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**U.S. DEPARTMENT OF TRANSPORTATION**

**NATIONAL HIGHWAY TRAFFIC SAFETY  
ADMINISTRATION**

**LABORATORY TEST PROCEDURE**

**FOR**

**FMVSS 135**

**Passenger Car Brake Systems**



**SAFETY ASSURANCE**  
**Office of Vehicle Safety Compliance**  
**Room 6115, NSA-30**  
**400 Seventh Street, SW**  
**Washington, DC 20590**

## OVSC LABORATORY TEST PROCEDURE NO. 135

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## 1. PURPOSE AND APPLICATION

The Office of Vehicle Safety Compliance (OVSC) provides contracted laboratories with Laboratory Test Procedures (TPs) which serve 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. Any contractor interpreting any part of an OVSC Laboratory Test Procedure to be in conflict with a Federal Motor Vehicle Safety Standard or observing any deficiencies in a Laboratory Test Procedure is required to advise the Contracting Officer's Technical Representative (COTR) and resolve the discrepancy prior to the start of compliance testing.

Contractors are required to submit a detailed test procedure to the COTR before initiating the compliance test program. The procedure must include a step-by-step description of the methodology to be used.

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.

**NOTE:** The OVSC Laboratory Test Procedures, prepared for use by independent laboratories under contract to conduct compliance tests for the OVSC, 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. Sometimes, recognizing applicable test tolerances, the Test Procedures specify test conditions which are less severe than the minimum requirements of the standards themselves. Therefore, compliance of a vehicle or item of motor vehicle equipment is not necessarily guaranteed if the manufacturer limits certification tests to those described in the OVSC Laboratory Test Procedures.

## 2. GENERAL REQUIREMENTS

This standard applies to passenger cars manufactured on or after Sept 1, 2000. In addition, passenger cars manufactured before Sept 1, 2000, may, at the option of the manufacturer, meet the requirements of this standard instead of Federal Motor Vehicle Safety Standard No. (FMVSS) 105. Standard 135 specifies requirements for hydraulic 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 ensure that 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.

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 from unauthorized personnel during the entire compliance testing program. The contractor is financially responsible for any acts of theft and/or vandalism which occur during the storage of test vehicles. Any security problems which arise shall be reported by telephone to the Industrial Property Manager (IPM), Office of Contracts and Procurement, within two working days after the incident. A letter containing specific details of the security problem will be sent to the IPM (with copy to the COTR) within 48 hours. The contractor shall protect and segregate the data that evolves from compliance testing before and after each vehicle test. 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.

**NOTE:** 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 COTR.

**6. TEST DATA DISPOSITION**

The contractor shall make all preliminary compliance test data available to the COTR on location within four hours after the test. Final test data, including digital printouts and computer generated plots (if applicable), shall be furnished to the COTR within five working days. Additionally, the contractor shall analyze the preliminary test results as directed by the COTR.

All backup data tapes and sheets, plots, technicians' 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)

### TEST VEHICLES

The Contractor has the responsibility of accepting test vehicles from either new car dealers or vehicle transporters. In both instances, the contractor acts in the OVSC's behalf when signing an acceptance of test vehicles. If a vehicle is delivered by a dealer, the contractor must check to verify the following:

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

If the test vehicle is delivered by a government contracted transporter, the contractor should check for damage which may have occurred during transit.

A "Vehicle Condition" form will be supplied to the contractor by the COTR when the test vehicle is transferred from the new car dealer or between test contracts. Vehicle Condition forms must be returned to the COTR with the Final Test Reports or the reports will NOT be accepted.

### NOTIFICATION OF COTR

The COTR must be notified within 24 hours after a vehicle has been delivered, including any discrepancies found among the vehicle conditions described above.

## 8. CALIBRATION OF TEST INSTRUMENTS

Before the contractor initiates the safety compliance test program, a test instrumentation calibration system will be implemented and maintained in accordance with established calibration practices. The calibration system shall include the following as a minimum:

- 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.
- F. Daily pretest and post test Instrumentation calibration sheets, shown in section 20, ARE TO BE INCLUDED IN THE FINAL TEST REPORT.

**8. CALIBRATION OF TEST INSTRUMENTS....Continued**

Further guidance is provided in the International Standard ISO 10012-1, "Quality Assurance Requirements for Measuring Equipment", and the American National Standard ANSI/NCSL Z540-1, "Calibration Laboratories and Measuring and Test Equipment - General Requirements".

**9. PHOTOGRAPHIC DOCUMENTATION**

Photographs shall be black and white, 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 15.
- L. Brake fluid reservoir label as defined in test procedure section 15.
- M. Close up of any failures.

**10. DEFINITIONS (S4)**

**NOTE:** Parenthetical references, shown as above (S4), relate to sections in FMVSS 135 as revised August 28, 1995.

**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**

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

**AVERAGE DECELERATION**

Average value calculated from the initiation of pedal force until completion of 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.

**10. DEFINITIONS (S4)....Continued****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.

**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 instrumentation.

**10. DEFINITIONS (S4)....Continued****MAXIMUM SPEED ( $V_{max}$ )**

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.

