/h (62.1 mph) for a braking ratio > 0.50 .
- C. Pedal Force:
 - (1) Pedal Force is applied and controlled by the vehicle driver or by a mechanical brake pedal actuator.
 - (2) Pedal Force is increased at a linear rate such that the first axle lockup occurs no less than 0.5 second and no more than 1.5 seconds after the initial application of the pedal.
 - (3) The pedal is released when the second axle locks, or when the pedal force reaches 1kN (225 lbs), or 0.1 seconds after first axle lockup, whichever occurs first.
- D. Wheel Lockup: Only wheel lockups above a vehicle speed of 15 km/h (9.3 mph) are considered in determining the results of this test.
- E. Test Surfaces: This test is conducted, for each loading condition, ON TWO DIFFERENT TEST SURFACES THAT WILL RESULT IN A BRAKING RATIO OF BETWEEN 0.15 AND 0.80, inclusive. NHTSA reserves the right to choose the test surfaces to be used based on adhesion utilization curves or any other method of determining "worst case" conditions. Contact COTR for test surfaces to use.
- F. The data recording equipment shall have a minimum sampling rate of 40 Hz.

- G. Data to be Recorded. 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.
- (1) Vehicle speed.
 - (2) Brake pedal force.
 - (3) Angular velocity at each wheel.
 - (4) Actual instantaneous vehicle deceleration or the deceleration calculated by differentiation of the vehicle speed.
- H. Speed Channel Filtration. For analog instrumentation, the speed channel shall be filtered by using a low-pass filter having a cut-off frequency of less than one fourth the sampling rate.
- I. Test procedure —
For each test surface, 3 runs meeting the pedal force application and time for wheel lockup requirements shall be made. Up to a total of 6 runs will be allowed to obtain 3 valid runs. Only the first 3 valid runs obtained shall be used for data analysis purposes.

14.2.4 Performance Requirements (S7.2.4)

- A. In order to pass this test a vehicle shall be capable of meeting the test requirements on all test surfaces that will result in a braking ratio of between 0.15 and 0.80, inclusive where braking ratio is defined as the vehicle deceleration divided by the gravitational acceleration constant. This will require a range of brake force applications on various surfaces in order to achieve the various deceleration values.
- B. If all 3 valid runs on each surface result in the front axle locking before or simultaneously with the rear axle, or the front axle locks up with only one or no wheels locking on the rear axle, the torque wheel procedure need not be run, and the vehicle is considered to meet the adhesion utilization requirements of this procedure. This performance requirement shall be met for all vehicle braking ratios between 0.15 and 0.80.
- C. If any one of the 3 valid runs on any surface results in the rear axle locking before the front axle or the rear axle locks up with only one or no wheels locking on the front axle the torque wheel procedure shall be performed. This performance requirement shall be met for all vehicle braking ratios between 0.15 and 0.80.

- D. If any one of the 3 valid runs on any surface results in neither axle locking (i.e., only one or no wheels locked on each axle) before a pedal force of 1kN (225 lbs) is reached, the vehicle shall be tested to the torque wheel procedure.
- E. If the conditions listed in paragraph C or D of this section occur, vehicle compliance shall be determined from the results of a torque wheel test performed in accordance with Section 14.5.
- F. *An EV with RBS that is part of the service brake system shall meet the performance requirements over the entire normal operating range of the RBS. If the RBS contribution to braking varies according to vehicle speed, deceleration, etc. then the worst case must be determined i.e. where RBS provides limited braking, and the test conducted at this condition at a minimum.*

14.3 WHEEL LOCKUP SEQUENCE (S7.2)

(Record Results on Data Sheet 7)

Repeat Wheel Lockup Sequence test 14.2 with vehicle load LLVW (again on two different test surfaces)

14.4 ABS PERFORMANCE (S7.3)

NOTE: Reserved for future revision of FMVSS 135

14.5 ADHESION UTILIZATION (Torque Wheel Method) (S7.4)

(Record Results on Data Sheet 8, if performed)

14.5.1 General Information (S7.4.1)

This test is for vehicles WITHOUT ANY ABS. The purpose of the test is to determine the adhesion utilization of a vehicle.

14.5.2 Vehicle Conditions (S7.4.2)

- A. Vehicle Load: LLVW
- B. Transmission Position: In neutral.
- C. Tires: For this test, a separate set of tires, identical to those used for all other tests under Section 14 (S7.0), may be used.

14.5.3 Test Conditions and Procedures (S7.4.3)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speeds: 100 km/h (62.1 mph), and 50 km/h (31.1 mph)

- C. Pedal Force: Pedal force is increased at a linear rate between 100 and 150 N/sec (22.5 and 33.7 lbs/sec) for the 100 km/h test speed, or between 100 and 200 N/sec (22.5 and 45.0 lbs/sec) for the 50 km/h test speed, until the first axle locks or until a pedal force of 1 kN (225 lbs) is reached, whichever occurs first
- D. Cooling: Between brake applications, the vehicle is driven at speeds up to 100 km/h (62.1 mph) until the IBT specified in 14.5.3(A) is reached.
- E. Number of Runs: With the vehicle at LLVW, run five stops from a speed of 100 km/h (62.1 mph) and five stops from a speed of 50 km/h (31.1 mph), while alternating between the two test speeds after each stop.
- F. Test Surface: PFC of at least 0.9
- G. Data to be Recorded. 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:
 - (1) Vehicle speed
 - (2) Brake pedal force
 - (3) Angular velocity at each wheel
 - (4) Brake torque at each wheel
 - (5) Hydraulic brake line pressure in each brake circuit. Hydraulically proportioned circuits shall be fitted with transducers on at least one front wheel and one rear wheel downstream of the operative proportioning or pressure limiting valve(s)
 - (6) Vehicle deceleration
- H. Sample Rate: All data acquisition and recording equipment shall support a minimum sample rate of 40 Hz on all channels.

- I. Determination of Front versus Rear Brake Pressure. Determine the front versus rear brake pressure relationship over the entire range of line pressures. Unless the vehicle has a variable brake proportioning system, this determination is made by static test. If the vehicle has a variable brake proportioning system, dynamic tests are run with the vehicle both empty and loaded. 15 snubs from 50 km/h (31.1 mph) are made for each of the two load conditions, using the same initial conditions specified in this section.

14.5.4 Data Reduction (S7.4.4)

- A. The data from each brake application under 14.5.3(E) (S7.4.3) is filtered using a five point, on-center moving average for each data channel.
- B. For each brake application under 14.5.3(E) (S7.4.3) determine the slope (brake factor) and pressure axis intercept (brake hold-off pressure) of the linear least squares equation best describing the measured torque output at each braked wheel as a function of measured line pressure applied at the same wheel. Only torque output values obtained from data collected when the vehicle deceleration is within the range of 0.15g to 0.80g are used in the regression analysis.
- C. Average the results of paragraph (b) of this section to calculate the average brake factor and brake hold-off pressure for all brake applications for the front axle.
- D. Average the results of paragraph B of this section to calculate the average brake factor and brake hold-off pressure for all brake applications for the rear axle.
- E. Using the relationship between front and rear brake line pressure determined in 14.5.3(l) (S7.4.3(i)) and the tire rolling radius, calculate the braking force at each axle as a function of front brake line pressure
- F. Calculate the braking ratio of the vehicle as a function of the front brake line pressure using the following equation

$$z = (T_1 + T_2)/P, \text{ where —}$$

z = braking ratio at a given front line pressure

T_1, T_2 = Braking forces at the front and rear axles, respectively, corresponding to the same front brake line pressure
 P = total vehicle weight

- G. Calculate the adhesion utilized at each axle as a function of braking ratio using the following equations:

$$f_1 = (T_1) / [P_1 + (zhP/E)]$$

$$f_2 = (T_2) / [P_2 - (zhP/E)], \text{ where —}$$

f_i = adhesion utilized by axle i

T_i = braking force at axle i (from (e))

P_i = static weight on axle i

i = 1 for the front axle, or 2 for the rear axle

z = braking ratio (from (f))

h = height of center of gravity of the vehicle

P = total vehicle weight

E = wheelbase

- H. Plot f_1 and f_2 obtained in G as a function of z , for LLVW load conditions. These are the adhesion utilization curves for the vehicle, which are compared to the performance requirements in 14.5.5 (S7.4.5) shown graphically in Figure 2:

14.5.5 Performance Requirements (S7.4.5)

For all braking ratios between 0.15 and 0.80, each adhesion utilization curve for a rear axle shall be situated below a line defined by $z = 0.9k$ where z is the braking ratio and k is the PFC.

An EV with RBS that is part of the service brake system shall meet the performance requirement over the entire normal operating range of the RBS. (S7.4.5.1)

14.6 ADHESION UTILIZATION (Torque Wheel Method) (S7.4) (Record Results on Data Sheet 9, if performed)

Repeat test 14.5 at vehicle load — GVWR

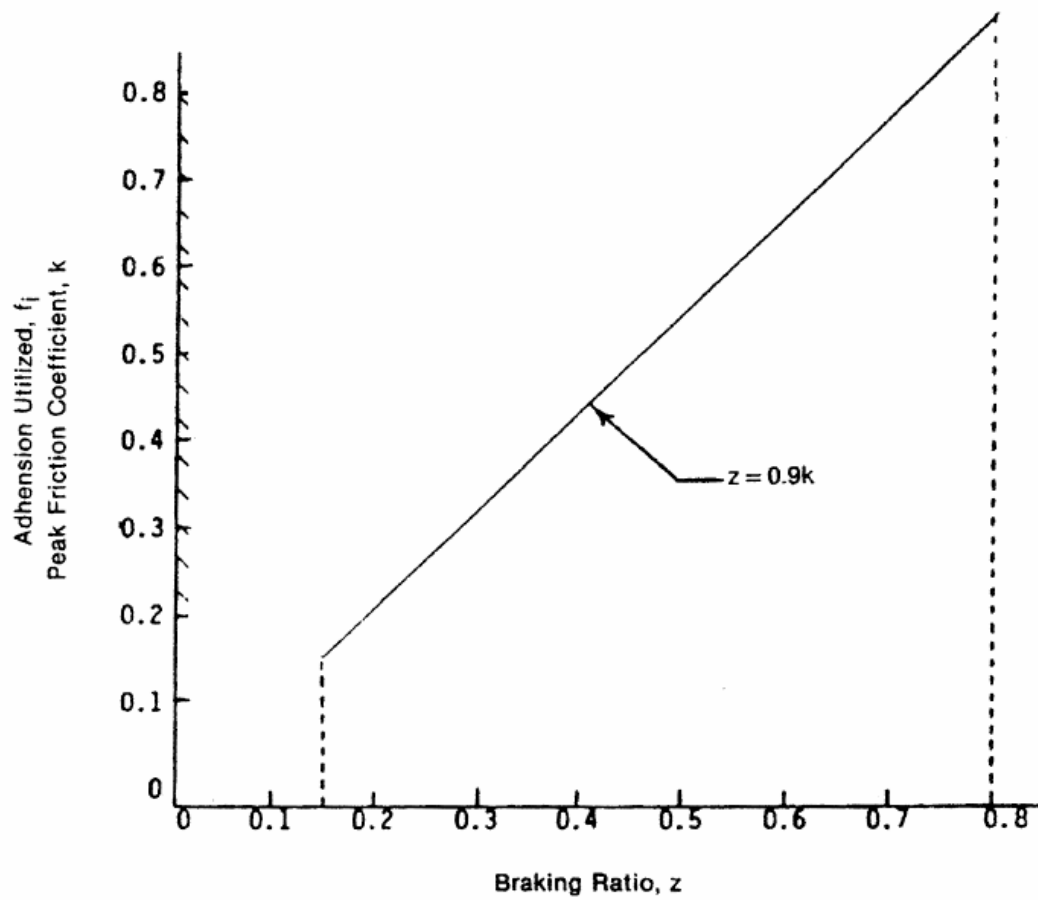


Figure 2-Adhesion Utilization Requirements

14.7 COLD EFFECTIVENESS (S7.5)
(Record Results on Data Sheet 10)

14.7.1 Vehicle Conditions (S7.5.1)

- A. Vehicle Load: GVWR
- B. Transmission position: In neutral

14.7.2 Test Conditions and Procedures (S7.5.2)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9
- G. For each stop, bring the vehicle to test speed and then stop the vehicle in the shortest possible distance under the specified conditions

NOTE: The average pedal force used during the cold effectiveness test establishes the allowable average pedal force, and therefore the stringency, for the subsequent hot performance (thermal) and recovery performance tests.

14.7.3 Performance Requirements (S7.5.3)

- A. Stopping Distance for 100 km/h Test Speed: $\leq 70\text{m}$ (230 ft)
- B. Stopping Distance for Reduced Test Speed: $S \leq 0.10V + 0.0060V^2$

14.8 HIGH SPEED EFFECTIVENESS (S7.6)
(Record Results on Data Sheet 11)

This test is not run if vehicle maximum speed is less than or equal to 125 km/h (77.7 mph).

14.8.1 Vehicle Conditions (S7.6.1)

- A. Vehicle Load: GVWR

- B. Transmission Position: In gear

14.8.2 Test Conditions and Procedures (S7.6.2)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 80% of vehicle maximum speed if 125 km/h (77.7 mph) $<$ vehicle maximum speed $< 200 \text{ km/h}$ (124.3 mph), or 160 km/h (99.4 mph) if vehicle maximum speed $\geq 200 \text{ km/h}$ (124.3 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph).
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9

14.8.3 Performance Requirements (S7.6.3)

Stopping distance: $S \leq 0.10V + 0.0067V^2$

14.9 STOPS WITH ENGINE OFF (S7.7) (Record Results on Data Sheet 12)

14.9.1 General Information (S7.7.1)

This test is for vehicles equipped with one or more brake power units or brake power assist units. *This test is also for **EV's**.*

14.9.2 Vehicle conditions (S7.7.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In neutral
- C. Vehicle Engine: Off (not running) .

For an EV, this test is conducted with no electrical power supplied to the vehicle's propulsion motor(s), but with the RBS and brake power or power assist still operating, unless cutting off the supply of electrical power to the propulsion motor(s) also disables those systems.

- D. Ignition Key Position: May be returned to "on" position after turning engine off, or a device may be used to "kill" the engine while leaving the ignition key in the "on" position. **NOTE:** If key is turned "off" and then back "on", it must be done with enough time to allow any system self-diagnostic checks

to be completed before the stop is made. Contact the COTR if this condition exists.

14.9.3 Test Conditions and Procedures (S7.7.3)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel allowed for longer than 0.1 seconds at speeds greater than 15 km/h (9.3 mph).
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9
- G. All system reservoirs (brake power and/or assist units) are fully charged and the vehicle's engine is off (not running) at the beginning of each stop

14.9.4 Performance Requirements (S7.7.4)

- A. Stopping Distance for 100 km/h Test Speed: $\leq 70\text{m}$ (230 ft.)
- B. Stopping Distance for Reduced Test Speed: $S \leq 0.10V + 0.0060V^2$

14.10 COLD EFFECTIVENESS (S7.5) (Record Results on Data Sheet 13)

Repeat test 14.7 with vehicle loading — LLVW

14.11 HIGH SPEED EFFECTIVENESS (S7.6) (Record Results on Data Sheet 14)

Repeat test 14.8 with vehicle load — LLVW

14.12 ANTILOCK FUNCTIONAL FAILURE (S7.8) (Record Results on Data Sheet 15)

14.12.1 Vehicle Conditions (S7.8.1)

- A. Vehicle Loading: LLVW
- B. Transmission Position: In neutral

14.12.2 Test conditions and Procedures (S7.8.2)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel for more than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9
- G. Functional Failure Simulation:
 - (1) Disconnect the functional power source, or any other electrical connector that creates a functional failure.
 - (2) Determine whether the brake system indicator is activated when any electrical functional failure of the antilock system is created.
 - (3) Restore the system to normal at the completion of this test.
- H. If more than one antilock brake subsystem is provided, repeat test for each subsystem.

