U.S. Department of Transportation
National Highway Traffic Safety Administration

DYNAMIC BRAKE SUPPORT SYSTEM PERFORMANCE EVALUATION

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Office of Vehicle Safety Research
1200 New Jersey Avenue, SE
Washington, DC 20590

DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUTION

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1.0 PURPOSE AND APPLICATION

This laboratory test procedure provides specifications for objectively quantifying the performance of a Dynamic Brake Support (DBS) system installed in a passenger vehicle with a gross vehicle weight rating (GVWR) of under 10,000 pounds. Current DBS technology is dependent on RADAR, LIDAR, and/or vision based sensors capable of detecting traffic. Although it is impossible to predict what sensing technologies could be used in future DBS systems, it is believed that with minor modifications to the test setup, systems with alternative sensing methods may be also be evaluated.

The requirements of this indicant test procedure must be strictly adhered to. The Contractor's in-house test procedure must have NHTSA approval prior to conducting the first test of a particular fiscal year program. The Contractor's test procedure cannot deviate in any way from the NHTSA procedure without the prior approval of the NHTSA COTR.

2.0 GENERAL REQUIREMENTS

This test evaluates the ability of a DBS system to detect, and respond to via automatic supplementation to the vehicle's foundation brake system, a hazard in the forward path of the vehicle being evaluated. Two driving scenarios are utilized to assess DBS performance. In the first test, a subject vehicle (SV) approaches a stopped principal other vehicle (POV) in the same lane of travel. The second test consists of the SV, traveling at a constant speed, approaching a slower POV moving at a constant speed. In both tests, the POV is a strikeable object with the characteristics of a compact passenger car. The specific attributes of the POV are described in S7.4.

3.0 SECURITY

The Contractor shall provide appropriate security measures to protect test vehicles and equipment during the entire test program, and shall be responsible for all equipment removed from test vehicles before and after the test. Vehicle equipment thefts or act of vandalism must be reported to NHTSA authorities immediately. Under no circumstances shall any vehicle components be removed during a visitor inspection unless authorized by an Office of Crash Avoidance Standards (OCAS) representative. All data developed from the test program shall be protected.

3.1 Rules for Contractors

1. No vehicle manufacturer's representative(s), or anyone other than the Contractor's personnel working on the Contracts and NHTSA personnel, shall be allowed to inspect NHTSA vehicles or witness vehicle preparations and/or testing without prior permission of the OCAS. Such permission can never be assumed.

1. All communications with vehicle manufacturers shall be referred to the OCAS, and at no time shall the Contractor release test data without the permission of the OCAS.

2. Unless otherwise specified, the vehicle manufacturer's representatives shall only be authorized to visit the Contractor's test facility on the day that the test is scheduled, and the representatives must be escorted by NHTSA and/or Contractor personnel.

3. Test vehicle inspection by the vehicle manufacturer's representative(s) shall be limited to 30 minutes prior to the start of vehicle test. Post-test inspection shall be limited to one (1) hour after Contractor personnel have completed their test tasks.

4. Photographs and videos of the test vehicle, associated test equipment and test event shall be allowed. However, test personnel shall not be included in any photographic coverage, and video data collection of vehicle preparation must be approved by the OCAS. The Contractor's personnel shall not respond to any questions from the manufacturer's representatives regarding this test program. All questions shall be referred to the COTR, an OCAS representative present at the test site, or to the OCAS.

5. The Contractor shall permit public access to and inspection of the test vehicles and related data during the times specified by the NHTSA COTR. NHTSA shall advise interested parties that such access and inspection shall be limited to a specified day, specified hours, and require prior approval from the OCAS. The Contractor shall refer all visit requests from vehicle manufacturer's representatives and consumers to the OCAS. This service shall be included as an incidental part of the test program and will not result in any additional cost to the NHTSA. The Contractor shall make their own arrangements with interested parties for expenses incurred beyond providing access and inspection services. All inquiries by manufacturers concerning the test program (vehicle, procedures, data, etc.) shall be directed to OCAS representatives.

4.0 GOOD HOUSEKEEPING

The Contractor shall maintain the entire test area, vehicle pre-test preparation facility, instrumentation building, and equipment configuration and performance verification test laboratory in a clean, organized, and painted condition. All test instrumentation must be setup in an orderly manner consistent with good engineering practices.