**MINIMUM PEDAL FORCE**

Measured at point within stop after initial force application (consult with COTR).

**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.

**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 leakage-type failure of a pressure component in a single subsystem (except structural failure of a housing that is common to two or more subsystems) 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.

**10. DEFINITIONS (S4)....Continued****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 to measure vehicle velocity, 150 fps range with accuracy of  $\pm 0.7$  fps at 88 fps, maximum non-linearity of  $\pm 1.5$  fps over the range and visual output resolution of 0.15 fps.
- B. 140-tooth gear magnetic pickup or equivalent to measure stopping distance, 10<sup>5</sup> feet range with accuracy of + 10 feet in 1,000 feet, maximum non-linearity of  $\pm 20$  feet, per 2,000 feet increment, and visual output resolution of 0.1 foot.
- C. Two load cells to measure normal pedal force on service brake and parking brake, (perpendicular to pedal face), 300 pound range with accuracy of  $\pm 1.5$  pounds at 150 pounds, maximum non-linearity of + 3 pounds over the range, and visual output resolution of 1.5 pounds.
- 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 range with  $\pm 10^\circ\text{F}$  accuracy at 300°F, maximum non-linearity of  $\pm 20^\circ\text{F}$  over the range and visual output resolution of 5°F.
- F. Decelerometer to measure vehicle deceleration rate, 1G range with  $\pm 0.5$  fpsps accuracy at 32.2 fpsps, maximum non-linearity of  $\pm 0.5$  fpsps over the range, and visual output resolution of 0.5 fpsps.
- G. Ambient temperature gauge to record ambient test temperatures, 32°F to 100°F range with  $\pm 0.5^\circ\text{F}$  accuracy at 70°F, maximum non-linearity  $\pm 1.0^\circ\text{F}$  over the range, and visual output resolution of 1°F.
- H. Stopwatch to measure elapsed time during certain tests, 15 minute range with accuracy  $\pm 0.5$  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 range with  $\pm 1$  mph accuracy at 15 mph, maximum non-linearity of  $\pm 2$  mph over the range and visual output resolution of 1 mph.

**11. TEST EQUIPMENT AND REFERENCES....Continued**

- J. Ballast to simulate passenger, cargo, etc. Ballast with a density of 50 to 450 lb/ft<sup>3</sup> is used in the seating area of all vehicles, as well as the cargo areas of vehicles with a GVWR of 10,000 pounds or less.
- 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, + 1 mph, - 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. 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.
- 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)
- 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)

## 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 checkoff 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)

**NOTE:** Record Results where applicable on Data Sheets 1,2, and 3

Each vehicle must be performance tested (Section 15) 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 8/28/95.

#### 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).

#### TEST TRACK 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. Pavement must be clean and dry.

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.

**13. GENERAL TEST CONDITIONS (S6)....Continued**

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), 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.

**13. GENERAL TEST CONDITIONS (S6)....Continued****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. 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.