14.12.3 Performance Requirements (S7.8.3)

For service brakes on a vehicle equipped with one or more antilock systems, in the event of any single functional failure in any such system, the service brake system shall continue to operate and shall stop the vehicle as specified in A (S7.8.3(a)) or B (S7.8.3(b)) below.

- A. Stopping Distance for 100 km/h Test Speed: $\leq 85\text{ m}$ (279 ft)
- B. Stopping Distance for Reduced Test Speed: $S \leq 0.10V + 0.0075V^2$

14.13 **VARIABLE BRAKE PROPORTIONING SYSTEM FUNCTIONAL FAILURE (S7.9)** — (Record Results on Data Sheet 16)

14.13.1 Vehicle Conditions (S7.9.1)

- A. Vehicle Load: LLVW
- B. Transmission Position: In neutral

14.13.2 Test Conditions and Procedures (S7.9.2)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9
- G. Functional Failure Simulation:
 - (1) Disconnect the functional power source or mechanical linkage to render the variable brake proportioning system inoperative. Consult COTR on what to do with linkage once disconnected (if it needs to be secured).
 - (2) If the system utilizes electrical components, determine whether the brake system indicator is activated when any electrical functional failure of the variable proportioning system is created.
 - (3) Restore the system to normal at the completion of this test.
- H. If more than one variable brake proportioning subsystem is provided, repeat the test for each subsystem.

14.13.3 Performance requirements (S7.9.3)

The service brakes on a vehicle equipped with one or more variable brake proportioning systems, in the event of any single functional failure in any such system, shall continue to operate and shall stop the vehicle as specified in A (S7.9.3(a)) or B (S7.9.3(b)) below.

- A. Stopping Distance for 100 km/h Test Speed: $\leq 110\text{ m}$ (361 ft)
- B. Stopping Distance for Reduced Test Speed: $S \leq 0.10V + 0.0100V^2$

14.14 HYDRAULIC CIRCUIT FAILURE [Circuits 1 and 2] (S7.10)

(Record Results on Data Sheets 17 and 18)

A. Includes single failure of transmitted electric signal to foundation brakes.

B. Includes for an EV equipped with RBS, single failure of RBS.

- 14.14.1 General Information (S7.10.1)
This test is for vehicles manufactured with or without a split service brake system.
NOTE: Separate data sheets will be provided for testing of vehicles without a split system
- 14.14.2 Vehicle Conditions (S7.10.2)
- A. Vehicle Load: LLVW
 - B. Transmission Position: In neutral
- 14.14.3 Test Conditions and Procedures (S7.10.3)
- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
 - B. Test Speed: 100 km/h (62.1 mph)
 - C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
 - D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
 - E. Test Surface: PFC of 0.9
 - F. Alter the service brake system to produce any single failure. For a hydraulic circuit, this may be any single rupture or leakage type failure, other than a structural failure of a housing that is common to two or more subsystems.

For a vehicle in which the brake signal is transmitted electrically between the brake pedal and some or all of the foundation brakes, regardless of the means of actuation of the foundation brakes, this may be any single failure in any circuit that electrically transmits the brake signal. For an EV with RBS that is part of the service brake system, this may be a single failure in the RBS.
 - G. Determine the control force pressure level (differential pressure between intact and failed subsystems) or fluid level (as appropriate for the indicator being tested – see 14.24.6) necessary to activate the brake warning indicator
 - H. Number of Runs: After the brake warning indicator has been activated, make the following stops depending on the type of brake system
 - (1) 4 stops for a SPLIT SERVICE brake system

(2) 10 consecutive stops for a NON-SPLIT SERVICE brake system

- I. Each stop is made by a continuous application of the service brake control
- J. Restore the service brake system to normal at the completion of this test
- K. Repeat the entire sequence for each of the other subsystems (Hydraulic system number 2)

14.14.4 Performance Requirements (S7.10.4)

For vehicles manufactured with a split service brake system, in the event of any failure in a single subsystem, as specified in 14.14.3 (S7.10.3(f)) of this procedure, and after activation of the brake system indicator as specified in 14.24.6 (S5.5.1), the remaining portions of the service brake system shall continue to operate and shall stop the vehicle as specified in A (S7.10.4(a)) or B (S7.10.4 (b)) below.

For vehicles not manufactured with a split service brake system, in the event of any failure in any component of the service brake system, as specified in 14.14.3 (S7.10.3(f)), and after activation of the brake system indicator as specified in 14.24.6 (S5.5.1), the vehicle shall by operation of the service brake control stop 10 times consecutively as specified in A (S7.10.4(a)) or B (S7.10.4(b)) below.

A. Stopping distance from 100 km/h test speed: ≤ 168 m (551 ft)

B. Stopping distance for reduced test speed: $S \leq 0.10V + 0.0158V^2$

14.15 **HYDRAULIC CIRCUIT FAILURE [Circuits 1 and 2] (S7.10)** (Record Results on Data Sheets 19 and 20)

Repeat test 14.14 with vehicle load at GVWR.

14.16 **ANTILOCK FUNCTIONAL FAILURE (S7.8)** (Record Results on Data Sheet 21)

Repeat test 14.12 with vehicle load at GVWR.

14.17 **VARIABLE BRAKE PROPORTIONING SYSTEM FUNCTIONAL FAILURE (S7.9)** (Record Results on Data Sheet 22)

Repeat test 14.13 with vehicle load at GVWR.

**14.18 POWER BRAKE UNIT OR BRAKE POWER ASSIST UNIT
INOPERATIVE (SYSTEM DEPLETED) and *ELECTRICALLY -
ACTUATED SERVICE BRAKES (S7.11)* (Record Results on Data Sheet
23)**

14.18.1 General Information (S7.11.1)

This test is for vehicles equipped with one or more brake power units or brake power assist units.

14.18.2 Vehicle Conditions (S7.11.2)

- A. Vehicle load: GVWR
- B. Transmission position: In neutral

14.18.3 Test Conditions and Procedures (S7.11.3)

- A. IBT: $\geq 65^{\circ}\text{C}$ (149°F), $\leq 100^{\circ}\text{C}$ (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: $\geq 65\text{N}$ (14.6 lbs), $\leq 500\text{N}$ (112.4 lbs)
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- E. Number of Runs: 6 stops
- F. Test Surface: PFC of 0.9
- G. Disconnect the primary source of power for one brake power assist unit or brake power unit, or one of the brake power unit or brake power assist unit subsystems if two or more subsystems are provided
- H. If the brake power unit or power assist unit operates in conjunction with a backup system and the backup system is automatically activated in the event of a primary power service failure, the backup system is operative during this test
- I. EXHAUST ANY RESIDUAL BRAKE POWER RESERVE CAPABILITY OF THE DISCONNECTED SYSTEM
- J. Make each of the 6 stops by a continuous application of the service brake control

- K. Restore the system to normal at completion of this test
- L. For vehicles equipped with more than one brake power unit or brake power assist unit, conduct tests for each in turn
- M. *For vehicles with electrically-actuated service brakes (brake power unit), this test is conducted with any single electrical failure in the electrically-actuated service brakes instead of a failure of any other brake power or brake power assist unit, and all other systems intact.*

14.18.4 Performance Requirements (S7.11.4)

The service brakes on a vehicle equipped with one or more brake power assist units or brake power units, with one such unit inoperative and depleted of all reserve capability, shall stop the vehicle as specified in A (S7.11.4(a)) or B (S7.11.4(b)) below.

- A. Stopping Distance from 100 km/h Test Speed: ≤ 168 m (551 ft)
- B. Stopping Distance for Reduced Test Speed: $S \leq 0.10V + 0.0158V^2$

14.18A **Additional Test for Electrically-Actuated Service Brakes (S6.3.12)** (Record results on Data Sheet 23A)

ELECTRICALLY-ACTUATED SERVICE BRAKES; State of charge of batteries for electrically-actuated service brakes.

*A vehicle equipped with ELECTRICALLY-ACTUATED SERVICE BRAKES also performs the following test series. Conduct 10 stopping tests from a speed of 100 kph or the maximum vehicle speed, whichever is less. At least two of the 10 stopping distances must be less than or equal to 70 meters. The vehicle is loaded to **GVWR** and the transmission is in the neutral position when the service brake control is actuated and throughout the remainder of the test. 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. An auxiliary means may be used to accelerate an EV to test speed.*

- 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 five percent 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 and averaging the states-of-charge recorded.*

- 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 five percent above the actual state of charge at which the brake failure warning signal, required by S5.5.1(e) of this standard, is illuminated.*
- C. *For a vehicle which has an auxiliary battery (or batteries) that provides electrical energy to operate the ELECTRICALLY-ACTUATED SERVICE BRAKES, the auxiliary battery(batteries) is (are) at (at an average of) not more than five percent above the actual state of charge at which the brake failure warning signal, required by 14.24.6 (S5.5.1(e)) of this standard, is illuminated.*

14.19 PARKING BRAKE - STATIC (S7.12)

(Record Results on Data Sheet 24)

14.19.1 Vehicle Conditions (S7.12.1)

- A. Vehicle Load: GVWR
- B. Transmission Position: In neutral
- C. Parking Brake Burnish:
- (1) For vehicles with parking brake systems not utilizing the service friction elements, the friction elements of such a system are burnished prior to the parking brake test according to the published recommendations furnished to the purchaser by the manufacturer.
 - (2) If no recommendations are furnished, the vehicle's parking brake system is tested in an unburnished condition.

14.19.2 Test Conditions and Procedures (S7.12.2)

- A. IBT:
- (1) Parking brake systems utilizing service brake friction materials shall be tested with the IBT $\leq 100^{\circ}\text{C}$ (212°F) and shall have no additional burnishing or artificial heating prior to the start of the parking brake test.
 - (2) Parking brake systems utilizing non-service brake friction materials shall be tested with the friction materials at ambient temperature at the start of the test. The friction

materials shall have no additional burnishing or artificial heating prior to or during the parking brake test.

- B. Parking Brake Control Force: Hand control ≤ 400 N (89.9 lbs); foot control ≤ 500 N (112.4 lbs).
- C. Hand Force Measurement Locations: The force required for actuation of a hand-operated brake system is measured at the center of the hand grip area or at a distance of 40 mm (1.57 in) from the end of the actuation lever as illustrated in Figure 3.
- D. Parking Brake Applications: 1 application and up to 2 re-applications, if necessary.

14. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE
TEST EXECUTION (S7)...Continued

LOCATION FOR MEASURING HAND BRAKE
APPLICATION FORCE

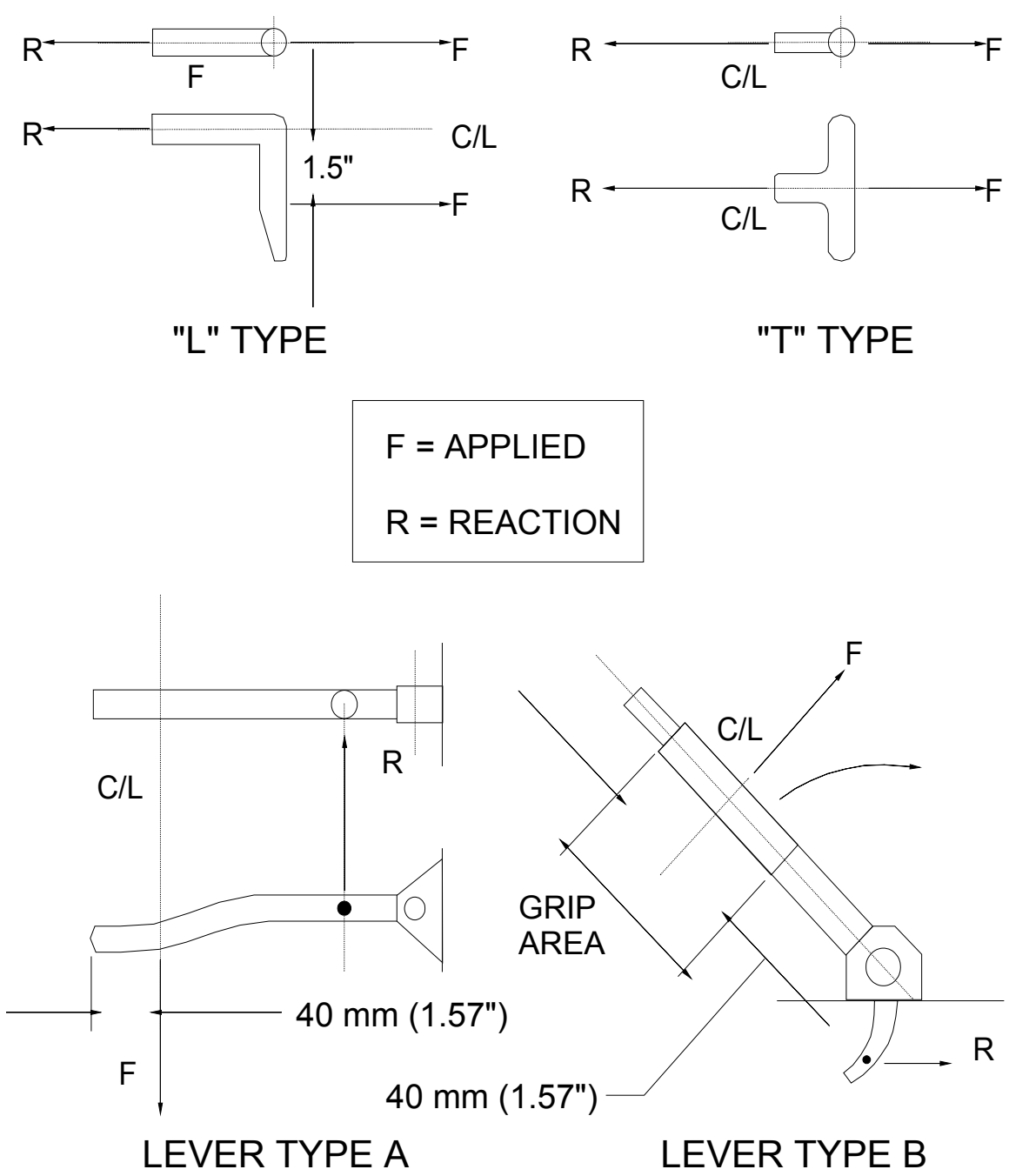


FIGURE 3

14. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE TEST EXECUTION (S7)...Continued

- E. Test Surface Gradient: 20% grade.
- F. Drive the vehicle onto the grade with the longitudinal axis of the vehicle in the direction of the slope of the grade.
- G. Stop the vehicle and hold it stationary by applying the service brake control and place the transmission in neutral.
- H. With the service brake applied sufficiently to just keep the vehicle from rolling, apply the parking brake as specified in 14.19.2 (S7.12.2(i)) or 14.19.2 (S7.12.2(j)).
- I. For a vehicle equipped with mechanically-applied parking brakes, make a single application of the parking brake control with a force not exceeding the limits specified in 14.19.2 (S7.12.2(b)).

For a vehicle using electrically-actuated parking brake, apply the parking brake by activating the parking brake control.
- J. In the case of a parking brake system that does not allow application of the specified force in a single application, a series of applications may be made to achieve the specified force.
- K. Following the application of the parking brakes, release all force on the service brake control and, if the vehicle remains stationary, start the measurement of time.
- L. If the vehicle does not remain stationary, re-application of a force to the parking brake control at the level specified in 14.19.2 (S7.12.2(b)) as appropriate for the vehicle being tested (without release of the ratcheting or other holding mechanism of the parking brake) is used up to two times to attain a stationary position.
- M. Verify the operation of the parking brake application indicator.
- N. Following observation of the vehicle in a stationary condition for the specified time in one direction, repeat the same test procedure with the vehicle orientation in the opposite direction on the same grade.