5.0 TEST SCHEDULING AND MONITORING

The Contractor shall commence testing within four (4) weeks after receipt of the first test vehicle. Subsequent tests will be conducted, if requested, at a minimum of one (1) vehicle test per week. The NHTSA COTR will make adjustments to the test schedule in cases of unusual circumstances such as inclement weather or difficulty experienced in the procurement of a

particular vehicle make and model. All testing shall be coordinated to allow monitoring by the COTR.

6.0 TEST DATA DISPOSITION

The Contractor shall make all test data available within two hours after the test event if so requested by NHTSA personnel. Under no circumstances shall this preliminary data be furnished to non-NHTSA personnel. The Contractor shall analyze the preliminary test results as directed by the COTR.

6.1 Test Data and Final Hardcopy

The Contractor shall deliver to the OCAS the final data, digital printouts, and plots highlighting key data traces on a CD or DVD within one (1) week after the test.

6.2 Test Report

6.2.1 Report Content

This test report shall include all of the items shown in the Sample Test Report. The text and data sheet portion of the test report shall be in Microsoft Word format. Digital pictures shall be in JPEG format. The Contractor shall submit two (2) CDs or DVDs and one (1) paper copy of the test report to the following address:

U. S. Department of Transportation
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards (NVS-120)
1200 New Jersey Avenue, SE, Room W43-478
Washington, DC 20590

6.2.2 Report Submission

All final test reports shall be submitted to the above listed NHTSA office within four (4) weeks from the date of the vehicle test.

6.3 Test Video

The OCAS shall receive one (1) copy of the color video for each test, and the copies shall be mailed directly to the OCAS within four (4) weeks of the vehicle test. The master print for each of the test videos shall be retained by the Contractor, but will be made available to the OCAS upon request. See Section 9.1 for a description of the video to be taken during CIB test conduct.

6.4 Data Loss

6.4.1 Conditions for Retest

The test vehicle shall be instrumented in order to obtain data needed for the test program. An invalid test is one which does not conform precisely to all requirements/specifications of the laboratory test procedure and Statement of Work applicable to the test.

The NHTSA Contracting Officer (CO) is the only NHTSA official authorized to notify the Contractor that a retest is required.

No test report is required for any test which is determined to be invalid unless NHTSA specifically decides to require the Contractor to submit such report. Invalidated test reports will not be publicly released.

RETEST CONDITIONS

Failure of the Contractor to obtain the specified data and to maintain acceptable limits of test parameters in the manner outlined in this test procedure shall require a retest at the expense of the Contractor. The provisions of this paragraph apply to, but are not limited to, the Contractor maintaining proper speed tolerance, vehicle performance, and test data acquisition, reduction, and processing.

The Contractor shall also be responsible for obtaining usable data from all primary channels from instrumentation placed in each vehicle. Failure to produce such data shall also be at the expense of the Contractor and shall include vehicle repair or replacement and retest unless the Office of Crash Avoidance Standards determines that the data loss occurred through conditions beyond reasonable and foreseeable control of the Contractor. Should it become necessary for the Contractor to procure another test vehicle, it must have identical equipment and options as the original vehicle. The retested vehicle shall be retained without fee by the testing facility until its disposal is authorized by the COTR.

6.4.2 Conditions for Partial Payment

The Contractor shall exercise reasonable and foreseeable control to insure that no data is lost or rendered useless. If some non-critical data (such as camera failure) and critical data (such as vehicle position data) are not obtained for the test and the test is accepted by the Agency, the Agency will not pay for the missing or lost data.

6.5 Data Retention by Contractor

The Contractor shall retain at no extra cost to the NHTSA, reproducible copies of all data (analog and digital), videos, and still photograph negatives or electronic files for a period of one (1) year after test completion.

6.6 Data Availability to the Public

The Contractor shall provide interested parties with copies of test report, test data on a CD or DVD, test video, and/or test still photographs, at a reasonable cost to the purchaser, but only after the OCAS representative has advised the Contractor that the results of that particular test have been released to the public by the NHTSA.

6.7 Indicant Failure Notification

Any indication of a “test failure” shall be communicated by telephone to the COTR within 24 hours of the test.

NOTE: In the event of a 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 cost.