TYPICAL PLUG TYPE THERMOCOUPLE INSTALLATION

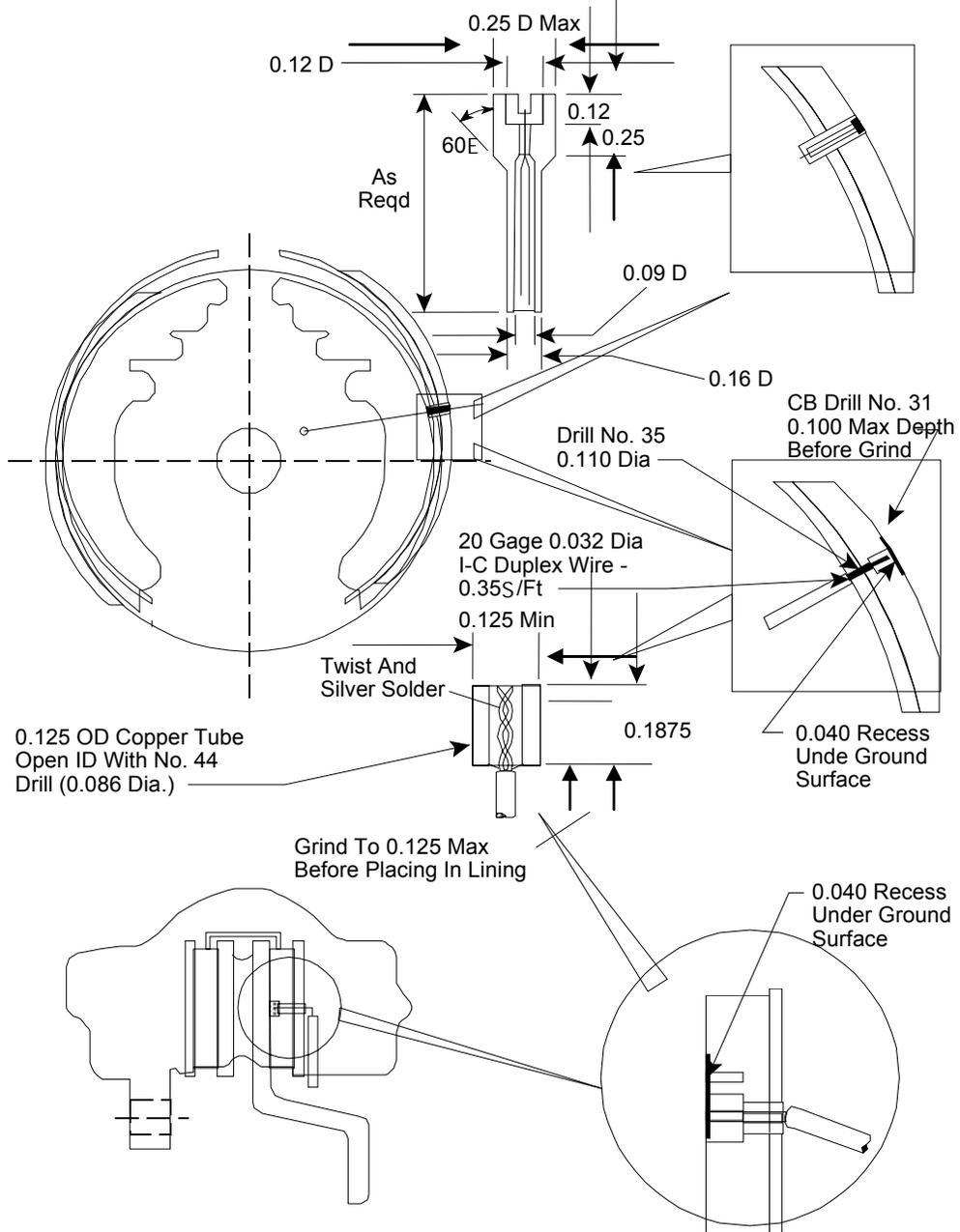


FIGURE 1

**NOTE:** The second thermocouple shall be installed at 0.080 inch depth within 1 inch circumferentially of the thermocouple installed at 0.040 inch depth.

**13. GENERAL TEST CONDITIONS (S6)....Continued**

**Q. Brake Fluid —**

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

**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 20 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 -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.

13. **GENERAL TEST CONDITIONS (S6)...Continued**

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

**NOTE:** Contact COTR regarding inclusion in test report of stopping distance corrected to speed for vehicles which can attain the specified normal test speed. (SAE J299).

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).

**13. GENERAL TEST CONDITIONS (S6)....Continued**

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<sup>2</sup> (9.8 fps<sup>2</sup>).

**14. EQUIPMENT REQUIREMENTS (S5)**

**NOTE:** Record Results on Data Sheet 4

14.1 Service Brake System (S5.1)

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

14.2 Wear Adjustment (S5.1.1)

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

14.3 Wear Status (S5.1.2)

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

- A. Acoustic or optical devices warning the driver at his or her driving position when lining replacement is necessary, or
- B. 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.

14.4 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.

14.5 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)

**14. EQUIPMENT REQUIREMENTS (S5)...Continued**

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

Requirements for **14.6 Reservoirs (S5.4)**, **14.7 Brake System Warning Indicator (S5.5)**, and **14.8 Brake System Integrity (S5.6)**, are evaluated in Final Inspection, Section 15.24 of Road Test Performance.

**15. 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)

Testing Order	Test	Test Procedure Section	FMVSS 135 Section
Initial	Speed Determination @LLVW	15	S4
Vehicle loaded to <b>GVWR</b> :			
1	Burnish/ Instrumentation Check	15.1	S7.1
2	Wheel Lock Sequence	15.2	S7.2
Vehicle Loaded to <b>LLVW</b> :			
3	Wheel Lock Sequence	15.3	S7.2
4	ABS Performance	15.4	S7.3
5	Torque Wheel	15.5	S7.4
Vehicle Loaded to <b>GVWR</b> :			
6	Torque Wheel	15.6	S7.4
7	Cold Effectiveness	15.7	S7.5
8	High Speed Effectiveness	15.8	S7.6
9	Stops with Engine Off	15.9	S7.7
Vehicle Loaded to <b>LLVW</b> :			
10	Cold Effectiveness	15.10	S7.5

(Table continued on next page)

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

<b>Testing Order</b>	<b>Test</b>	<b>Test Procedure Section</b>	<b>FMVSS 135 Section</b>
11	High Speed Effectiveness	15.11	S7.6
12	Failed Antilock	15.12	S7.8
13	Failed Proportioning Valve	15.13	S7.9
14	Failed Hydraulic circuit 1&2	15.14	S7.10
<b>Vehicle Loaded to GVWR</b>			
15	Failed Hydraulic Circuit 1& 2	15.15	S7.10
16	Failed Antilock	15.16	S7.8
17	Failed Proportioning Valve	15.17	S7.9
18	Power Brake Unit Failure	15.18	S7.11
19	Parking Brake - Static	15.19	S7.12
20	Heating Snubs	15.20	S7.13
21	Hot Performance	15.21	S7.14
22	Brake Cooling	15.22	S7.15
23	Recovery Performance	15.23	S7.16
24	Final Inspection -system integrity/reservoir/indicators	15.24	S7.17

SPEED DETERMINATION (Max. Speed) —  
(Record results on Data Sheet 5)

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.