14.19.3 Performance Requirement (S7.12.3)

The parking brake system shall hold the vehicle stationary for 5 minutes in both a forward and reverse direction on the grade.

14.20 HEATING SNUBS (S7.13)
(Record Results on Data Sheet 25)

14.20.1 General Information (S7.13.1)

The purpose of the snubs is to heat up the brakes in preparation for the hot performance test which follows immediately.

14.20.2 Vehicle Conditions (S7.13.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In gear

14.20.3 Test Conditions and Procedures (S7.13.3)

- A. IBT:
 - (1) Establish an IBT before the first brake application (snub) of $\geq 55^{\circ}\text{C}$ (131°F), $\leq 65^{\circ}\text{C}$ (149°F).
 - (2) IBT before subsequent snubs are those occurring at the distance intervals.
- B. Number of Snubs: 15
- C. Test Speeds: The initial speed for each snub is 120 km/h (74.6 mph) or 80% of V_{max} , whichever is slower. Each snub is terminated at one-half the initial speed.
- D. Deceleration Rate:
 - (1) Maintain a constant deceleration rate of 3.0 m/s^2 (9.8 fps^2).
 - (2) Attain the specified deceleration within one second and maintain it for the remainder of the snub.
- E. Pedal Force: Adjust as necessary to maintain the specified constant deceleration rate.
- F. Time Interval: Maintain an interval of 45 seconds between the start of brake applications (snubs).

- G. Accelerate as rapidly as possible to the initial test speed immediately after each snub.
- H. Immediately after the 15th snub, accelerate to 100 km/h (62.1 mph) and commence the hot performance test.

14.21 HOT PERFORMANCE (S7.14)
(Record Results on Data Sheet 26)

14.21.1 General Information (S7.14.1)

The hot performance test is conducted immediately after completion of the 15th heating snub.

14.21.2 Vehicle Conditions (S7.14.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In neutral

14.21.3 Test Conditions and Procedures (S7.14.3)

- A. IBT: Temperature achieved at completion of heating snubs
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force:
 - (1) **THE 1st STOP IS DONE WITH AN AVERAGE PEDAL FORCE NOT GREATER THAN THE AVERAGE PEDAL FORCE RECORDED DURING THE SHORTEST GVWR COLD EFFECTIVENESS STOP.**
 - (2) The 2nd stop is done with a pedal force not greater than 500 N (112.4 lbs).
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph).
- E. Number of Runs: 2 stops
- F. Immediately after the 15th heating snub, accelerate to 100 km/h (62.1 mph) and commence the 1st stop of the hot performance test.

- G. If the vehicle is incapable of attaining 100 km/h, it is tested at the same speed used for the GVWR cold effectiveness test.
- H. Immediately after completion of the 1st hot performance stop, accelerate as rapidly as possible to the specified test speed and conduct the 2nd hot performance stop.
- I. Immediately after completion of the 2nd hot performance stop, drive 1.5 km (0.93 mi) at 50 km/h (31.1 mph) before the 1st cooling stop.

14.21.4 Performance Requirements (S7.14.4)

DUAL REQUIREMENT — RELATIVE AND ABSOLUTE

- A. For the **1st** hot stop, the stopping distance must be less than or equal to a calculated distance which is based on 60 percent of the deceleration actually achieved on the shortest GVWR cold effectiveness stop. The following equations shall be used in calculating the performance requirement:

$$D_c = 0.0386V^2 / (S_c - 0.10V)$$

$$S = 0.10V + [0.0386V^2 / 0.60(D_c)], \text{ where —}$$

S_c = Actual stopping distance measured on the shortest cold effectiveness stop at GVWR (m/s)

V = Cold effectiveness test speed (km/h)

D_c = Average deceleration actually achieved during the shortest cold effectiveness stop at GVWR (m/ss)

S = Stopping Distance (meters)

- B. In addition to the requirement in 14.21.4 (S7.14.4(A)), the stopping distance for at least 1 of the 2 hot stops must be $S \leq 89$ m (292 ft) from a test speed of 100 km/h (62.1 mph) or, for reduced test speed, $S \leq 0.10V + 0.0079V^2$. The results of the 2nd stop may not be used to meet the requirements of 14.21.4 (S7.14.4(A)).

14.22 BRAKE COOLING STOPS (S7.15)
(Record Results on Data Sheet 27)

14.22.1 General Information (S7.15.1)

The cooling stops are conducted immediately after completion of the hot performance test.

14.22.2 Vehicle Conditions (S7.15.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In gear

14.22.3 Test Conditions and Procedures (S7.15.3)

- A. IBT: Temperature achieved at completion of hot performance
- B. Test Speed: 50 km/h (31.1 mph)
- C. Pedal Force: Adjust as necessary to maintain specified constant deceleration rate
- D. Deceleration Rate: Maintain a constant deceleration rate of 3.0 m/s² (9.8 fps²)
- E. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- F. Number of Runs: 4 stops
- G. Immediately after the Hot Performance Stops, drive 1.5 km (0.93 mi) at 50 km/h (31.1 mph) before the 1st cooling stop
- H. For the 1st through the 3rd cooling stops:
 - (1) After each stop, immediately accelerate at the maximum rate to 50 km/h (31.1 mph)
 - (2) Maintain that speed until beginning the next stop at a distance of 1.5 km (0.93 mi) from the beginning of the previous stop

- I. For the 4th cooling stop:
 - (1) Immediately after the 4th stop, accelerate at the maximum rate to 100 km/h (62.1 mph)
 - (2) Maintain that speed until beginning the recovery performance stops at a distance of 1.5 km (0.93 mi) after the beginning of the fourth cooling stop

14.23 RECOVERY PERFORMANCE (S7.16)
(Record Results on data Sheet 28)

14.23.1 General Information (S7.16.1)

The recovery performance test is conducted immediately after completion of the brake cooling stops.

14.23.2 Vehicle Conditions (S7.16.2)

- A. Vehicle Load: GVWR
- B. Transmission Position: In neutral

14.23.3 Test Conditions and Procedures (S7.16.3)

- A. IBT: Temperature achieved at completion of cooling stops
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: The average pedal force shall not be greater than the average pedal force recorded during the shortest GVWR cold effectiveness stop
- D. Wheel Lockup: No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h (9.3 mph)
- E. Number of Runs: 2 stops
- F. Immediately after the 4th cooling stop, accelerate at the maximum rate to 100 km/h (62.1 mph)
- G. Maintain that speed until beginning the 1st recovery performance stop at a distance of 1.5 km (0.93 mi) after the beginning of the 4th cooling stop

- H. If the vehicle is incapable of attaining 100 km/h, it is tested at the same speed used for the GVWR cold effectiveness test
- I. Immediately after completion of the 1st recovery performance stop accelerate as rapidly as possible to the specified test speed and conduct the 2nd recovery performance stop.

14.23.4 Performance Requirements (S7.16.4)

The stopping distance, S, for at least one of the two stops must be within the following limits:

$$S - 0.10V \geq 0.0386 V^2 / 1.50Dc$$

$$S - 0.10V \leq 0.0386 V^2 / 0.70Dc, \text{ where —}$$

V = Cold effectiveness test speed (km/h)

Dc = The average deceleration actually achieved during the shortest cold effectiveness stop at GVWR (m/ss).

14.24 FINAL INSPECTION (S7.17) & EQUIPMENT REQUIREMENTS (S5)

Service brake system (S5.1), Parking brake system (S5.2), Controls (S5.3), Reservoirs (S5.4), Brake system warning indicators (S5.5), Brake system integrity (S5.6)

(Record Results on Data Sheets 29, 30, and 31)

14.24.1 Brake System Integrity (S5.6) (S7.17)

At the completion of the road performance test, remove wheels from vehicle and verify that vehicle meets the complete performance requirements of this procedure without:

- A. Detachment or fracture of any component of the braking system, such as brake springs and brake shoes or disc pad facings other than minor cracks that do not impair attachment of the friction facings. All mechanical components of the braking system shall be intact and functional.

Friction facing tear-out (complete detachment of lining) shall not exceed **10 percent** of the lining on any single frictional element.

- B. Any visible brake fluid or lubricant on the friction surface of the

brake, or leakage at the master cylinder or brake power unit reservoir cover, seal, and filler openings.

14.24.2 Service Brake System (S5.1)

A. Verify that vehicle is equipped with a service brake system acting on all wheels.

B. Wear Adjustment (S5.1.1)

Verify that the service brakes are compensated for wear by means of a system of automatic adjustment.

C. Wear Status (S5.1.2)

Verify that the wear condition of all service brakes is indicated by either:

1. Acoustic or optical devices warning the driver at his or her driving position when lining replacement is necessary, or
2. A means of visually checking the degree of brake lining wear, from the outside or underside of the vehicle, utilizing only the tools or equipment normally supplied with the vehicle. The removal of wheels is permitted for this purpose. Drum brakes may have observation ports in the drum or backing plate for lining inspection.

D. *Regenerative braking system (S5.1.3)*

1. Verify that for an EV equipped with RBS, the RBS is considered to be part of the service brake system if it is automatically activated by an application of the service brake control, if there is no means provided for the driver to disconnect or otherwise deactivate it, and if it is activated in all transmission positions, including neutral

2. Verify that for an EV that is equipped with both ABS and RBS that is part of the service brake system, the ABS must control the RBS.

14.24.3 Parking Brake System (S5.2)

Verify that each vehicle is equipped with a parking brake system of a friction type with solely mechanical means to retain engagement.

14.24.4. Controls (S5.3)

Verify that the service brakes are activated by means of a foot control. The control of the parking brake shall be independent of the service brake control, and may be either a hand or foot control. (S5.3.1)

For vehicles equipped with ABS, a control to manually disable the ABS, either fully or partially, is prohibited. (S5.3.2)

14.24.5 Reservoirs (S5.4)

Master Cylinder Reservoirs (S5.4.1)

Inspect and verify that the master cylinder has a reservoir compartment for each service brake subsystem serviced by the master cylinder.

Verify that loss of fluid from one compartment shall not result in a complete loss of brake fluid from another compartment.

Reservoir Capacity (S5.4.2)

Inspect and verify that the reservoirs, whether for master cylinders or other type systems, have a total minimum capacity equivalent to the fluid displacement resulting when all the wheel cylinders or caliper pistons serviced by the reservoirs move from a new lining, fully retracted position (as adjusted initially to the manufacturer's recommended setting) to a fully worn, fully applied position. (In determining the fully applied worn condition, assume that the lining is worn to (1) rivet or bolt heads on riveted or bolted linings or (2) within 0.8 mm (1/32 inch) of shoe or pad mounting surface on bonded linings or (3) the limit recommended by the manufacturer, whichever is larger relative to the total possible shoe or pad movement. Drums or rotors are assumed to be at nominal design drum diameter or rotor thickness. Linings are assumed adjusted for normal operating clearance in the released position.)

Refer to Data Sheets 31 and 32 and to the Appendix for procedure to calculate master cylinder volume requirements (S7.17(C)).

To measure the fluid volume of the master cylinder, it is recommended to fill the reservoir to the **MAX.** mark indicated on the reservoir if so marked, or to a quantity specified by the manufacturer. Then completely drain by the output ports, by suction using a syringe, or an equivalent method.

Verify that reservoirs have completely separate compartments for each service brake subsystem except that in reservoir systems utilizing a portion of the reservoir for a common supply to two or more subsystems, individual partial compartments shall each have a minimum volume of fluid equal to at least the volume displaced by the master cylinder piston servicing the subsystem, during a full stroke of the piston.

To determine the fluid volume of each compartment, it is recommended to disconnect the hydraulic line for subsystem 1 which allows common fluid and the fluid for that subsystem to be depleted. Then disconnect the line to subsystem 2 and collect fluid for measurement of that subsystem compartment volume. Refill the master cylinder and repeat for subsystem compartment 1 volume. As an alternative, a syringe can be used to collect the fluid in each chamber.

Measurement for fluid displaced per stroke is similarly conducted by using a catch receptacle at each subsystem hydraulic line port while applying the brake pedal. Application of the brake pedal three times and dividing by three is the preferred method for per stroke determination.

If applicable, verify that each brake power unit reservoir servicing only the brake system shall have a minimum capacity equivalent to the fluid displacement required to charge the system piston(s) or accumulator(s) to normal operating pressure plus the displacement resulting when all the wheel cylinders or caliper pistons serviced by the reservoir or accumulator(s) move from a new lining, fully retracted position (as adjusted initially to the manufacturer's recommended setting) to a fully worn, fully applied position.

Reservoir Labeling (S5.4.3)

Verify that vehicle has a brake fluid warning statement that reads as follows, in letters at least 3.2 mm (1/8 inch) high: "WARNING: Clean filler cap before removing. Use only _____ fluid from a sealed container." (Inserting the recommended type of brake fluid as specified in 49 CFR 571.116, e.g. , "DOT 3.") Verify that the lettering is:

- A. Permanently affixed, engraved or embossed
- B. Located so as to be visible by direct view, either on or within 100 mm (3.94 inches) of the brake fluid reservoir filler plug or cap

- C. Of a color that contrasts with its background, if it is not engraved or embossed

Fluid Level Indication (S5.4.4)

Verify that the brake fluid reservoirs are constructed so that the level of fluid can be checked without need for the reservoir to be opened. This requirement is deemed to have been met if the vehicle is equipped with a transparent brake fluid reservoir or a brake fluid level indicator meeting the requirements of S5.5.1(A(1)).

14.24.6 Brake System Warning Indicator (S5.5)

Verify that vehicle has one or more visual brake system warning indicators, mounted in front of and in clear view of the driver, which meet the requirements of (S5.5.1) through (S5.5.5) as shown below. In addition, a vehicle manufactured without a split service brake system shall be equipped with an audible warning signal that activates under the conditions specified in (S5.5.1(A)).

Activation (S5.5.1)

Verify that an indicator is activated when the ignition (start) switch is in the "on" ("run") position and whenever any of conditions (A), (B), (C), (D), (E), (F), or (G) occur:

- A. A gross loss of fluid or fluid pressure (such as caused by rupture of a brake line but not by a structural failure of a housing that is common to two or more subsystems) as indicated by one of the following conditions (chosen at the option of the manufacturer):
 - (1) A drop in the level of the brake fluid in any master cylinder reservoir compartment to less than the recommended safe level specified by the manufacturer or to one-fourth of the fluid capacity of that reservoir compartment, whichever is greater.

The following procedure is recommended for measuring brake warning indicator activation:

With the vehicle on a level surface, engine running and the master cylinder fluid at the **MAX.** recommended level as shown on the side of the reservoir if so indicated or at the manufacturer specified level, slowly extract fluid from the master cylinder reservoir through a subsystem hydraulic line, or using a syringe or similar device. Record the fluid quantity extracted at the time of light activation. Some systems may have a time delay for activation. Replace the fluid back into the

reservoir and repeat. In most cases, the brake warning light will activate with each reservoir compartment at 100% of capacity and the fluid having only been removed from the common supply. If the common fluid is fully removed, and the light does not activate, then the individual compartment fluid must be extracted again by hydraulic line release, syringe suction, or similar to ensure that the fluid does not go below 25% of the compartment fluid capacity or the recommended safe level specified by the manufacturer, whichever is greater. Access to each compartment may require a very small diameter hole be drilled on the top of the reservoir for insertion of the syringe. Consult COTR prior to reservoir alterations.