7.0 VEHICLES AND EQUIPMENT

7.1 Acceptance of Test Vehicles

The Contractor has the responsibility of accepting leased or NHTSA-provided test vehicles from new car dealers, leasing companies, or vehicle transporters. In all instances, the Contractor acts in the NHTSA’s behalf when signing an acceptance of test vehicles. The Contractor must check to verify the following:

1. The equipment necessary to support DBS functionally is present on the test vehicle
2. All options listed on the “window sticker” are present on the test vehicle.
3. Tires and wheel rims are the same as listed.
4. There are no dents or other interior or exterior flaws.
5. The vehicle has been properly prepared and is in running condition.
6. Verify that spare tire, jack, lug wrench, and tool kit (if applicable) is located in the vehicle cargo area.

The Contractor shall check for damage that may have occurred during transit or prior use. The COTR is to be notified of any damage prior to preparation of the vehicle for testing.

7.2 Notification of COTR

The COTR must be notified within 24 hours after a vehicle has been delivered.

7.3 Government Furnished Equipment (GFE)

No Government Furnished Equipment will be available or provided for the tests described in this document.

7.4 Principal Other Vehicle (POV)

The Contractor shall use a strikeable object with the characteristics of a compact passenger car for use as the POV. This is intended to maximize the ability of the SV to detect the POV in the most realistic manner possible without compromising SV driver safety and minimizing the potential for SV damage. Specifically, the strikeable object must possess the following attributes:

1. Accurate physical characteristics (e.g., visual, dimensional, etc.) when approached with a SV heading angle of ±5 degrees

2. A RADAR return signature representative of the rear of a high volume compact passenger car equipped with a United States-specification license plate when approached with a SV heading angle of ±5 degrees

3. Remain consistently shaped (e.g., visually, dimensionally, internally, and from a RADAR sensing perspective) within each test series, and throughout the three series testing timeline.

4. Resistant to damage resulting from repeated SV-to-POV impacts

5. Impose minimal to no damage to the SV, even in the event of multiple impacts.

The Contractor shall present documentation that objectively qualifies how the POV used to perform the tests described in S12.3 and S12.4 satisfied the requirements of S7.4.1 through S7.4.5.

7.5 Principal Other Vehicle (POV) Moving Platform

For the Slower POV Moving tests described in S12.4, the POV is moved at one of two constant speeds. To eliminate abrasion between the POV and the test surface during these trials, a moving platform shall be utilized.

To reduce the potential for the POV moving platform to confound CIB RADAR sensor operation during test conduct, the platform shall not be fabricated from metal, or have a metallic frame.

To reduce the potential for the moving platform to confound CIB LIDAR sensor or camera operation during test conduct the top surface of the moving platform shall be low-gloss (i.e., to reduce glare when performing tests in direct sunlight, etc.).

Note: The POV moving platform presently used by NHTSA is measures 12 x 8 ft (3.7 x 2.4 m), and was constructed from two layers of 1/4-in plywood. To reduce wear, three 3-in (76.2 mm) ultra-high molecular weight (UHMW) plastic strips are secured along the length of the platform bottom; one close to each longitudinal edge, one near the center. To accommodate the POV lateral restraint track specified in S7.6, it is anticipated that the single center strip will be replaced by two strips of similar dimensions, spaced approximately 1/8-in (3.2 mm) wider than the 4-in (102 mm) track. The center of this "gap" will be the centerline of the platform.
Use of 3/16-in (4.8 mm) wide plastic zip-ties to secure the POV to the moving platform is recommended. This securing method allows the POV to easily break away from the attachment points in the event SV-to-POV contact occurs.

The front of the platform shall be connected to a tensile load cell attached to the rear of a tow vehicle with a low-creep, abrasion-resistant rope (e.g., 3/8-in (9.5 mm) diameter braided Vectran or equivalent). Due to the potential for damage to the SV during test conduct, use of tow line manufactured from braided steel cable is not recommended. Use of 1/4-in (6.4 mm) wide plastic zip-tie "fuses" to attach the tow rope to the moving platform and to the POV tow vehicle is recommended.

7.6 Principal Other Vehicle (POV) Lateral Restraint Track

To allow the POV tow vehicle to pull the POV in a straight line without affecting the lateral orientation between the two, a lateral restraint track shall be used during conduct of the Slower POV tests described in S12.4.

Note: Detailed POV lateral restrain track specifications are presently under development, and may ultimately be provided in the Appendix of this document. Conceptually, this straight track is envisioned to be a single 1000 ft (305 m) long plastic strip secured to the test surface in the center of the travel lane. This strip will likely have a rectangular cross section of approximately 0.75 x 4-in (19 x 102 mm). The bottom of the POV moving platform would have a similarly – sized "notch" that would allow the platform to interface with the track.