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

15.1 **BURNISH (S7.1)**

NOTE: Record results on Data Sheet 6

15.1.1 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.

15.1.2 Vehicle conditions (S7.1.2)

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

15.1.3 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: # 100°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<sup>2</sup> (9.8 fps<sup>2</sup>).
- 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.

## 17. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE

### TEST EXECUTION (S7)....Continued

- 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 as specified in S6.3.4.

## 15.2 WHEEL LOCKUP SEQUENCE (S7.2)

**NOTE:** Record Results on Data Sheet 7

### 15.2.1 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 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.

- 15. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE TEST EXECUTION (S7)....Continued**
- 15.2.2 Vehicle Conditions (S7.2.2)
- A. Vehicle Load: GVWR
  - B. Transmission Position: In neutral.
- 15.2.3 Test Conditions and Procedures (S7.2.3)
- A. IBT: \$ 65°C (149°F), # 100°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.

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

- 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.

**15.2.4 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.
- 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.

- 15. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE TEST EXECUTION (S7)....Continued**
- 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 15.5.
- 15.3 WHEEL LOCKUP SEQUENCE (S7.2)**  
**NOTE:** (Record Results on Data Sheet 8)
- Repeat Wheel Lockup Sequence test 15.2 with vehicle load LLVW (again on two different test surfaces)
- 15.4 ABS PERFORMANCE (S7.3)**  
**NOTE:** Reserved for future revision of FMVSS 135
- 15.5 ADHESION UTILIZATION (Torque Wheel Method) (S7.4)**  
**NOTE:** Record Results on Data Sheet 9, if performed
- 15.5.1 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.
- 15.5.2 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 7.0, may be used.
- 15.5.3 Test Conditions and Procedures (S7.4.3)
- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speeds: 100 km/h (62.1 mph), and 50 km/h (31.1 mph)

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

- 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 S7.4.3(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.

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

- 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.

**15.5.4 Data Reduction (S7.4.4)**

- A. The data from each brake application under S7.4.3 is filtered using a five-point, on-center moving average for each data channel.
- B. For each brake application under 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 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

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

- 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 both GVWR and LLVW load conditions. These are the adhesion utilization curves for the vehicle, which are compared to the performance requirements in S7.4.5. shown graphically in Figure 2:

**15.5.5 Performance Requirements (S7.4.5)**

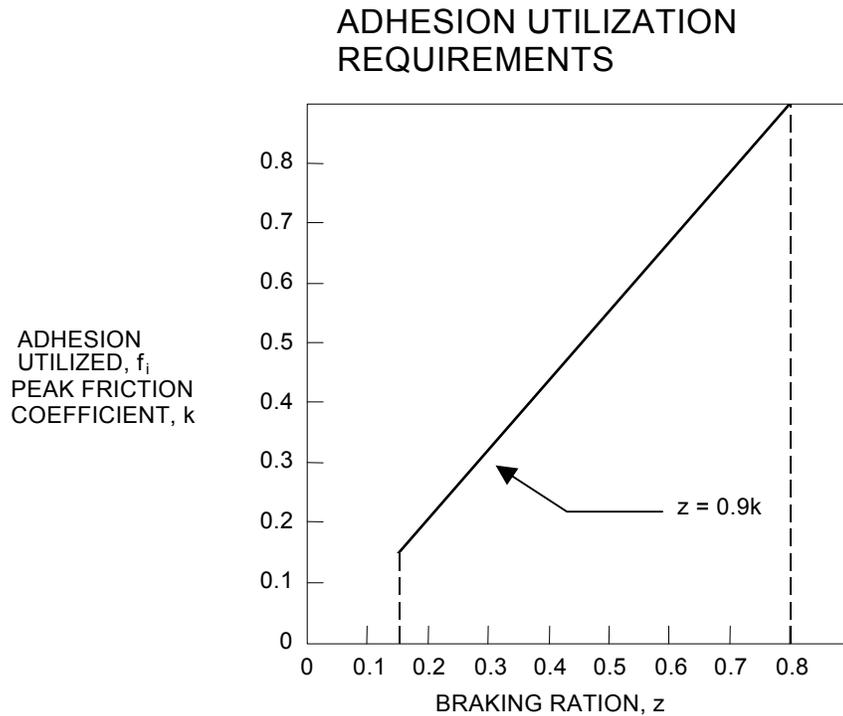
For all braking ratios between 0.15 and 0.80, each adhesion utilization curve for a rear axle shall be situated below a line defined by  $z = 0.9k$  where  $z$  is the braking ratio and  $k$  is the PFC.