- (2) For vehicles equipped with a split service brake system, a differential pressure of 1.5 MPa (218 psi) between the intact and failed brake subsystems measured at a master cylinder outlet or a slave cylinder outlet. Installation of pressure transducers may be required.
 - (3) A drop in the supply pressure in a brake power unit to one-half of the normal system pressure.
- B. Any electrical functional failure in an antilock or variable brake proportioning system
 - C. Application of the parking brake
 - D. Brake lining wear-out, if the manufacturer has elected to use an electrical device to provide an optical warning to meet the requirements of 14.24.2 (c) (S5.1.2(a)).
 - E. *For a vehicle with electrically-actuated service brakes, failure of the source of electric power to those brakes, or diminution of state of charge of the batteries to less than a level specified by the manufacturer for the purpose of warning a driver of degraded brake performance.*
 - F. *For a vehicle with electric transmission of the service brake control signal, failure of a brake control circuit.*
 - G. *For an EV with a regenerative braking system that is part of the service brake system, failure of the RBS.*

Function Check (S5.5.2)

- A. Verify that all indicators are activated as a check function by either:

- (1) Automatic activation when the ignition (start) switch is turned to the "on" ("run") position when the engine is not running, or when the ignition ("start") switch is in a position between "on" ("run") and "start" that is designated by the manufacturer as a check position, or
 - (2) A single manual action by the driver, such as momentary activation of a test button or switch mounted on the instrument panel in front of and in clear view of the driver, or, in the case of an indicator for application of the parking brake, by applying the parking brake when the ignition is in the "on" ("run") position.
- B. In the case of a vehicle that has an interlock device that prevents the engine from being started under one or more conditions, check functions meeting the requirements of S5.5.2(A) need not be operational under any condition in which the engine cannot be started.
- C. The manufacturer shall explain the brake check function test procedure in the owner's manual.

Duration (S5.5.3)

Verify that each indicator activated due to a condition specified in S5.5.1 shall remain activated as long as the condition exists, whenever the ignition ("start") switch is in the "on" ("run") position, whether or not the engine is running.

Function (S5.5.4)

Verify that when a visual warning indicator is activated, it is continuous or flashing, except that the visual warning indicator on a vehicle not equipped with a split service brake system shall be flashing. The audible warning required for a vehicle manufactured without a split service brake system may be continuous or intermittent.

Labeling (S5.5.5)

Verify the following labeling exists:

- A. Each visual indicator shall display a word or words in accordance with the requirements of Standard No. 101 (49 CFR 571.101) and this section, which shall be legible to the driver under all daytime and nighttime conditions when activated. Unless otherwise specified, the words shall have letters not less than 3.2 mm (1/8 inch) high and the letters and background shall be of contrasting colors, one of which is red. Words or

symbols in addition to those required by Standard No. 101 and this section may be provided for purposes of clarity.

- B. Vehicles manufactured with a split service brake system may use a common brake warning indicator to indicate two or more of the functions described in S5.5.1(A) through S5.5.1(G). If a common indicator is used, it shall display the word "**Brake**".
- C. A vehicle manufactured without a split service brake system shall use a separate indicator to indicate the failure condition in S5.5.1(A). This indicator shall display the words "STOP-BRAKE FAILURE" in block capital letters not less than 6.4 mm (1/4 inch) in height.
- D. If separate indicators are used for one or more than one of the functions described in S5.5.1(A) to S5.5.1(G), the indicators shall display the following wording:
 - (1) If a separate indicator is provided for the low brake fluid condition in S5.5.1(A)(1), the words "**Brake Fluid**" shall be used except for vehicles using hydraulic system mineral oil.
 - (2) If a separate indicator is provided for the gross loss of pressure condition in S5.5.1(A)(2), the words "**Brake Pressure**" shall be used.
 - (3) If a separate indicator is provided for the condition specified in S5.5.1(B), the letters and background shall be of contrasting colors, one of which is yellow. The indicator shall be labeled with the words "**Antilock**" or "**Anti-lock**" or "**ABS**"; or "**Brake Proportioning**," in accordance with Table 2 of Standard No. 101.
 - (4) If a separate indicator is provided for application of the parking brake as specified for S5.5.1(C), the single word "**Park**" or the words "**Parking Brake**" may be used.
 - (5) If a separate indicator is provided to indicate brake lining wear-out as specified in S5.5.1(D), the words "**Brake Wear**" shall be used.
 - (6) *If a separate indicator is provided for the condition specified in S5.5.1(G), RBS failure, the letters and background shall be of contrasting colors, one of which is **yellow**. The indicator shall be labeled with the symbol "**RBS**". RBS failure in a system that is part part of the service brake system may also be indicated by a yellow lamp that also indicates "ABS" failure and displays the symbol "ABS/RBS."*

- (7) If a separate indicator is provided for any other function, the display shall include the word "**Brake**" and appropriate additional labeling.

15. INSTRUCTIONS FOR COMPLETING DATA SHEETS

Data is to be furnished in every data blank provided on the report forms, or if not applicable, insert "NA". Corrections are to be made by drawing a line through the data, leaving it legible and adding the correct entry, initials, and date.

Record any unusual brake performance, such as pull, noise, smoke, wrap-up, or skid, that occurs during the testing.

Every sheet of any document relating to a test, including automatic continuous recorder data, will contain the NHTSA number of the vehicle, date, vehicle, and test identification.

NOTE: Average Pedal Force and Average Deceleration are calculated from the initiation of the pedal force until completion of the stop. (60 FR 6434, Feb. 2, 1995, page 6431)

NOTE: The exact target speeds specified for each test will, in most cases, not be achievable. As a result, all actual stopping distances are to be adjusted to represent the distances that would have been obtained had the exact test speed been achieved. These corrected distances are calculated using the Society of Automotive Engineers, Inc., "Stopping Distance Test Procedure – SAE J299", where the following expression is derived:

$$\text{Corrected stopping distance} = \frac{[(\text{Target initial speed})^2 / (\text{Actual initial test speed})^2] \times \text{Actual stopping distance}}{1}$$

16. POST TEST REQUIREMENTS

After the required tests are completed, the contractor shall:

Verify all instrumentation, test data records and photographs;

Restore the vehicle to its original configuration, if necessary;

Complete the Vehicle Condition Report form including word description of the vehicle's post test condition;

Move the test vehicle to a secure area; and

Place all original records in a secure and organized file awaiting test data disposition.

17. REPORTS

17.1 Monthly Status Reports

The contractor shall submit a monthly Test Status Report and a Vehicle Status Report to the FMVSS 135 COTR. The Vehicle Status report shall be submitted until all FMVSS 135 vehicles are transferred to another FMVSS or otherwise disposed of. Samples of the required reports are found in the report forms section.

17.2 Apparent Test Failure

Any indication of an test failure shall be communicated by telephone or to the COTR within 24 hours with written notification mailed within 48 hours (Saturday and Sunday hours excluded). A Notice of Test Failure (see report forms section) with a copy of the particular compliance test data sheet(s) and preliminary data plot(s) shall be included.

If possible, repeat that portion of the test where the failure was noted to ensure that there is a test failure.

In the event of a test failure, a post test calibration check of some critically sensitive test equipment and instrumentation (if applicable) may be required for verification of accuracy. The necessity for the calibration shall be at the COTR's discretion and shall be performed without additional costs to the OVSC.

17.3 Final Test Reports

17.3.1 Copies

In the case of an apparent test failure, 7 copies of the Final Test Report shall be submitted to the COTR for acceptance within 3 weeks of test completion.

Where there has been no indication of an apparent noncompliance, 3 copies of each Final Test Report shall be submitted to the COTR for acceptance within 3 weeks of test completion. No payment of contractor's invoices for conducting compliance tests will be made prior to the Final Test Report acceptance by the COTR. Contractors are requested to NOT submit invoices before the COTR is provided with copies of the Final Test Report.

Contractors are required to submit the first Final Test Report in draft form within 1 week after the compliance test is conducted. The contractor and the COTR will then be able to discuss the details of both test conduct and report content early in the compliance test program.

Contractors are required to PROOF READ all Final Test Reports before submittal to the COTR. The OVSC will not act as a report quality control office for contractors. Reports containing a significant number of errors will be returned to the contractor for correction, and a "hold" will be placed on invoice payment for the particular test.

17.3.2 Requirements

The Final Test Report, associated documentation (including photographs), are relied upon as the chronicle of the compliance test. The Final Test Report will be released to the public domain after review and acceptance by the COTR. For these reasons, each final report must be a complete document capable of standing by itself.

The contractor should use **detailed** descriptions of all compliance test events. Any events that are not directly associated with the standard but are of technical interest should also be included. The contractor should include as much **detail** as possible in the report.

Instructions for the preparation of the first three pages of the final test report are provided for standardization.

17.3.3 First Three Pages

A. FRONT COVER

A heavy paperback cover (or transparency) shall be provided for the protection of the final report. The information required on the cover is as follows:

- (1) Final Report Number such as 135-ABC-0X-001 where
 135 is the FMVSS tested
 ABC are the initials for the laboratory
 0X is the Fiscal Year of the test program
 001 is the Group Number (001 for the 1st test,
 002 for the 2nd test, etc.)
- (2) Final Report Title And Subtitle such as

COMPLIANCE TESTING FOR FMVSS 135
 Light Vehicle Brake Systems

XYZ Motor Co.
 200X Deluxe 4-door sedan
 NHTSA No. CX0101

- (3) Contractor's Name and Address such as

ABC TESTING LABORATORIES, INC.
4335 West Dearborn Street
Detroit, Michigan 48090

NOTE: DOT SYMBOL WILL BE PLACED BETWEEN ITEMS (3) AND (4)

- (4) Date of Final Report completion
- (5) The words "**FINAL REPORT**"
- (6) The sponsoring agency's name and address as follows

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Enforcement
Office of Vehicle Safety Compliance
400 Seventh Street, SW
Room 6115 (NVS-220)
Washington, DC 20590

B. FIRST PAGE AFTER FRONT COVER

A disclaimer statement and an acceptance signature block for the COTR shall be provided as follows:

This publication is distributed by the U. S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' names or products are mentioned, it is only because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

Prepared By: _____

Approved By: _____

Approval Date: _____

FINAL REPORT ACCEPTANCE BY OVSC:

Accepted By: _____

Acceptance Date: _____

- C. **SECOND PAGE AFTER FRONT COVER**
A completed Technical Report Documentation Page (Form DOT F1700.7) shall be completed for those items that are applicable with the other spaces left blank. Sample data for the applicable block numbers of the title page follows.

Block 1 — REPORT NUMBER

135-ABC-0X-001

Block 2 — GOVERNMENT ACCESSION NUMBER

Leave blank

Block 3 — RECIPIENT'S CATALOG NUMBER

Leave blank

Block 4 — TITLE AND SUBTITLE

Final Report of FMVSS 135 Compliance Testing of 200X XYZ
Deluxe 4-door sedan, NHTSA No. CX0101

Block 5 — REPORT DATE

March 1, 200X

Block 6 — PERFORMING ORGANIZATION CODE

ABC

Block 7 — AUTHOR(S)

John Smith, Project Manager / Bill Doe, Project Engineer

Block 8 — PERFORMING ORGANIZATION REPORT NUMBER

ABC-DOT-XXX-001

Block 9 — PERFORMING ORGANIZATION NAME AND ADDRESS

ABC Laboratories
4335 West Dearborn Street
Detroit, Michigan 48090

Block 10 — WORK UNIT NUMBER

Leave blank

Block 11 — CONTRACT OR GRANT NUMBER

DTNH22-9X-D-12345

Block 12 — SPONSORING AGENCY NAME AND ADDRESS

US Department of Transportation
National Highway Traffic Safety Administration
Enforcement
Office of Vehicle Safety Compliance
400 Seventh Street, SW, Room 6115 (NVS-220)
Washington, DC 20590

Block 13 — TYPE OF REPORT AND PERIOD COVERED

Final Test Report
Feb. 15 to Mar. 15, 200X

Block 14 — SPONSORING AGENCY CODE

NVS-220

Block 15 — SUPPLEMENTARY NOTES

Leave blank

Block 16 — ABSTRACT

Compliance tests were conducted on the subject 200X XYZ Deluxe 4-door sedan in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No. TP-135-0X for the determination of FMVSS 135 compliance.

Test failures identified were as follows:

None

NOTE: Above wording must be shown with appropriate changes made for a particular compliance test. Any questions should be resolved with the COTR.

Block 17 — KEY WORDS

Compliance Testing
Safety Engineering
FMVSS 135

Block 18 — DISTRIBUTION STATEMENT

This report is available via NHTSA's web site. Search www.nhtsa.dot.gov/cars/problems/comply/ for the HS# and then input this number into (<http://www-odi.NHTSA.dot.gov/tis/index.cfm>) for the report.

Copies of this report are also available from —

NHTSA Technical Information Services (TIS)
Mail Room: 2336 (NPO-405)
Visitors Room: PL403
400 Seventh St., SW
Washington, DC 20590
Telephone No.: 202-366-4947

Block 19 — SECURITY CLASSIFICATION OF REPORT

Unclassified

Block 20 — SECURITY CLASSIFICATION OF PAGE

Unclassified

Block 21 — NUMBER OF PAGES

Add appropriate number

Block 22 — PRICE

Leave blank

17.3.4 Table of Contents

Final test report Table of Contents shall, at a minimum, include the following:

Section 1 — Purpose of Compliance Test

Section 2 — Test Procedure and Summary of Results

Section 3 — Compliance Test Data Sheets

Section 4 — Noncompliance Data (if applicable)

Section 5 — Photographs

Section 6 — Test Equipment List and Calibration Information

18. DATA SHEETS

**DATA SHEET 1
VEHICLE INFORMATION**

MAKE/MODEL/BODY STYLE:

MODEL YEAR: _____ ; MANUFACTURE DATE: _____

NHTSA NO.: _____ ; VIN: _____

GVWR: _____ ; WHEELBASE: _____

GAWR FRONT: _____ ; GAWR REAR: _____

FOR BUSES ONLY –

CHASSIS MFR.: _____

SERIAL NO.: _____ ; NO. OF SEATS: _____

MANUFACTURE DATE: _____

ENGINE TYPE: _____ ; DISPLACEMENT: _____

ENGINE HORSEPOWER: _____ ; IDLE SPEED: _____

TRANSMISSION TYPE: _____ ; NO. OF AXLES: _____

ELECTRIC VEHICLE: _____ ; *HYBRID VEHICLE:* _____

TIRE SIZE: _____ ; TYPE: _____

TIRE MANUFACTURER: _____

RECOMMENDED PRESS. AT GVWR: FRONT - _____ kPa ; REAR - _____ kPa

BRAKES - FRONT: DRUM _____ DISC _____

BRAKES - REAR: DRUM _____ DISC _____

BRAKE ACTUATION - Describe Hydraulic Circuit Split:

FOUNDATION BRAKES :

HYDRAULIC _____ ; *ELECTRIC* _____ ; SPLIT _____*ELECTRICALLY-ACTUATED SERVICE BRAKES:* YES__ NO__*ELECTRIC TRANSMISSION OF SERVICE BRAKE CONTROL SIGNAL:* YES__ NO__*REGENERATIVE BRAKING SYSTEM (RBS):* YES__ NO__

RBS PART OF SERVICE BRAKE SYSTEM: YES__ NO__

BRAKE POWER UNIT: __ Hydraulic ; __ Vacuum ; __ Other__

BRAKE POWER ASSIST UNIT: YES_____ NO_____

BRAKE POWER UNIT WITH ACCUMULATOR: _____

BRAKE POWER ASSIST OR POWER UNIT WITH BACKUP: _____

VARIABLE PROPORTIONING SYSTEM: _____

ANTISKID DEVICE: MFR- _____

DIRECTLY CONTROLLED WHEELS:

PARKING MECHANISM: _____

DESCRIBE - _____

BRAKE MASTER CYLINDER DIAMETER: _____

BRAKE PEDAL RATIO: _____

FRONT BRAKE COMPONENT MATERIALS AND CONSTRUCTION:

FOR DRUM BRAKES				FOR DISC BRAKES			
	MATERIAL		CONSTRUCTION		MATERIAL		CONSTRUCTION
	Cast Iron		Cast		Cast Iron		Integral Cast
	Steel		Composite		Steel		2-Piece
	Bi-Metallic		Centrifused		Bi-Metallic		Vented
			Pressed				Unvented

FRONT BRAKE DIAMETER: Inside - _____ ; Outside - _____

FRONT DISC BRAKE THICKNESS (include vent): _____

FRONT DRUM BRAKE SHOE CAGE DIA.: Left - _____ ; Right - _____
 DIAMETER RESET TO: Left - _____ ; Right - _____

FRONT BRAKE COMPONENT DIMENSIONS AND LINING CODE/COLOR:

	FOR DRUM BRAKES		FOR DISC BRAKES	
WIDTH	Primary		Inboard	
	Secondary		Outboard	
LENGTH	Primary		Inboard	
	Secondary		Outboard	
THICKNESS	Primary		Inboard	
	Secondary		Outboard	
CODE/COLOR	Primary *		Inboard	
	Secondary *		Outboard	

* Primary/Secondary may be leading/trailing or other

HYDRAULIC PISTON DIAMETER: _____

DRUM BRAKE WHEEL CYLINDER - _____

DISC BRAKE CALIPER - _____

REAR BRAKE COMPONENT MATERIALS AND CONSTRUCTION:

FOR DRUM BRAKES				FOR DISC BRAKES			
	MATERIAL		CONSTRUCTION		MATERIAL		CONSTRUCTION
	Cast Iron		Cast		Cast Iron		Integral Cast
	Steel		Composite		Steel		2-Piece
	Bi-Metallic		Centrifused		Bi-Metallic		Vented
			Pressed				Unvented

REAR BRAKE DIAMETER: Inside - _____ ; Outside - _____

REAR DISC BRAKE THICKNESS (include vent): _____

REAR DRUM BRAKE SHOE CAGE DIA.: Left - _____ ; Right - _____
 DIAMETER RESET TO: Left - _____ ; Right - _____

REAR BRAKE COMPONENT DIMENSIONS AND LINING CODE/COLOR:

	FOR DRUM BRAKES		FOR DISC BRAKES	
WIDTH	Primary		Inboard	
	Secondary		Outboard	
LENGTH	Primary		Inboard	
	Secondary		Outboard	
THICKNESS	Primary		Inboard	
	Secondary		Outboard	
CODE/COLOR	Primary *		Inboard	
	Secondary *		Outboard	

* Primary/Secondary may be leading/trailing or other

HYDRAULIC PISTON DIAMETER: _____

DRUM BRAKE WHEEL CYLINDER - _____
 DISC BRAKE CALIPER - _____

OTHER COMPONENT INFORMATION:

Friction-type Parking Brake - _____ Hand Operated

_____ Foot Operated

Nonservice Brake Type Parking Brake - _____ Hand Operated

_____ Foot Operated

ELECTRIC BRAKES INFORMATION: _____

NOTE (do not include this note in final report): If at any time after the test series has begun, any brake system part requires replacement or the brake system requires adjustments other than permitted in burnish and reburnish procedures, discontinue testing and notify the COTR immediately.

**DATA SHEET 2
SUMMARY OF TESTING (Sample)**

VEHICLE: _____
DATE: _____

NHTSA NO.: _____

TEST	Loading Condition	Specification and Limit				TEST RESULTS - SHORTEST STOP (In compliance if one stop meets requirement)			
		Speed (km/h)	Min. Pedal Force (N)	Max. Pedal Force (N)	Stopping Distance Requirement (m)	After ramp up, Min. pedal force remains above specified value	Max. Pedal Force (N)	Stopping Distance (m)	PASS Fail
Vehicle Maximum Speed	LLVW					-			
Burnish	GVWR					-			
Wheel Lockup Sequence w/o ABS	GVWR				Lockup of front wheels prior to rear				
Wheel Lockup Sequence w/o ABS	LLVW								
Adhesion Utilization w/o ABS	LLVW				Rear axle adhesion utilization curve below specified value				
Adhesion Utilization w/o ABS	GVWR								
Cold Effectiveness	GVWR	100	65	500	70 m				
High Speed Effectiveness	GVWR		65	500	speed dependant				
Stops with Engine Off	GVWR	100	65	500	70 m				
Cold Effectiveness	LLVW	100	65	500	70				
High Speed Effectiveness	LLVW		65	500	speed dependant				
Failed Antilock	LLVW	100	65	500	85				
Failed Proportioning Valve	LLVW	100	65	500	110				
Failed Hydraulic Circuit #1 *	LLVW	100	65	500	168				
Failed Hydraulic Circuit #2	LLVW	100	65	500	168				
Failed Hydraulic Circuit #1 *	GVWR	100	65	500	168				
Failed Hydraulic Circuit #2	GVWR	100	65	500	168				
Failed Antilock	GVWR	100	65	500	85				
Failed Proportioning Valve	GVWR	100	65	500	110				
Power Brake Unit Failure *	GVWR	100	65	500	168				
Parking Brake - Uphill	GVWR	-	-	-	-				
Parking Brake - Downhill	GVWR	-	-	-	-				
Heating Snubs	GVWR								
Hot Performance Stop #1	GVWR	100	65						
Hot Performance Stop #2	GVWR	100	65	500	89				
Recovery Performance Stop #1	GVWR	100	65						
Recovery Performance Stop #2	GVWR	100	65						
Final Inspection-Brake Integrity									
Final Inspection- Reservoirs/Warning Indicators Equipment Requirements	Specified Requirements and Equipment								

* **NOTE: May be additional requirements for Electric Vehicles or vehicles utilizing electrically-actuated brakes, electric brake signal, and RBS.**

**DATA SHEET 3
VEHICLE WEIGHT**

VEHICLE: _____ ; NHTSA NO.: _____ ; DATE: _____

TIRE PRESSURE (Cold): Front - _____ kPa Rear - _____ kPa

ODOMETER READING: Start - _____ Finish - _____

SCALE(S) USED: _____

NOTE: GVWR, LLVW and axle weights to measured within + 0% and -1%.

GVWR/GAWR INFORMATION (taken from vehicle Certification Label):

GVWR - _____ kg (GAWR Front = _____ kg and GAWR Rear = _____ kg)

UNLOADED VEHICLE WEIGHT (**UVW**):

Left Front - _____ kg Left Rear - _____ kg

Right Front - _____ kg Right Rear - _____ kg

Total Front - _____ kg Total Rear - _____ kg

TOTAL **UVW** - _____ kg

Front Axle Load % = Total Front / TOTAL **UVW** = _____ %

Rear Axle Load % = Total Rear / TOTAL **UVW** = _____ %

LIGHT LOADED VEHICLE WEIGHT (**LLVW**):

Note 1: LLVW = UVW + 400 lb (181 kg)

Note 2: Weight distributed in front passenger seat area

Note 3: Neither axle load at LLVW less than at UVW; ballast as required

Left Front - _____ kg Left Rear - _____ kg

Right Front - _____ kg Right Rear - _____ kg

(Continued on next page)

Total Front - _____ kg Total Rear - _____ kg

TOTAL **LLVW** - _____ kg

Front Axle Load % = Total Front / TOTAL **LLVW** = _____ %

Rear Axle Load % = Total Rear / TOTAL **LLVW** = _____ %

ACTUAL TEST LLVW:

Left Front - _____ kg Left Rear - _____ kg

Right Front - _____ kg Right Rear - _____ kg

Total Front - _____ kg Total Rear - _____ kg

TOTAL ACTUAL TEST LLVW - _____ kg

Front Axle Load % = Total Front / TOTAL ACTUAL TEST LLVW = _____ %

Rear Axle Load % = Total Rear / TOTAL ACTUAL TEST LLVW = _____ %

Load: Driver/Observer-_____kg + Instrumentation.-_____kg + Ballast-_____kg = 400 lbs (181kg)

FULLY LOADED VEHICLE WEIGHT (GVWR):

Note 1: Vehicle loaded so axle loads proportional to GAWR shown previously

Note 2: But no axle weight to be less than at LLVW

Note 3: If weight on any axle at LLVW exceeds the axle's proportional share of the GVWR, the load required to reach GVWR is placed so that the weight on that axle remains the same as at LLVW. Neither axle load at LLVW **LESS THAN** at UDW.

Load: Driver/Observer-_____kg + Instrumentation.-_____kg + Ballast-_____kg = _____ kgs

Left Front - _____ kg Left Rear - _____ kg

Right Front - _____ kg Right Rear - _____ kg

Total Front - _____ kg Total Rear - _____ kg

(Continued on next page)

FULLY LOADED VEHICLE WEIGHT (GVWR) - _____ kg

Front Axle Load % = Total Front / FULLY LOADED VEH. WT. (GVWR) = _____ %

Rear Axle Load % = Total Rear / FULLY LOADED VEH. WT. (GVWR) = _____ %

Comments:

TECHNICIAN: _____ ; QUALITY ASSURANCE: _____

APPROVING LAB. OFFICIAL: _____ DATE: _____

**DATA SHEET 4
MAXIMUM SPEED**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

Establish vehicle maximum speed

VEHICLE LOAD: LLVW
 GEAR: Drive
 PEDAL FORCE: Not applicable
 TEST SPEED: Maximum attainable from a standing start in 3.2 km.
 IBT: Not applicable
 DECEL RATE: Not applicable
 WHEEL LOCKUP: Not applicable
 INTERVAL: Not applicable

Ballast vehicle to LLVW

Accelerate at a maximum rate from a standing start for a distance of 3.2 km on a level surface.

Repeat in opposite direction.

Record speed attained in each direction and use the average of the two runs.

	DIRECTION	MAX. SPEED (km/h)		Time 0-100 km/h
		Visual	Recorded	
Run No. 1				
Run No. 2				

Average = _____ km/h

Tested by: _____

Date: _____

DATA SHEET 5
14.1 BURNISH (S7.1)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

TEST WEIGHT: Total = _____ kg; Front = _____ kg ; Rear = _____ kg

VEHICLE LOAD: GVWR

GEAR: Drive

PEDAL FORCE: Adjust as necessary to maintain constant decel rate.

TEST SPEED: 80 km/h to 0

IBT: $\leq 100^{\circ}\text{C}$ (Record temperatures 0.32 km before stop)

DECEL RATE: 3.0 m/s^2

WHEEL LOCKUP: None longer than 0.1 seconds at speeds $> 15 \text{ km/h}$.

INTERVAL: 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.

Comments:

BURNISH

RECORDED DATA

STOP NO.	Initial SPEED (KM/H)	INITIAL BRAKE TEMPERATURE (C) (Secondary Shoe or Hottest Pad)				MAX. PEDAL FORCE (N)	AVG. PEDAL FORCE (N)	AVERAGE SUSTAINED DECELERATIO N (m/s ²)	COMMENTS
		LF	RF	LR	RR				
1									
10									
20									
30									
40									
50									
60									
70									
80									
90									
100									
110									
120									
130									
140									
150									
160									
170									
180									
190									
200									

Comments:

Driver: _____ Date: _____

Brake Adjustment (Post Burnish)

Adjust to manufacturer's published recommended practice

Record method used: _____

Adjusted by: _____ Date _____

DATA SHEET 6
14.2 WHEEL LOCK SEQUENCE @ GVWR (S7.2)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER. FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S7.2 Wheel Lockup Sequence:

NOTE: Wheel lockup sequence is **NOT** an S135 compliance requirement for ABS equipped vehicles.

NOTE: Vehicles that lock their front axle simultaneously or at lower deceleration rates than their rear axle need not be tested to the torque wheel procedure.

S7.2.2 Vehicle Conditions:

- A. Vehicle load: GVWR
- B. Transmission Position: Neutral

S7.2.3 Test Conditions and Procedures

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEEDS:

65 km/h for braking ratio $\leq .50$, 100 km/h for braking ratio $> .50$

PEDAL FORCE:

Is increased at a linear rate such that the first axle lockup occurs no less than 0.5 second and no more than 1.5 seconds after the initial application of the pedal.

The pedal is released when the second axle locks, or when the pedal force reaches 1 kN (225 lbs), or 0.1 seconds after first axle lockup, whichever occurs first.

WHEEL LOCKUP:

Only wheel lockups above a vehicle speed of 15 km/h are considered in determining the results of this test.

TEST SURFACES:

Each loading condition on two different test surfaces, resulting in a braking ratio of between 0.15 and 0.80.

TEST PROCEDURE:

Each test surface, three runs meeting pedal and time for wheel lockup requirements. Six (6) runs allowed to obtain 3 valid runs.

S7.2.4 PERFORMANCE REQUIREMENTS:

Meets test requirements on all test surfaces.

All 3 valid runs on each test surface result in front axle locking before or simultaneously with rear axle.

An EV with RBS that is part of the service brake system shall meet the performance requirements over the entire normal operating range of the RBS. If the RBS contribution to braking varies according to vehicle speed, deceleration, etc. then the worst case must be determined i.e. where RBS provides limited braking, and the test conducted at this condition at a minimum.

Comments:

WHEEL LOCK SEQUENCE @ GVWR

RECORDED DATA

Stop No.	IBT Front/Rear	Braking Ratio	Initial Vehicle Speed	Pedal Force Rate (N/Sec)	Vehicle Deceleration & Pedal Force @ Time of each Wheel at Lockup				RESULT Front/Rear Lockup
					LF	RF	LR	RR	
Test Surface PFC_____									
1									
2									
3									
4									
5									
6									
Test Surface PFC_____									
1									
2									
3									
4									
5									
6									

Data indicates compliance: YES _____ NO _____

Comments:

Driver: _____

Observer: _____

Date: _____

**DATA SHEET 7
14.3 WHEEL LOCK SEQUENCE @ LLVW(S7.2)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 15.2 WITH VEHICLE LOAD AT LLVW

WHEEL LOCKUP SEQUENCE @ LLVW

RECORDED DATA

Stop No.	IBT Front/Rear	Braking Ratio	Initial Vehicle Speed	Pedal Force Rate (N/Sec)	Vehicle Deceleration & Pedal Force @ Time of each Wheel at Lockup				RESULT Front/Rear Lockup
					LF	RF	LR	RR	
Test Surface PFC _____									
1									
2									
3									
4									
5									
6									
Test Surface PFC _____									
1									
2									
3									
4									
5									
6									

Data indicates compliance: YES _____

NO _____

Comments:

Driver: _____

Observer: _____

Date: _____

DATA SHEET 8
14.5 ADHESION UTILIZATION (TORQUE WHEEL) @ LLVW (S7.4)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S7.4 Adhesion Utilization (Torque Wheel Method)

NOTE: Adhesion Utilization results are not an FMVSS 135 compliance requirement for ABS equipped vehicles.

S7.4.2 Vehicle Conditions:

A. Vehicle Load: LLVW

B. Transmission Position: In neutral

C. Tires:

For this test, a separate set of tires, identical to those used for all other sections of this test, may be mounted on torque wheels and used to complete this portion of test.

S7.4.3 Test Conditions and Procedures:

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEEDS: 100 km/h and 50 km/h

PEDAL FORCE:

100 km/h test speed —

Ramp apply between 100 and 150 N/sec apply rate until the first axle locks or a max. of 1000 N pedal force is reached, whichever occurs first.

50 km/h test speed —

Ramp apply between 100 and 200 N/sec apply rate until the first axle locks or a max. of 1000 N pedal force is reached, whichever occurs first.