7.7 Principal Other Vehicle (POV) Tow Vehicle

During conduct of the Slower Moving POV tests described in S12.4, a tow vehicle shall be used to bring the POV and POV Moving Platform combination to the desired test speed. This mitigates many of the logistic issues associated with having the POV being self-propelled. However, since the POV does not contain any instrumentation, its state must be derived by translating known parameters of the POV tow vehicle back to the POV. The accuracy of this translation strongly depends maintaining a known longitudinal and lateral distance between the POV and POV tow vehicle. For the sake of driver safety, the distance between the POV and

POV tow vehicle shall nominally be 100 ft (31 m), however the actual distance shall be measured and recorded in S8.3.10.

8.0 INSTRUMENTATION AND CALIBRATION

8.1 Required Test Equipment

1. Portable tire pressure gauge with an operating pressure of at least 100 psi (700 kPa), graduated increments of 0.1 psi (1 kPa), and an accuracy of at least ±2.0% of the applied pressure.

2. Global Positioning System (GPS) equipment capable of providing position data (latitude and longitude) with at least 1.6 in (4.1 cm) static accuracy, 3.9 in (10 cm) dynamic accuracy, and update at a rate of at least 10 Hz. Use of a GPS system that provides real-time SV-to-POV headway data to the SV driver is recommended (e.g., via a windshield-mounted display)

    A. For the Stopped POV tests described in S12.3, one GPS rover (a receiver) shall be installed in the SV. The rear-most location of the POV shall be surveyed and represented by a fixed point. For these tests, SV-to-POV headway is defined as the longitudinal distance from the front most location of the SV to the fixed point.

    B. For the Slower Moving POV tests described in S12.4, one GPS rover shall be installed in the SV and one in the POV tow vehicle. For this test, SV-to-POV headway is defined as the longitudinal distance from the front most location of the SV to the rear of the POV.

3. A data acquisition system (DAS) shall be installed in the SV. The DAS shall record GPS data from the SV and POV tow vehicle, SV yaw rate and longitudinal acceleration, and POV tow rope tension. Alternatively, POV rope tension may be recorded by a DAS installed in the POV if the respective data files are synchronized with those collected by the SV DAS.

4. All data shall be sampled at 100 Hz.

5. Signal conditioning shall consist of amplification and digitizing. Amplifier gains shall be selected to maximize the signal-to-noise ratio of the digitized data. Filtering of the data as it is collected is not necessary. However, if a filter is applied to incoming data, it shall be of a low-pass Butterworth specification with nominal cutoff frequencies selected to prevent aliasing.

8.2 Calibration

Before the Contractor initiates the test program, a test instrumentation calibration system must be implemented and maintained in accordance with established calibration practices. Guidelines for setting up and maintaining such calibration systems are described in MIL-C-45662A, "Calibration System Requirements." The calibration system shall be set up and maintained as follows:

1. Standards (e.g., reference equipment) for calibrating the measuring instruments and test equipment will be stored and used under appropriate environmental conditions to assure their accuracy and stability.

2. All measuring instruments, test equipment, and test standards shall be calibrated by the Contractor, or a commercial facility, against a higher order standard at periodic intervals not exceeding 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. The calibration frequency can be increased if deemed necessary by NHTSA.

3. All measuring instruments, test equipment, and test standards will be labeled with the following information:

    A. Date of calibration

    B. Date of next scheduled calibration

    C. Name of the organization and 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:

        i. Type of equipment, manufacturer model number, etc.

        ii. Measurement range

        iii. Accuracy

        iv. Calibration interval

        v. Type of standard used to calibrate the equipment (calibration traceability of the standard must be evident)

        vi. The actual procedures and forms used to perform the calibrations.

4. Records of calibration for all test instrumentation shall be kept by the Contractor in a manner that assures the maintenance of established calibration schedules. All such

records shall be readily available for inspection when requested by the COTR and shall be included in the final test report. The calibration system will need the acceptance of the COTR before testing commences.

5. Test equipment shall receive a pre- and post-test zero and calibration checks. These checks shall be recorded by the test technician(s) and submitted with the final report.

NOTE: If review of these data provided in S6.1 reveals questionable or inconsistent results, additional calibration checks of some critically sensitive test equipment and instrumentation may be required for verification of accuracy. The necessity for the calibration will be at the COTR's discretion and will be performed without additional cost to the OCAS.