**15.6 ADHESION UTILIZATION (Torque Wheel Method) (S7.4)**

**NOTE:** Record Results on Data Sheet 10, if performed)

Repeat test 15.5 at vehicle load — GVWR

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



**FIGURE 2**

**15.7 COLD EFFECTIVENESS (S7.5)**

**NOTE:** Record Results on Data Sheet 11

15.7.1 Vehicle Conditions (S7.5.1)

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

15.7.2 Test Conditions and Procedures (S7.5.2)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: \$ 65N (14.6 lbs), # 500N (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)

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

- 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.

15.7.3 Performance Requirements (S7.5.3)

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

**15.8 HIGH SPEED EFFECTIVENESS (S7.6)**

**NOTE:** Record Results on Data Sheet 12

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

15.8.1 Vehicle Conditions (S7.6.1)

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

15.8.2 Test Conditions and Procedures (S7.6.2)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 80% of vehicle maximum speed if 125 km/h (77.7 mph) < vehicle maximum speed < 200 km/h (124.3 mph), or 160 km/h (99.4 mph) if vehicle maximum speed \$200 km/h (124.3 mph)
- C. Pedal Force: \$ 65N (14.6 lbs), # 500N (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

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

15.8.3 Performance Requirements (S7.6.3)

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

**15.9 STOPS WITH ENGINE OFF (S7.7)**

**NOTE:** Record Results on Data Sheet 13

15.9.1 General Information (S7.7.1)

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

15.9.2 Vehicle conditions (S7.7.2)

- A. Vehicle Load: GVWR
- 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, 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.

15.9.3 Test Conditions and Procedures (S7.7.3)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: \$ 65N (14.6 lbs), # 500N (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

- 15. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE TEST EXECUTION (S7)....Continued**
- 15.9.4 Performance Requirements (S7.7.4)
- A. Stopping Distance for 100 km/h Test Speed: # 70m (230 ft.)
  - B. Stopping Distance for Reduced Test Speed: S #  $0.10V + 0.0060V^2$
- 15.10 COLD EFFECTIVENESS (S7.5)**  
**NOTE:** Record Results on Data Sheet 14
- Repeat test 15.7 with vehicle loading — LLVW
- 15.11 HIGH SPEED EFFECTIVENESS (S7.6)**  
**NOTE:** Record Results on Data Sheet 15
- Repeat test 15.8 with vehicle load — LLVW
- 15.12 ANTILOCK FUNCTIONAL FAILURE (S7.8)**  
**NOTE:** Record Results on Data Sheet 16
- 15.12.1 Vehicle Conditions (S7.8.1)
- A. Vehicle Loading: LLVW
  - B. Transmission Position: In neutral
- 15.12.2 Test conditions and Procedures (S7.8.2)
- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
  - B. Test Speed: 100 km/h (62.1 mph)
  - C. Pedal Force: \$ 65 N (14.6 lbs), # 500 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

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

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.

15.12.3 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 S7.8.3(a) or S7.8.3(b).

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

**15.13 VARIABLE BRAKE PROPORTIONING SYSTEM FUNCTIONAL FAILURE (S7.9) — NOTE: Record Results on Data Sheet 17**

15.13.1 Vehicle Conditions (S7.9.1)

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

15.13.2 Test Conditions and Procedures (S7.9.2)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force \$ 65 N (14.6 lbs), # 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)

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

- 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.

15.13.3 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 S7.9.3(a) or S7.9.3(b).

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

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

**NOTE:** Record Results on Data Sheets 18 and 19

15.14.1 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

15.14.2 Vehicle Conditions (S7.10.2)

- A. Vehicle Load: LLVW

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

B. Transmission Position: In neutral

15.14.3 Test Conditions and Procedures (S7.10.3)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: \$ 65N (14.6 lbs), # 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. Test Surface: PFC of 0.9
- F. Alter the service brake system to produce any one rupture or leakage type of failure other than a structural failure of a housing that is common to two or more subsystems
- G. Determine the control force pressure level, pressure differential (see 15.24.7) or fluid level (as appropriate for the indicator being tested) 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)

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

15.14.4 Performance Requirements (S7.10.4)

For vehicles manufactured with a split service brake system, in the event of any rupture or leakage type of failure in a single subsystem, other than a structural failure of a housing that is common to two or more subsystems, and after activation of the brake system indicator as specified in S5.5.1 (Section 15.24.7), the remaining portions of the service brake system shall continue to operate and shall stop the vehicle as specified in S7.10.(a) or S7.10.4(b)

For vehicles not manufactured with a split service brake system, in the event of any one rupture or leakage type of failure in any component of the service brake system and after activation of the brake system indicator as specified in S5.5.1, the vehicle shall by operation of the service brake control stop 10 times consecutively as specified in S7.10.4(a) or S7.10.4(b). Each of the 10 stops shall meet the applicable stopping distance requirement.

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

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

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

**NOTE:** Record Results on Data Sheets 20 and 21

Repeat test 15.14 with vehicle load at GVWR.

**15.16 ANTILOCK FUNCTIONAL FAILURE (S7.8)**

**NOTE:** Record Results on Data Sheet 22

Repeat test 15.12 with vehicle load at GVWR.