COOLING:

Between brake applications, drive at speeds up to 100 km/h until IBT is reached.

NUMBER OF RUNS:

5 Stops from 50 km/h and 5 stops from 100 km/h, alternating between speeds after each stop.

TEST SURFACE: PFC of at least 0.9

DATA TO BE RECORDED:

Vehicle speed Pedal Force

Wheel Velocity Deceleration

Brake Torque at each wheel, and hydraulic line pressure in each brake circuit (at least one front wheel and one rear wheel downstream of the proportioning valve).

Sampling Rate:

10 HZ on temperature channels — 100 HZ on all other channels

Performance Criteria – Data below line as shown in figure 2 on page 36. For an EV with RBS, meets requirement over entire range of RBS operation.

RECORDED DATA

STOP NO.	Speed (km/h)		Maximum Pedal Force (N)	Wheel Velocity at Lockup (km/h)				Max. Decel (m/s ²)	Rate of Apply (N/s)	Brake Torque at each wheel	Brake Line Press. in each brake circuit	Comments
	Target	Actual		LF	RF	LR	RR					
1	100											
2	50											
3	100											
4	50											
5	100											
6	50											
7	100											
8	50											
9	100											
10	50											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

**DATA SHEET 9
14.6 ADHESION UTILIZATION (TORQUE WHEEL) @ GVWR (S7.4)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.5 WITH VEHICLE LOAD AT GVWR

RECORDED DATA

STOP NO.	Speed (km/h)		Maximum Pedal Force (N)	Wheel Velocity at Lockup (km/h)				Max. Decel (m/s ²)	Rate of Apply (N/s)	Brake Torque at each wheel	Brake Line Press. in each brake circuit	Comments
	Target	Actual		LF	RF	LR	RR					
1	100											
2	50											
3	100											
4	50											
5	100											
6	50											
7	100											
8	50											
9	100											
10	50											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 10
14.7 COLD EFFECTIVENESS @ GVWR (S7.5)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S.7.5.1 Vehicle conditions:

- A. Vehicle Load: GVWR
- B. Transmission Position: Neutral

S.7.5.2 Test Conditions and Procedures

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP: No lockup of any wheel for longer than 0.1 seconds at speeds greater than 15 km/h

NUMBER OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9

WIND SPEED: Not greater than 5 m/s

S.7.5.3 Performance Requirements

Sc for hot performance stop = _____

*STOPPING DISTANCE: ≤70 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

$S \leq 0.10V + 0.0060V^2$ (Stopping Distance formula for vehicles with top speed of <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 11
14.8 HIGH SPEED EFFECTIVENESS @ GVWR (S7.6)
(Not required if vehicle maximum speed is ≤ 125 km/h)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S.7.6.1 Vehicle conditions:

- A. Vehicle Load: GVWR
- B. Transmission Position: In Drive

S.7.6.2 Test Conditions and Procedures:

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 80 % of vehicle maximum speed but not greater than 160 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP: No lockup of any wheel for longer than 0.1 seconds at speeds greater than 15 km/h

NUMBER OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9

WIND SPEED: Not greater than 5 m/s

S.7.6.3 Performance Requirements

STOPPING DISTANCE: $S \leq 0.10V + 0.0067V^2$

Calculated distance = _____ m

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 12
14.9 STOPS WITH ENGINE OFF @ GVWR (S7.7)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S7.7.1 General Information:

This test is for vehicles equipped with one or more brake power or assist units.

S7.7.2 Vehicle Conditions

- A. Vehicle Load: GVWR only
- B. Transmission Position: In Neutral
- C. Vehicle Engine: Off (not running)
- D. Ignition Key Position:
May be returned to "on" position after turning engine off.

S.7.7.3 Test Conditions and Procedures:

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

NOTE: All system reservoirs (brake power and / or assist units) are fully charged and the vehicle's engine is off (not running) at the beginning of each stop.

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:

No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NUMBER OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9

WIND SPEED: Not greater than 5 m/s

S.7.7.4 Performance Requirements:

*STOPPING DISTANCE: ≤70 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0060V^2$ (Stopping Distance formula for vehicles with top speed <100 km/h)

For EV – describe method used to disable electric power to the vehicle propulsion motor(s) if applicable: _____

Data Indicates Compliance: YES _____ NO _____

DRIVER: _____ OBSERVER: _____

DATE: _____

**DATA SHEET 13
14.10 COLD EFFECTIVENESS @ LLVW (S7.5)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.7 WITH VEHICLE AT LLVW

S.7.5.3 Performance Requirements:

Sc for hot performance stop = _____

Avg. PF for hot performance stop = _____

*STOPPING DISTANCE: ≤70 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0060V^2$ (Stopping Distance formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 14
14.11 HIGH SPEED EFFECTIVENESS @ LLVW (S7.6)
(Not required if vehicle maximum speed is ≤125 km/h)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.8 WITH VEHICLE AT LLVW

S.7.6.3 Performance Requirements:

STOPPING DISTANCE: $S \leq 0.10V + 0.0067V^2$

Calculated distance = _____ m

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 15
14.12 ANTILOCK FUNCTIONAL FAILURE @ LLVW (S7.8)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

S7.8.1 Vehicle Conditions:

- A. Vehicle Load: LLVW
- B. Transmission Position: In Neutral

S.7.8.2 Test Conditions and Procedures:

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:

No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NO. OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9

WIND SPEED: Not greater than 5 m/s

FAILURE SIMULATION:

- A. Disconnect the functional power source, or any electrical connector that creates a functional failure.

Record method used to induce failure: _____

B. Brake system indicator light activated? YES ___ NO ___

C. Restore the system to normal at the completion of this test.

NOTE: If more than one antilock brake subsystem is provided, repeat test for each subsystem.

S.7.8.3 Performance Requirements:

*STOPPING DISTANCE: ≤85 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0075V^2$ (Stopping Distance formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES ___ NO ___

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 16
14.13 Variable Brake Proportioning System Functional Failure @ LLVW(S7.9)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

Is vehicle equipped with variable proportioning? Yes ____ No ____

If "No", skip this section and continue to section S7.10.1

S.7.9.1 Vehicle Conditions

- A. Vehicle Load: LLVW
- B. Transmission Position: In Neutral

S.7.9.2 Test Conditions and Procedures:

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:

No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NUMBER OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9

WIND SPEED: Not greater than 5 m/s

FAILURE SIMULATION:

- A. Disconnect the functional power source or mechanical linkage to render the variable brake proportioning system inoperative.

Record method used to induce failure: _____

- B. Brake system indicator light activated? Yes ___ No ___
- C. Restore the system to normal at the completion of this test.

NOTE: If more than one variable brake proportioning subsystem is provided, repeat the test for each subsystem.

S.7.9.3 Performance Requirements:

*STOPPING DISTANCE: ≤110 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES ___ NO ___

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 17
14.14 HYDRAULIC CIRCUIT FAILURE # 1 @ LLVW (S7.10)
& FAILED ELECTRICALLY TRANSMITTED SIGNAL
& FAILED RBS

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S.7.10 Hydraulic Circuit Failure CIRCUIT NO. 1
 Or Failed Brake Signal or Failed RBS

S.7.10.1 General Information: This test is for vehicles manufactured with a split service brake system. *It is also for failed electric brake signal and **failed RBS**.*

- S.7.10.2 Vehicle Conditions:
- A. Vehicle Load: LLVW
 - B. Transmission Position: In Neutral

S.7.10.3 Test Conditions and Procedures:
 NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

IBT: ≥65°C, ≤100°C

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:
 No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NUMBER OF RUNS: 4 stops

TEST SURFACE: PFC of 0.9
 WIND SPEED: Not greater than 5 m/s

FAILURE SIMULATION (for hydraulic circuit, *electronic brake signal*, *failed ABS*):

Method of simulating failure: _____

System Portion Failed: _____

Determine the control force pressure level (differential pressure between intact and failed subsystem) or fluid level drop, necessary to activate the brake warning indicator.

- A. Differential pressure to activate light: _____ , or
- B. Fluid level required to activate light: _____
Make stops after the brake warning indicator has been activated.
- C. *For failed electric brake signal or failed RBS, warning indicators activated:* _____
- D. Restore the system to normal at the completion of this test.

S.7.10.4 Performance Requirements:

*STOPPING DISTANCE: ≤168 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

DRIVER: _____ OBSERVER: _____

DATE: _____

DATA SHEET 18
14.14 HYDRAULIC CIRCUIT FAILURE # 2 @ LLVW (S7.10)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.14 With Hydraulic Circuit #2 Failure

S.7.10.4 Performance Requirements:

*STOPPING DISTANCE: ≤168 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

**DATA SHEET 19
 14.15 HYDRAULIC CIRCUIT FAILURE #1 @ GVWR (S7.10)
 & FAILED ELECTRICALLY TRANSMITTED SIGNAL
 & FAILED RBS**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.14 With Hydraulic Circuit #1 Failure @ GVWR

S.7.10.4 Performance Requirements:

*STOPPING DISTANCE: ≤168 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____ OBSERVER: _____

DATE: _____

DATA SHEET 20
14.15 HYDRAULIC CIRCUIT FAILURE # 2 @ GVWR (S7.10)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

REPEAT 14.14 With Hydraulic Circuit #2 Failure @ GVWR

S.7.10.4 Performance Requirements:

*STOPPING DISTANCE: ≤168 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Distance formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____ OBSERVER: _____

DATE: _____

**DATA SHEET 21
14.16 ANTILOCK FUNCTIONAL FAILURE @ GVWR (S7.8)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

REPEAT 14.12 WITH VEHICLE AT GVWR

S.7.8.3 Performance Requirements:

*STOPPING DISTANCE: ≤85 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

* $S \leq 0.10V + 0.0075V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES ____ NO ____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 22
14.17 Variable Brake Proportioning System Functional Failure @ GVWR(S7.9)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

Repeat 14.13 with vehicle at GVWR

S.7.9.3 Performance Requirements:

*STOPPING DISTANCE: ≤110 m from 100 km/h speed

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 23
14.18 Power Brake Unit or Brake Power Assist Unit
Inoperative @ GVWR (System Depleted) (S7.11)
& Electrical failure in the electrically-actuated service brakes

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

S7.11.1 General Information:

This test is for vehicles equipped with one or more brake power units or brake power assist units. *It is also for electrical failure in the electrically-actuated service brakes.*

S7.11.2 Vehicle Conditions:

- A. Vehicle Load: GVWR
- B. Transmission Position: In Neutral

S7.11.3 Test Conditions and Procedures:

NOTE: STOP IN SHORTEST DISTANCE ACHIEVABLE (BEST EFFORT) ON ALL STOPS.

IBT: ≥65°C, ≤100°C

TEST SPEED: 100 km/h

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:
 No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NUMBER OF RUNS: 6 stops

TEST SURFACE: PFC of 0.9
 WIND SPEED: Not greater than 5 m/s

FAILURE SIMULATION:

Disconnect the primary source of power or *fail electrically-actuated service brakes.*

(Deplete all reserve power capability.)

Method of rendering inoperative_____

Restore the system to normal at the completion of this test. Repeat test for other power unit if vehicle has more than one.

S7.11.4 Performance Requirements:

*STOPPING DISTANCE: ≤168 m

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											
5											
6											

* $S \leq 0.10V + 0.0100V^2$ (Stopping Dist. formula for vehicles with top speed <100 km/h)

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

**14.18A - DATA SHEET 23A
ELECTRICALLY - ACTUATED BRAKES
POWERED BY AUXILIARY BATTERIES (S6.3.12)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

ELECTRICALLY – ACTUATED BRAKES POWERED BY AUXILIARY BATTERIES

GVWR, 10 stops, Neutral, 100 kph or Max. speed – whichever is less
Auxiliary batteries depleted (5% charge above light illumination),

Condition (a), (b), or (c) per S6.3.12 _____

IBT: $\geq 65^{\circ}\text{C}$, $\leq 100^{\circ}\text{C}$

TEST SPEED: 100 km/h or Max. Speed (whichever is less)

PEDAL FORCE: 65 N minimum to 500 N maximum

WHEEL LOCKUP:

No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

Performance Requirement: 2 stops max. 70 meters

Stop No.	Initial Brake Temperature, C		Speed (kph)	Stopping Distance (meters)	MAX. Pedal Force (n)	MAX. Decel. (mpsps)	Wheel Lockup Above 16 kph	Dir. Of Stop	Stay in Lane	Battery State Of Charge %	AVG. Pedal Force (n)	AVG. Decel. (mpsps)
	Front Avg. L/R	Rear Avg. L/R										
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Brake warning Light Operation: On - _____ Off - _____ (for aux. battery. discharge)

DATA INDICATES COMPLIANCE: Yes - _____ ; No - _____ ; No Requirements - _____

DRIVER: _____ ; OBSERVER: _____

RECORDED DATA PROCESSED BY: _____ DATE: _____

APPROVING LAB. OFFICIAL: _____ DATE: _____

DATA SHEET 24
14.19 PARKING BRAKE @ GVWR (S7.12)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = _____ kg; Front = _____ kg; Rear = _____ kg

Parking Brake: Hand Control? _____ Foot Control? _____ *Electrically-Actuated?* _____

S7.12.1 Vehicle Conditions:

- A. Vehicle Load: GVWR
- B. Transmission Position: In Neutral
- C. Parking Brake Burnish:

For vehicles with parking brake systems not utilizing the service brake friction elements, the friction elements of such systems are to be burnished prior to parking brake tests according to the manufacturer's published recommendations as furnished to the purchaser. If no recommendations are furnished, test the system in an un-burnished condition. If recommendations are furnished, record method used. _____

S7.12.2 Test Conditions and Procedures:

- A. Parking brake systems utilizing service brake friction materials.

 IBT: ≤100°C
 (No additional burnishing or artificial heating prior to the start of the parking brake test is allowed).
- B. Parking brake systems utilizing non-service brake friction materials.

 IBT: Ambient Temperature
 (No additional burnishing or artificial heating prior to the start of the parking brake test is allowed).

PEDAL FORCE:

Hand control: ≤ 400 N

Foot control: ≤ 500 N

Drive onto 20% grade. Apply service brake just enough to hold vehicle stationary, and shift to Neutral. Apply park brake to force of ≤ 400 N hand control and ≤ 500 N foot control.

Release service brake; If vehicle remains stationary, start the measurement of time. Terminate after 5 minutes. If vehicle is not held stationary, reapply service brake just enough to hold vehicle on the grade. Reapply the specified force to parking lever or pedal (without releasing ratchet mechanism).

Release service brake. If vehicle still doesn't hold, repeat application. If vehicle is not held stationary for 5 minutes after two re-applications, check with engineer for further instructions. Repeat test in the opposite direction.

Did parking brake indicator operate each time the parking brake was applied?

Yes _____ No _____

S7.12.3 Performance Requirements:

The parking brake must hold the vehicle stationary in both directions for 5 minutes.

Comments:

RECORDED DATA

		20% Grade - Uphill			20% Grade - Downhill		
		Initial Apply	1st Reapply	2nd Reapply	Initial Apply	1st Reapply	2nd Reapply
Service Brake Force to Hold Vehicle Stationary (N)							
Parking Brake Force Applied (N)							
Number of Clicks (Optional)							
Vehicle Stationary for 5 minutes?							
Initial Brake Temperature (°C)	Left						
	Right						
	Average						

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

DATA SHEET 25
14.20 HEATING SNUBS @ GVWR (S7.13)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

IBT: $\geq 55^{\circ}\text{C}$, $\leq 65^{\circ}\text{C}$.

Establish IBT before the first brake application. IBT before subsequent snubs are those occurring at the distance intervals.