8.3 Test Vehicle Measurement and Preparation

1. All sensors used by the SV CIB system, and any part of the vehicle immediately ahead of them (e.g., plastic trim, the windshield, etc), shall be free of debris or obstructions.

2. The SV airbags shall be disabled using instructions provided by the OCAS.

3. Use of adhesive-backed temporary paint protection applied to the front bumper, front fenders, hood, A-pillars, and the front face of the side mirrors of the SV is highly recommended. However, the protective material must not obstruct any sensor providing data to the DBS system.

4. The SV tires shall be inflated to the recommended cold inflation pressure specified on the vehicle placard or optional tire inflation pressure label.

5. All non-consumable fluids must be at 100 percent capacity for the SV. SV Fuel must be maintained at least 75 percent capacity during the testing.

6. The SV shall be loaded with one driver and all required equipment during the testing. Where possible, the equipment shall be placed on the passenger side of the vehicle. Inclusion of an in-vehicle experimenter to assist the SV driver with test conduct (e.g., data acquisition, completion of logs, etc.) is permitted. Where possible, the in-vehicle experimenter shall be seated in the first seating position behind the driver’s seat.

7. The centerline of the SV, POV, and POV tow vehicle shall be measured and recorded.

8. The lateral, longitudinal, and vertical positions of the GPS antennas installed on the SV and POV tow vehicle shall be measured and recorded.

9. For the SV, the longitudinal distance from the GPS antenna to the front-most position of the front bumper shall be measured and recorded.

10. With the POV tow rope tension at the magnitude determined in S12.1.1.3, the longitudinal distance from the GPS antenna of the POV tow vehicle to the rear-most position of the POV rear bumper shall be measured and recorded.

9.0 PHOTOGRAPHIC DOCUMENTATION

Each vehicle shall be documented with color still pictures. Each test trial shall be documented using a color video camera. To facilitate visual analyses, light glare and shadows must be minimal.

9.1 Cameras Required

CAMERA 1: Real-time video inside of the SV.

CAMERA 2: Real-time video camera to one side of the most significant even area of the test.

CAMERA 3: A still camera to document the vehicle.

9.2 Informational Placards

Vehicle identification placards shall be positioned so that at least one placard will be visible in the field-of-view for at least one video camera. The following information will be shown:

1. Vehicle's NHTSA Number
2. The words “OCAS DYNAMIC BRAKE SUPPORT TEST”
3. Date of test
4. Name of contract laboratory
5. Vehicle year, make, and model

9.3 Test Video Title and Ending

Test video shall include the following title frames:

1. “The following Dynamic Brake Support test was conducted under contract with the National Highway Traffic Safety Administration by (name and location of test laboratory)”
2. OCAS DYNAMIC BRAKE SUPPORT TEST
3. TEST VEHICLE MODEL YEAR, MAKE, AND MODEL
4. NHTSA No. CXXXXX

5. DATE OF EVENT
6. CONTRACT NO.: DTNH22-XX-X-XXXXX
7. The ending frame shall state "THE END"

9.4 Film Editing

The film shall be edited in the following sequence below. Any vehicle failures shall be completely documented.

1. Title
2. Pretest Coverage
3. Real Time Pan Coverage
4. Post test Coverage
5. "The End"

9.5 Still Photographs

The following still photographs (8 x 10 inch or 8.5 x 11 inch color prints properly focused for clear images) are required for the test:

1. Pretest, uninstrumented pictures of the SV (front, rear, and four three-quarter pictures)
2. Pretest, instrumented pictures of the SV, POV, and POV tow vehicle (front, rear, four three-quarter pictures, and pictures of the instrumentation)
3. SV tire placards
4. Window Sticker (i.e., Monroney label)

10.0 DEFINITIONS

Dynamic Brake Support (DBS) is a technology that actively increases the amount of braking provided to the driver during a rear-end crash avoidance maneuver. If the driver has applied force to the brake pedal, DBS uses forward-looking sensor data provided by technologies such as RADAR, LIDAR, video cameras, etc. to assess the potential for a rear-end crash. Should DBS ascertain a crash is likely (i.e., the sensor data indicate the driver has not applied enough braking to avoid the crash), DBS automatically intervenes. Although the manner in which DBS has been implemented differs among vehicle manufacturers, the objective of the interventions is largely the same: supplement the driver's commanded brake input by increasing the output of the foundation brake system. In some situations, the increased brake force provided by DBS may allow the driver to avoid a crash. In other cases, DBS interventions mitigate crash severity.