**15.17 VARIABLE BRAKE PROPORTIONING SYSTEM FUNCTIONAL FAILURE (S7.9) NOTE:** Record Results on Data Sheet 23

Repeat test 15.13 with vehicle load at GVWR.

**15.18 POWER BRAKE UNIT OR BRAKE POWER ASSIST UNIT INOPERATIVE (SYSTEM DEPLETED) (S7.11) NOTE:** Record Results on Data Sheet 24

15.18.1 General Information (S7.11.1)

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

15.18.2 Vehicle Conditions (S7.11.2)

A. Vehicle load: GVWR

B. Transmission position: In neutral

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

15.18.3 Test Conditions and Procedures (S7.11.3)

- A. IBT: \$ 65°C (149°F), # 100°C (212°F)
- B. Test Speed: 100 km/h (62.1 mph)
- C. Pedal Force: \$ 65 N (14.6 lbs), # 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: 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

15.18.4 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 S7.11.4(a) or S7.11.4(b).

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

- 15. ROAD TEST PERFORMANCE REQUIREMENTS AND COMPLIANCE  
TEST EXECUTION (S7)....Continued**
- 15.19 PARKING BRAKE - STATIC (S7.12)**  
**NOTE:** Record Results on Data Sheet 25
- 15.19.1 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.
- 15.19.2 Test Conditions and Procedures (S7.12.2)
- A. IBT:
    - (1) Parking brake systems utilizing service brake friction materials shall be tested with the IBT # 100°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-application, if necessary.

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

LOCATION FOR MEASURING HAND BRAKE APPLICATION FORCE

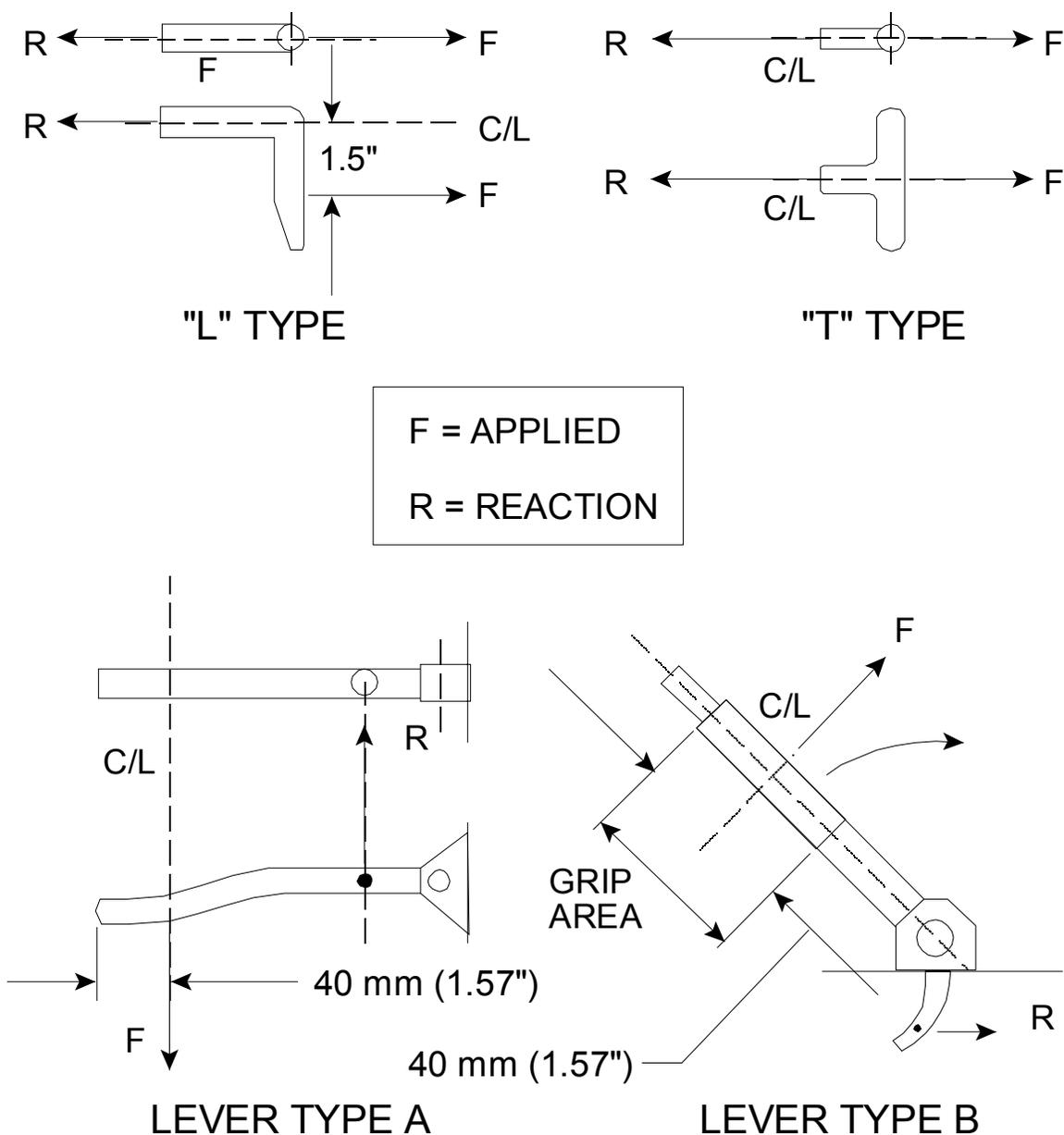


FIGURE 3

**15. 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 S7.12.2(i) or S7.12.2(j).
- I. The parking brake system is actuated by a single application not exceeding the limits specified in S7.12.2(b).
- 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 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.