TRANSMISSION POSITION: In gear

NUMBER OF SNUBS: 15

TEST SPEEDS:
The initial speed for each snub is 120 km/h or 80% of Vmax, whichever is slower. Each snub is terminated at one-half the initial speed.

DECELERATION RATE:
Maintain a constant deceleration rate of 3.0 m/s². Attain the specified deceleration within one second and maintain it for the remainder of the snub.

PEDAL FORCE:
Adjust as necessary to maintain the specified constant deceleration rate.

TIME INTERVAL:
Maintain an interval of 45 seconds between the start of brake applications (snubs).

NOTE 1: Accelerate as rapidly as possible to the initial test speed immediately after each snub.

NOTE 2: Immediately after the 15th snub, accelerate to 100 km/h and commence the hot performance test.

HEATING SNUBS

RECORDED DATA

NOTE: Modify as needed according to feasibility and instrumentation.

Snub No.	Max. Decel. Rate (m/s ²)	Avg. Decel. Rate (m/s ²)	Time Interval	Max. Pedal Force (N)	Avg. Pedal Force (N)	Brake Lining Temp. C				Speed (km/h)	Comments
						LF	RF	LR	RR		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER _____

OBSERVER _____

DATE: _____

**DATA SHEET 26
14.21 HOT PERFORMANCE @ GVWR (S7.14)**

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

S7.14 Hot Performance: GVWR

IBT: Temperature achieved at completion of heating snubs.

TRANSMISSION POSITION: In neutral

NUMBER OF RUNS: 2 stops

TEST SPEEDS: 100 km/h (62.1 mph). If vehicle is incapable of attaining 100 km/h, it is tested at the same speeds used for the cold effectiveness test.

PEDAL FORCE:

Stop No. 1: Average pedal force not greater than the average pedal force recorded during the shortest GVWR cold effectiveness stop.

AVG. Pedal force from cold effectiveness stop: _____ N

NOTE: To insure Average Pedal Force is not GREATER THAN the Average Pedal Force on shortest GVWR cold effectiveness stop, driver can observe instrument panel mounted real time pedal force gauge and maintain a force lower than the average value which must NOT be exceeded.

Stop No. 2: <500 N (112.4 lbs.)

WHEEL LOCKUP: No lockup of any wheel for longer than 0.1 seconds at speeds greater than 15 km/h

Relative and Absolute Performance Requirements:

- A. For the **1st** hot stop, the stopping distance must be less than or equal to a calculated distance which is based on 60 percent of the deceleration actually achieved on the shortest GVWR cold effectiveness stop. The following equations shall be used in calculating the performance requirement.

$$Dc = 0.0386V^2 / (Sc - 0.10V)$$

$$S = 0.10V + (0.0386V^2 / 0.60Dc), \text{ where —}$$

Sc = actual stopping distance measured on the shortest cold effectiveness stop at GVWR (m/s)

V = cold effectiveness test speed (km/h)

Dc = the average deceleration actually achieved during the shortest cold effectiveness stop at GVWR (m/ss)

S = stopping distance.

- B. In addition to the requirement above, the stopping distance for **at least one** of the two hot stops must be $S \leq 89 \text{ m}$ (292 ft.) from a test speed of 100 km/h or, for reduced test speed $S \leq 0.10V + 0.0079V^2$. The results of the second stop may not be used to meet the requirements of the first stop.

NOTE 1: Accelerate as rapidly as possible to the initial test speed immediately after each stop.

NOTE 2: Immediately after the hot performance stops, drive 1.5 km at 50 km/h before the first cooling stop.

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER _____

OBSERVER _____

DATE: _____

DATA SHEET 27
14.22 BRAKE COOLING @ GVWR (S7.15)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

S7.15 Brake Cooling Stops: GVWR

IBT: Temperature achieved at completion of hot performance.

TRANSMISSION POSITION: In gear

NUMBER OF RUNS: 4 stops

TEST SPEEDS: 50 km/h (31.1 mph)

PEDAL FORCE:
Adjust as necessary to maintain specified constant deceleration rate

DECELERATION RATE:
Maintain a constant deceleration rate of 3.0 m/s²

WHEEL LOCKUP:
No lockup of any wheel for longer than 0.1 seconds at speeds > 15 km/h

NOTE 1: Immediately after the hot performance stops, drive 1.5 km at 50 km/h before the first cooling stop.

NOTE 2: For the first through third cooling stops, immediately accelerate at the maximum rate to 50 km/h. Maintain that speed until beginning the next stop at a distance of 1.5 km from the beginning of the previous stop.

NOTE 3: Immediately after the fourth stop, accelerate at the maximum rate to 100 km/h. Maintain that speed until beginning the recovery performance stops at a distance of 1.5 km after the beginning of the fourth cooling stop.

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											
3											
4											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER _____

OBSERVER _____

DATE: _____

DATA SHEET 28
14.23 Recovery Performance @ GVWR (S7.16)

VEHICLE:		NHTSA NUMBER:		DATE:	
TEMP.:		WIND VELOCITY:		ROAD PFC:	
ODOMETER START:		ODOMETER FINISH:			

Test Weight: Total = ____ kg; Front = ____ kg; Rear = ____ kg

S7.16 Recovery Performance. GVWR

NOTE: The recovery performance test is conducted immediately after completion of the brake cooling stops.

IBT: Temperature achieved at completion of cooling stops.

TRANSMISSION POSITION: In neutral.

NUMBER OF RUNS: 2 Stops

TEST SPEED:

100km/h (62.1 mph). If vehicle is incapable of attaining 100 km/h, it is tested at the same speeds used for the cold effectiveness test.

PEDAL FORCE:

Average pedal force not greater than the average pedal force recorded during the shortest GVWR cold effectiveness stop. _____N

WHEEL LOCKUP:

No lockup of any wheel for longer than 0.1 seconds allowed at speeds greater than 15 km/h.

Immediately after the 4th cooling stop, accelerate at the maximum rate to 100 km/h. Maintain that speed until beginning the 1st recovery performance stop at a distance of 1.5 km after the beginning of the 4th cooling stop.

Immediately after completion of the 1st recovery performance stop, accelerate as rapidly as possible to the specified test speed and conduct the 2nd recovery performance stop.

Performance Requirements: The stopping distance S for **at least one** of the two stops must be within the following limits:

$$S - 0.10V \geq (0.0386 V^2 / 1.50Dc), \text{ and}$$

$$S - 0.10V \leq (0.0386 V^2 / 0.70Dc), \text{ where —}$$

V = cold effectiveness test speed (km/h)

Dc = average deceleration actually achieved during the shortest cold effectiveness stop at GVWR (m/s²).

RECORDED DATA

Stop No.	Test Speed (km/h)	Initial Brake Temp. (C)		Actual Stopping Distance (m)	Corrected Stopping Distance (m)	Pedal Force (N)		Vehicle Decel. (m/s ²)		Wheel Lockup	Stay In Lane
		Front	Rear			Max.	Avg.	Max.	Avg.		
1											
2											

Data Indicates Compliance: YES _____ NO _____

Comments:

DRIVER: _____

OBSERVER: _____

DATE: _____

**DATA SHEET 29 (Part 1 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)**

VEHICLE: _____ ; NHTSA NO.: _____ ; DATE: _____

TEMPERATURE: _____ °C ; WIND VELOCITY & DIRECTION: _____

TEST COMPLETION INSPECTION REQUIREMENTS:

No detachment or fracture of any components such as brake springs, brake shoe, or disc pads facing. All mechanical components shall be intact and functional. Friction facing tearout shall not exceed 10% of the lining on any single frictional element. No visible brake fluid or lubricant on the friction surface of the brake. No leakage at any system reservoir cover, seal, or filler opening.

BRAKE SYSTEM INTEGRITY (S5.6) (S7.17):

Friction Material condition: Primary/Inner		Friction Material Condition: Secondary/Outer	
LF		LF	
RF		RF	
LR		LR	
RR		RR	
DRUM (OR ROTOR) CONDITION:		BRAKE FLUID/LUBRICANT INSIDE BRAKES:	
LF		LF	
RF		RF	
LR		LR	
RR		RR	
HYDRAULIC COMPONENT CONDITION:		MECHANICAL COMPONENT CONDITION:	
LF		Brk/Ped	
RF		Pow/Brk	
LR		Stop/Lamp	
RR		Linkage	
M/CYL		Other	

DATA INDICATES COMPLIANCE: Yes - _____ ; No - _____ ; No Requirements - _____

DRIVER: _____ ; OBSERVER: _____

RECORDED DATA PROCESSED BY: _____ DATE: _____

APPROVING LAB. OFFICIAL: _____ DATE: _____

DATA SHEET 29 (Part 2 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)

EQUIPMENT REQUIREMENTS (S5)

Service Brake System (S5.1):

Vehicle equipped with a service brake system acting on all wheels? YES___ NO ___

Wear Adjustment (S5.1.1):

Service Brakes are compensated for wear by means of a system of automatic adjustment?

YES___ NO___

Describe: _____

Wear Status (S5.1.2):

Wear status of service brakes is indicated by:

(A) Acoustic or optical device? YES___ NO___

Describe: _____

(B) Visual check outside or under vehicle? YES___ NO___

Describe: _____

Regenerative Brake System (S5.1.3):

(A) EV with RBS, RBS is part of the service brake system if automatically activated , there is no means to deactivate, and functions in all transmission positions.

YES___ NO___

(B) If equipped with ABS and RBS that is part of the service brake system, ABS controls RBS.

YES___ NO___

Parking Brake System (S5.2):

Vehicle equipped with a parking brake system of a friction type with solely mechanical means to retain engagement:

YES ___ NO ___

Controls (S5.3):

- (A) Service brakes activated by means of a foot control?
YES ___ NO ___
- (B) Parking brake control is independent of the service brake control?
YES ___ NO ___
- (C) Parking brake control is hand or foot operated?
YES ___ NO ___
- (D) ABS, if equipped, cannot be manually disabled?
YES ___ NO ___

DATA INDICATES COMPLIANCE: YES ___ NO ___

Comments:

Tested By: _____ DATE: _____

DATA SHEET 29 (Part 3 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)

VEHICLE: _____ ; NHTSA NO.: _____ ; DATE: _____

MASTER CYLINDER RESERVOIR:

DATE		Requirements	Pass	Fail
Reservoir Compartments (S5.4.1)				
(1) Does master cylinder have a reservoir compartment for each brake subsystem?	Yes	Master cylinder shall have a reservoir compartment for each subsystem.		
	No			
(2) Does loss of fluid in one compartment result in complete loss from another compartment?	Yes	Loss of fluid from one compartment shall not cause complete loss from another compartment.		
	No			
Reservoir Capacity (S5.4.2)				
NOTE: Reservoir total minimum capacity is defined as Total Capacity of Reservoir.				
Shall conform to requirements (1) or (2), state units:				
(1) For reservoirs having completely separate compartments for each subsystem (two separate, independent reservoirs):				
Subsystem 1 Subsystem reservoir capacity		Each compartment (reservoir) shall have a minimum capacity equivalent to the fluid displacement resulting when all wheel cylinders or caliper pistons serviced by that independent compartment/reservoir moves from a new lining, fully retracted position to a fully worn, properly adjusted, fully applied position. (Use Data Sheet 31 and Appendix)		
Subsystem 1 Fluid displaced from new to worn lining				
Subsystem 2 Subsystem reservoir capacity				
Subsystem 2 Fluid displaced from new to worn lining				
2) For reservoirs utilizing a portion of the reservoir for a common supply to two or more subsystems:				
Total minimum capacity for the entire master cylinder reservoir (includes individual compartment reservoirs)		Shall at a minimum, have a total reservoir capacity greater than the displacement resulting from all subsystem wheel cylinders or caliper positions moving from new lining to full worn condition as above.		
Fluid displaced from new to worn linings (ALL linings)				

Comments:

DATA SHEET 29 (Part 4 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)

VEHICLE: _____; NHTSA NO.: _____: DATE _____

MASTER CYLINDER RESERVOIR:

DATE		Requirements	Pass	Fail
Master Cylinder Piston Displacement(S5.4.2) [If Common Reservoir Supply - continued from previous page]				
	Fluid displaced by three strokes of master cylinder piston for Primary (Subsystem No. 1)	Individual partial compartments of reservoir shall each at a minimum have a fluid capacity equal to at least the volume displaced by the master cylinder piston servicing the subsystem during a full stroke of the piston. NOTE: Procedure uses three strokes to ensure an accurate measurement.		
	Fluid displaced by three strokes of master cylinder piston for Secondary (Subsystem No. 2)			
	Fluid displaced per stroke, Primary			
	Fluid displaced per stroke, Secondary			
	Fluid available in partial compartment Subsystem No. 1			
	Fluid available in partial compartment Subsystem No. 2			
Brake Power Unit Reservoir (S5.4.2)				
	Volume displaced in charging system piston or accumulator to normal operating pressure plus wheel cylinder or caliper piston displacement.	Shall have a capacity at least equal to fluid displacement required to charge the system pistons on accumulators to normal operating pressure <u>plus</u> displacement when wheel cylinders or caliper pistons move from new lining to full worn condition as above.		
Reservoir Labeling (S5.4.3)				
	Exact copy of reservoir label: _____ _____ _____	Label shall read: "Warning, clean filler cap before removing; use only * fluid from a sealed container". * Fluid type specified in 49 CFR 571.116		
	Measure letter height	Letters shall be at least 3.2mm/ 0.125" high		
	Describe label attachment method and location. _____ _____ _____	Lettering shall be permanently affixed, engraved or embossed and located so as to be visible by direct view either on or within 100mm/3.94 inches of the brake fluid reservoir filler plug or cap.		
	Does the lettering contrast with the background?	If label is not engraved or embossed, letters shall be of a color that contrasts with the background		
	Yes No			

DATA SHEET 29 (Part 5 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)

VEHICLE: _____ ; NHTSA NO.: _____ ; DATE: _____

BRAKE SYSTEM WARNING INDICATOR (S5.5)

CONDITION	ANSWER	REQUIREMENTS	PASS	FAIL
Brake Systems Indicator Lamp Function Check (S5.5.2) (Bulb and systems check)				
Describe location of brake indicator lamp:		Shall be in front, and in clear view, of driver.		
Does lamp light with ignition (start) switch at ON/RUN?		Automatic activation when ignition switch is "on" when engine not running , or ignition between "on" and "start" if is manufacturer check position- OR -single manual action by driver		
Does lamp light with ignition between ON and Start?				
Brake check description in owner's manual?		Manufacturer shall explain the brake check function test procedure in the owner's manual.		
Brake System Warning Indicator ACTIVATION (S5.5.1) DURATION (S5.5.3) FUNCTION (S5.5.4) FLUID LEVEL INDICATION (S5.4.4)				
CONDITION	Light ON?	REQUIREMENT	PASS	FAIL
A. In event of hydraulic leak (1) On or before appearance of pressure differential of 218 psi (split system) value _____		When ignition (Start) switch is ON , lamp must light whenever (A), (B), (C), (D), (E), (F), or (G) occurs. IN addition, if service brake system is not a split system, audible warning must be activated when any condition in (A) exists. Visual warning indicator for non-split systems must be flashing.		
(2) If any reservoir <u>compartment</u> falls below either "safe" level or 25% of capacity, whichever is greater. Values _____ ml or cc				
(3) On or before supply pressure to brake power unit falls to 50% value _____				
B. Electrical functional failure in an antilock or variable brake proportioning system. C. Application of the parking brake. D. Brake lining wear-out if optical warning E. <i>For a vehicle with <u>electrically-actuated service brakes</u>, failure of the source of electric power to the brakes, or diminution of state of charge of the batteries.</i> F. <i>For a vehicle with <u>electric transmission</u> of the <u>service brake control signal</u>, failure of a brake control circuit.</i> G. <i>For an EV with RBS that is part of the service brake system, failure of RBS.</i>				
<p>Must have Audible alarm if <u>not split system</u> and a condition in (a) above exists?</p> <p>If condition (a) (1) above exists, and light does not activate, then fluid reservoir must be transparent for fluid check without need for reservoir to be opened? (S5.4.4)</p> <p>Indicator lamps remain activated as long as condition exists - ignition "on", and engine on or off? _____ (S5.5.3 DURATION))</p> <p>Visual warning - continuous or flashing? _____</p> <p>Audible warning -continuous or flashing? _____</p>				