**15.19.3 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.

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

**15.20 HEATING SNUBS (S7.13)**

**NOTE:** Record Results on Data Sheet 26

15.20.1 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.

15.20.2 Vehicle Conditions (S7.13.2)

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

15.20.3 Test Conditions and Procedures (S7.13.3)

- A. IBT:
  - (1) Establish an IBT before the first brake application (snub) of \$ 55°C (131°F), # 65°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 Vmax, 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<sup>2</sup> (9.8 fps<sup>2</sup>).
  - (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).

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

- 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.

**15.21 HOT PERFORMANCE (S7.14)**

**NOTE:** Record Results on Data Sheet 27

15.21.1 General Information (S7.14.1)

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

15.21.2 Vehicle Conditions (S7.14.2)

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

15.21.3 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.

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

- 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.

15.21.4 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:

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

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

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

V = Cold effectiveness test speed (km/h)

Dc = 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 S7.14.4(a), the stopping distance for at least 1 of the 2 hot stops must be  $S \geq 89 \text{ m (292 ft)}$  from a test speed of 100 km/h (62.1 mph) or, for reduced test speed,  $S \geq 0.10V + 0.0079V^2$ . The results of the 2nd stop may not be used to meet the requirements of S7.14.4(a).

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

**15.22 BRAKE COOLING STOPS (S7.15)**

**NOTE:** Record Results on Data Sheet 28

15.22.1 General Information (S7.15.1)

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

15.22.2 Vehicle Conditions (S7.15.2)

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

15.22.3 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/s<sup>2</sup> (9.8 fps<sup>2</sup>)
- 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

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

- 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

**15.23 RECOVERY PERFORMANCE (S7.16)**  
**NOTE:** Record Results on data Sheet 29

15.23.1 General Information (S7.16.1)

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

15.23.2 Vehicle Conditions (S7.16.2)

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

15.23.3 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

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

- 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.

15.23.4 Performance Requirements (S7.16.4)

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

$$S - 0.10V > 0.0386 V^2 / 1.50Dc$$

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

V = Cold effectiveness test speed (km/h)

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

**15.24 FINAL INSPECTION(S7.17) [System Integrity (S5.6) ,Reservoirs (S5.4), Warning Indicators (S5.5)]**

**NOTE:** Record Results on Data Sheets 30,31, and 32

15.24.1 Brake System Integrity (S5.6)

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 tearout (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.

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

15.24.2 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.

15.24.3 Reservoir Capacity (S5.4.2)

INSPECT AND VERIFY that the reservoirs, whether for master cylinders or other type systems, have a total **minimum** capacity (full reservoir 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 Appendix Section 21 for procedure to calculate master cylinder volume requirements.

**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 volume displaced by a full stroke of each piston may require disconnecting hydraulic lines from each piston chamber, applying brakes and catching the displaced fluid in a calibrated receptacle.]

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.

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

15.24.4 Reservoir Labeling (S5.4.3)

**VERIFY** that the 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

15.24.5 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).

15.24.6 Brake System Warning Indicator (S5.5)

**VERIFY** that the 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. 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).

15.24.7 Activation (S5.5.1 - frequent reference)

**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) or (d) 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):

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

- (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.
  - (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 S5.1.2(a) (Section 14).

[To test the indicator activation, the above conditions may require simulation i.e. disconnection of hydraulic lines, disconnection of ABS fuse, etc.]

15.24.8 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.

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

- 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.

15.24.9 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.

15.24.10 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.

15.24.11 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(d). 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.

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

- 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(d), 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 any other function, the display shall include the word "Brake" and appropriate additional labeling.

**16. INSTRUCTIONS FOR COMPLETING DATA SHEETS**

Data from each test is entered on the appropriate data sheet in Section 19.

**VISUAL** data is to be recorded manually into the data sheets as the test is conducted.

**RECORDED** data is copied from the machine-read data tapes, charts, or computer sources and is entered into the appropriate data sheets at the completion of the testing.

RECORDED DATA SHALL BE USED TO DETERMINE COMPLIANCE WITH THE REQUIREMENTS. IF RECORDED DATA IS NOT AVAILABLE, THEN VISUAL DATA CAN BE UTILIZED.

**16. INSTRUCTIONS FOR COMPLETING DATA SHEETS....Continued**

Visual data recorded by the driver or an on-board observer provides feedback to the driver and backup to the instrumentation in the event of instrumentation failure.