**DATA SHEET 29 (Part 6 of 6)
14.24 TEST COMPLETION INSPECTION (S7.17)**

VEHICLE: _____ ; NHTSA NO.: _____ ; DATE: _____

BRAKE SYSTEM WARNING INDICATOR LABELING (S5.5.5)

CONDITION AND REQUIREMENT	ANSWER NOTE: Standard requires that the answer to questions be YES	PASS	FAIL
Are visual indicators legible to driver in daylight and nighttime conditions when activated?			
Are visual indicator words 3.2mm (.125") high minimum? Record Height _____			
Visual indicator words and background contrasting colors, one of which is red. Record colors _____			
If split system is there one brake indicator? If yes does it say the word "Brake"?			
If not split system, is there a separate indicator for loss of fluid or fluid pressure? Does this indicator say "Stop-Brake Failure" ? Are the letters block and not less than 6.4mm (.25") in height? Record letter height _____			
<p>If separate indicator for:</p> <p>1. Low brake fluid per S5.5.1(a)(1), does indicator say "Brake Fluid"? NOTE: not required for mineral oil system Record wording _____</p> <p>2. Gross pressure loss per S5.5.1(a)(2), does indicator say "Brake Pressure"? Record wording _____</p> <p>3. Electrical functional failure in antilock or variable proportioning system per S5.5.1(b), letters and background contrasting colors one of which is yellow? Record colors _____ Does indicator say "Antilock" or "ABS" or "Brake Proportioning"? Record wording _____</p> <p>4. Parking brake per S5.5.1(c), does indicator say "Park" or "Parking Brake"? Record wording _____</p> <p>5. Brake lining wear-out per S5.5.1(d), does indicator say "Brake Wear"? Record wording _____</p> <p>6. <i>If separate indicator for RBS, the letters and background shall be of contrasting colors, one of which is yellow. The indicator shall be labeled "RBS". RBS failure in a system which is part of the service brake system may also be indicated by a yellow lamp that also indicates "ABS" failure and displays the symbol "ABS/RBS."</i> Record wording _____</p> <p>7. For any other function? If yes, Record _____</p>			

DATA INDICATES COMPLIANCE: YES _____ NO _____

Comments:

Technician: _____

Date: _____

**DATA SHEET 30
CALCULATION OF MINIMUM RESERVOIR VOLUME REQUIREMENTS**

BRAKE		LINING		
LOCATION	TYPE	DESCRIPTION	MINIMUM THICKNESS	THICKNESS TO FULLY WORN (1) in.
Left Front	Drum	Leading	Pretest	
		Primary	Post Test	
		Inboard)	
	Disc	Trailing	Pretest	
		Secondary	Post Test	
		Outboard)	
LINING CLEARANCE:	Diametral (2) -	Inboard -	Outboard -	
WHEEL CYLINDER DIAMETER (3)		CALIPER PISTON DIAMETER (3)		
SHOE CAGE DIAMETER (4) _____ ; CENTER POINT OF BRAKE ASSY TO CENTER POINT OF W.C.				
Right Rear	Drum	Leading	Pretest	
		Primary	Post Test	
		Inboard)	
	Disc	Trailing	Pretest	
		Secondary	Post Test	
		Outboard)	
LINING CLEARANCE:	Diametral (2)	Inboard	Outboard	
WHEEL CYLINDER DIAMETER (3)		CALIPER PISTON DIAMETER (3)		
SHOE CAGE DIAMETER (4) _____ ; CENTER POINT OF BRAKE ASSY TO CENTER POINT OF W.C.				
SUBSYSTEM 1 CONSISTS OF:	LF	LR	RF	RR
SUBSYSTEM 2 CONSISTS OF:	LF	LR	RF	RR
(1) MFRS RECOMMENDATIONS - REAR - TOP OF RIVET HEADS - FRONT - 1/32 INCH -				
(2) DRUM BRAKES, MEASURED AT HORIZONTAL CENTERLINE				
(3) MFRS DATA				
(4) RESET POSITION				

**DATA SHEET 31
(SAMPLE)**

DATA FOR CALCULATION OF MINIMUM RESERVOIR VOLUME REQUIREMENTS

BRAKE		LINING		
LOCATION	TYPE	DESCRIPTION	MINIMUM THICKNESS	THICKNESS TO FULLY WORN (1) in.
Left Front	Drum	Leading	Pretest - 0.425	0.324
		Primary	Post Test - 0.403	
		Inboard - X) - 0.022	
	Disc - X	Trailing	Pretest - 0.393	0.300
		Secondary	Post Test - 0.380	
		Outboard - X) - 0.013	
LINING CLEARANCE:	Diametral (2) - N/A	Inboard - 0	Outboard - 0	
WHEEL CYLINDER DIAMETER (3) - N/A		CALIPER PISTON DIAMETER (3) - 2.38"		
SHOE CAGE DIAMETER (4) - N/A ; CENTER POINT OF BRAKE ASSY TO CENTER POINT OF W.C. - N/A				
Right Rear	Drum - X	Leading - X	Pretest - 0.206	0.122
		Primary	Post Test - 0.200	
		Inboard) - 0.006	
	Disc	Trailing - X	Pretest - 0.238	0.179
		Secondary	Post Test - 0.231	
		Outboard) - 0.007	
LINING CLEARANCE:	Diametral (2) - 0.030"	Inboard - N/A	Outboard - N/A	
WHEEL CYLINDER DIAMETER (3) - 0.750"		CALIPER PISTON DIAMETER (3) - N/A		
SHOE CAGE DIAMETER (4) - 9.45" ; CENTER POINT OF BRAKE ASSY TO CENTER POINT OF W.C. - 3"				
SUBSYSTEM 1 CONSISTS OF:	LF - X	LR	RF - X	RR
SUBSYSTEM 2 CONSISTS OF:	LF	LR - X	RF	RR - X
(1) MFRS RECOMD:	REAR - TOP OF RIVET HEADS -		FRONT - 1/32 INCH -	
(2) DRUM BRAKES, MEASURED AT HORIZONTAL CENTERLINE				
(3) MFRS DATA				
(4) RESET POSITION				

19. FORMS

**INSTRUMENT CALIBRATION (12 MONTH MAXIMUM INTERVAL)
(SAMPLE)**

INSTRUMENT	SERIAL NUMBER	CALIBRATION DATE	NEXT CALIBRATION
Data Acquisition System			
Computer			
Software			
LF Torque Wheel			
Rf Torque Wheel			
LR Torque Wheel			
RR Torque Wheel			
LF slip Ring			
RF Slip Ring			
LR Slip Ring			
RR Slip Ring			
Pedal Force Transducer			
Park Brake Force Transducer			
LF Hydraulic Pressure Transducer			
RF Hydraulic Pressure Transducer			
LR Hydraulic Pressure Transducer			
RR Hydraulic Pressure Transducer			
Accelerometer			
Fifth Wheel			
Wind Velocity			
Ambient Temperature Gauge			
LF Brake Thermocouple			
RF Brake Thermocouple			
LR Brake Thermocouple			
RR Brake Thermocouple			
Fifth Wheel Velocity			
Lock-up Detection System			

QUALITY ASSURANCE _____

DAILY INSTRUMENT CALIBRATION (SAMPLE)

NOTE: A daily Pretest and Post test instrumentation calibration is required per Section 8.

INSTRUMENT	(EXAMPLES) CALIBRATION PROCEDURE	DESIRED VALUE	INDICATED VALUE MORNING	INDICATED VALUE EVENING	ALLOWED DEVIATION
Velocity Meter	2.568 kHz Input				
5th Wheel Distance Meter	Drive Measured Distance				
5th Wheel Velocity Meter	Drive Measured Distance vs. Time				
Pedal Force Transducer	Dead Weight/Shunt				
Accelerometer	Known Accel. Or to Known Angles				
Brake Thermocouple					
Slip Ring					
Torque Wheel					
Lock-up Detector	Hand Spin Wheel Over 9.3 mph - Vehicle Stopped				

Comments:

TECHNICIAN: _____

QUALITY ASSURANCE: _____

DATE: _____

LABORATORY NOTICE OF TEST FAILURE TO OVSC

FMVSS NO.: 135 _____ TEST DATE: _____

LABORATORY: _____

CONTRACT NO.: DTNH22- _____ ; DELV. ORDER NO.: _____

LABORATORY PROJECT ENGINEER'S NAME: _____

TEST VEH. MAKE/MODEL/BODY STYLE: _____

VEHICLE NHTSA NO.: _____; VIN: _____

VEHICLE MODEL YEAR: _____; BUILD DATE: _____

TEST FAILURE DESCRIPTION:

S135 REQUIREMENT, PARAGRAPH ____ :

NOTIFICATION TO NHTSA (COTR):

DATE: _____ BY: _____

REMARKS:

MONTHLY TEST STATUS REPORT
FMVSS 135
DATE OF REPORT:

NO.	VEHICLE NHTSA NO., MAKE & MODEL	COMPLIANCE TEST DATE	PASS/ FAIL	DATE REPORT SUBMITTED	DATE INVOICE SUBMITTED	INVOICE PAYMENT DATE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

MONTHLY VEHICLE STATUS REPORT
FMVSS 135
DATE OF REPORT:

NO.	VEHICLE NHTSA NO., MAKE & MODEL	DATE OF DELIVERY	ODOMETER READING	TEST COMPLETE DATE	VEHICLE SHIPMENT DATE	ODOMETER READING
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

20. APPENDIX

APPENDIX 1

Procedure and Example for Determining Master Cylinder Volume Requirement

The procedure followed for determining the minimum volume requirements is outlined in the example shown below. The required data is taken from Table 1A-1.

DETERMINATION OF MASTER CYLINDER MINIMUM VOLUME REQUIREMENTS

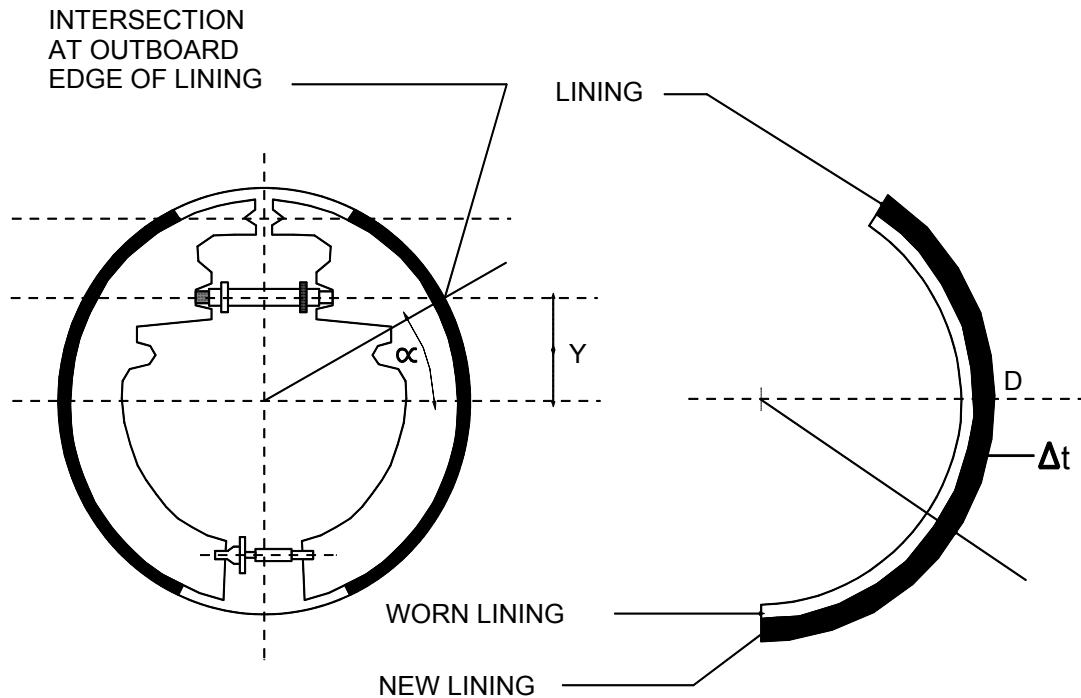


FIGURE 1A

DRUM BRAKES

Volume Required, $V_r = [(2C + \Delta t_s + \Delta t_p)/\cos\alpha] \times A \times \text{NWC}$, where –

:	V_r =	Volume required per wheel
	C =	Manufacturer's recommended drum-to-lining clearance
	Δt_p =	Change in thickness of primary lining
	Δt_s =	Change in thickness of secondary lining
	Y =	Center point of wheel cylinder to center point of brake assembly
	A =	Cross sectional area of the wheel cylinder bore
	NWC =	Number of wheel cylinders serviced by the reservoir in question
	α =	$\sin^{-1}(2Y/D)$
	D =	Cage diameter

APPENDIXContinued

DISC BRAKES

Volume Required, $V_v = (\Delta t_i + \Delta t_{ic} + \Delta t_o + t_{oc}) \times [\Pi (D^2)]/4$, where –

- : V_v = Volume required per wheel
- Δt = Change in thickness (average)
- i = inboard
- o = Outboard
- D = Caliper cylinder diameter
- c = Average clearance

Using the above equations, the volume requirements for Subsystem No. 1 (LF, RR) and Subsystem No. 2 (LF, RF) were calculated as shown below:

Drum Brakes (rear):

$$V_r = (2C + \Delta t_p + \Delta s \times 1)/\cos \alpha$$

$$C = 0.025 \text{ in.}$$

$$\Delta t_p = 0.122 \text{ in.}$$

$$\Delta t_s = 0.179 \text{ in.}$$

$$D = 9.45 \text{ in.}$$

$$\alpha = \sin^{-1} (2 \times 3)/9.45 = 39.4^\circ; \cos \alpha = 0.772$$

$$A = \Pi \times (0.75)^2 = 0.44 \text{ in.}^2$$

$$V_r = [(2 \times 0.025 \times 0.179 + 0.122)/0.772] \times 0.44$$

$$V_r = 0.13 \text{ in.}^3 (2.1 \text{ ml})$$

Disc Brakes (front):

$$V_r = (\Delta t_i + \Delta t_o + t_{ic} + t_{oc}) \times (\Pi D^2)/4$$

$$\Delta t_i = 0.324 \text{ in.}$$

$$\Delta t_o = 0.300 \text{ in.}$$

$$t_{ic} = t_{oc} = 0$$

$$D = 2.38 \text{ in.}$$

$$V_r = (0 + 0.324 + 0.300)[(\Pi \times 2.38^2)/4]$$

$$V_r = 2.77 \text{ in.}^3 (45.0 \text{ ml})$$

For System 1 (LF, RR)

$$V_{r1} = 2.77 \text{ in.}^3 + 0.13 \text{ in.}^3$$

$$V_{r1} = 2.90 \text{ in.}^3 (47.1 \text{ ml})$$

For System 2 (LR, RF)

$$V_{r2} = V_{r1} = 2.90 \text{ in.}^3 (47.1 \text{ ml})$$

TOTAL VOLUME REQUIRED = $V_t = 5.8 \text{ in.}^3 (94.3 \text{ ml})$