**NOTE:** Visual data sheets may be more extensive than the driver or observer can complete. Record what data is feasible. Modify what visually recorded data as needed (i.e., maximum deceleration vs. average deceleration, maximum pedal force vs. average pedal force, etc.).

If visual and recorded data is identical (i.e., obtained from the same instrumentation), then the visual data sheets should be retained by the laboratory but **NOT** included in the final test report.

Summary data sheet(s) 2 indicating requirements, actual performance, and pass or fail, are to utilize recorded data.

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.

Addition of a column on recorded data sheets for stopping distance corrected to speed is acceptable but not required.

**NOTE:** Average Pedal Force and Average Deceleration are calculated from initial brake application to the time at which the vehicle has stopped.

Minimum pedal force is measured at a point within the stop after initial force application. Consult with the COTR.

**17. POST TEST REQUIREMENTS**

Contractor shall re-verify all instrumentation and check data sheets.

## 18. REPORTS

### 18.1 Monthly Status Reports

The contractor shall submit a monthly Test Status Report and a Vehicle or Equipment Status Report to the COTR. The Vehicle or Equipment Status Report shall be submitted until all vehicles or items of equipment are disposed of. See Forms Section for samples of the required Monthly Status Reports.

### 18.2 Apparent Test Failure

Any indication of a test failure shall be communicated by telephone to the COTR within 24 hours with written notification mailed within 48 hours (Saturday and Sunday hours excluded). A Notice of Test Failure (see Section 20, "Forms") with a copy of the particular compliance test data sheet(s) and preliminary data plot(s) shall be included. In the event of a test failure, a post test calibration check of some critically sensitive test equipment and instrumentation 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.

### 18.3 Final Test Reports

#### 18.3.1 Copies

In the case of a test failure, **seven** copies of the Final Test Report shall be submitted to the COTR for acceptance within three weeks of test completion. The Final Test Report format to be used by all contractors can be found in this section.

Where there has been no indication of a test failure, **three** copies of each Final Test Report shall be submitted to the COTR for acceptance within three weeks of test completion. Payment of contractor's invoices for completed compliance tests may be withheld until 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 two weeks 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.

## 18. REPORTS....Continued

### 18.3.2 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 and containing all data sheets.

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.

### 18.3.3 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-9X-001, or 135-ABC-0X-001, where —

135 is the FMVSS tested  
 ABC are the initials for the laboratory  
 9X is the Fiscal Year of the test program, 1998, 1999  
 0X is the Fiscal Year of the test program, 2000, 2001, etc.  
 001 is the Group Number —  
 (001 for the 1st test, 002 for the 2nd test, etc.)

- (2) Final Report Title And Subtitle such as

SAFETY COMPLIANCE TESTING FOR FMVSS 135  
 Passenger Car Brake Systems  
 \* \* \* \* \*

Name of Vehicle Manufacturer  
 Model Year, Make/Model, Body Style  
 NHTSA Number for Test Vehicle

**18. REPORTS....Continued**

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

ABC COMPLIANCE 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 such as "March 15, 199X" or "March 15, 2000"

- (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  
Safety Assurance  
Office of Vehicle Safety Compliance  
400 Seventh Street, SW  
Room 6115 (NSA-30)  
Washington, DC 20590

**18. REPORTS....Continued****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: \_\_\_\_\_

**18. REPORTS....Continued****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-9X-001 (same as Final Report on cover)

**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 199X Ace Super 2-door Coupe, NHTSA No. CX0401

**Block 5 — REPORT DATE**

March 15, 199X (same as Final Report Completion date on cover)

**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

**18. REPORTS....Continued**

## Block 9 — PERFORMING ORGANIZATION NAME AND ADDRESS

ABC Laboratories  
405 Main Street  
Detroit, MI 48070

## Block 10 — WORK UNIT NUMBER

Leave blank

## Block 11 — CONTRACT OR GRANT NUMBER

DTNH22-9X-D-12345

## Block 12 — SPONSORING AGENCY NAME AND ADDRESS

U.S. Department of Transportation  
National Highway Traffic Safety Administration  
Safety Assurance  
Office of Vehicle Safety Compliance (NSA-30)  
400 Seventh Street, SW, Room 6115  
Washington, DC 20590

## Block 13 — TYPE OF REPORT AND PERIOD COVERED

Final Test Report  
Feb. 15 to Mar. 15, 199X

## Block 14 — SPONSORING AGENCY CODE

NSA-30

## Block 15 — SUPPLEMENTARY NOTES

Leave blank

**18. REPORTS....Continued**

## Block 16 — ABSTRACT

Compliance tests were conducted on the subject 199X Ace Super 2-door coupe 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

Copies of this report are available from —

NHTSA Technical Reference Division  
Mail Code: NAD-40  
400 Seventh St., SW, Room 5108  
Washington, DC 20590  
Telephone No.: 202-366-4949

## 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

**18. REPORTS....Continued**

## 18.3.4 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