10.1 System Purpose

DBS systems intervene in driving situations where a rear-end collision is expected to be unavoidable unless additional braking is realized. Since they are designed to occur so late in the pre-crash timeline, and the driver has already initiated crash avoidance braking, DBS systems are not required to alert the driver a DBS intervention has occurred. Although DBS may be provided in combination with an adaptive cruise control (ACC) system, **use of any form of cruise control (i.e., conventional or ACC), to automatically control the SV speed is not permitted during test conduct**.

10.2 System Attributes

1. Provides for continuous monitoring of vehicles in the forward pathway of the SV vehicle using sensing/communications technologies such as RADAR, LIDAR (laser), video cameras, etc., or any combination thereof.

2. The DBS system shall initialize, and be available to automatically supplement the SV brakes, when the vehicle is traveling ≥10 mph (≥16 km/h), and remain operational throughout the vehicle's attainable speed range (up to V_{max}).

3. There may be weather and/or infrastructure situations when the DBS system cannot detect vehicles in the forward pathway of the SV. DBS systems may also be limited in capability and/or accuracy due to other factors such as sensor blockage or interference, visibility conditions, roadway geometry, roadside clutter, etc. It is not the intention of the test procedures described in this document to simulate or accommodate these situations, as false, delayed, or missed warnings may occur.

10.3 Failure Mode Operation

If the DBS system is operating in a failure mode (e.g., the system is not operational due to environmental, mechanical, or software-related reasons), the system shall suppress DBS interventions and notify the driver of the failure condition.

10.4 Suppressed Operation During Test Conduct

Some DBS systems include control algorithms capable of delaying and/or suppressing system activation under certain real-world operating conditions. These algorithms are intended to minimize the likelihood of "false activations" (i.e., DBS interventions that occur when not necessary) or "undesired activations" (i.e., during times where an individual is actively driving, but operating their vehicle within a close proximity to another immediately in front of them). In either case, the intent of DBS suppression is to avoid activations that violate the expectation of an attentive driver.

The tests described in this document are expected to be performed within the idealized confines of a test track with careful and deliberate inputs from the driver. As such, DBS system suppression is not expected to occur during conduct of valid test trials.

11.0 PRETEST AND FACILITY REQUIREMENTS

11.1 Detailed Test and Quality Control Procedures Required

Prior to conducting any test, Contractors are required to submit a detailed in-house test procedure to the COTR which includes:

1. A step-by-step description of the methodology to be used.

2. A written Quality Control (QC) Procedure which shall include calibrations, the data review process, report review, and the people assigned to perform QC on each task.

3. A complete listing of test equipment which shall include instrument accuracy and calibration dates.

4. Detailed check-off lists to be used during the test and during data review. These lists shall include all test procedure requirements. Each separate check off sheet shall identify the lab, test date, vehicle, and test technicians. These check sheets shall be used to document that all requirements and procedures have been complied for each test. The check sheets should be kept on file.

5. There shall be no contradiction between the laboratory test procedure and the Contractor's in-house test procedure. The procedures shall cover all aspects of testing from vehicle receipt to submission of the final report. Written approval of the procedures must be obtained from the COTR before initiating the test program so that all parties are in agreement.

11.2 Road Test Surface

Unless specified otherwise, the road surface where the tests are performed shall be dry (without visible moisture on the surface). The roadway shall be straight and flat, with pavement in good condition. The roadway surface shall be constructed from asphalt or concrete, and free of potholes, bumps, and/or cracks that could cause the SV to pitch excessively.

Each trial shall be conducted with no other vehicles (except the POV and the POV tow vehicle, where applicable), obstructions, or stationary objects within one lane width of either side of the SV lane of travel.

The roadway used for the DBS tests may be delineated with up to two solid white lane lines. If a single lane line is used, the centerline of the SV and POV shall nominally be 6 ft from the inside edge of the line for the duration of the test. Additionally, the orientation of the SV, POV, and POV tow vehicle centerlines to the single lane line shall remain constant for the duration of the test. See S12.3.3.6 and S12.4.3.6 for lateral tolerances allowable during test conduct.

Example: If the single line is 6 ft (1.8 m) from left side of the SV centerline at the beginning of the test, the line shall also be 6 ft (1.8 m) from the left side of the POV centerline. If two lane lines are present, the distance between the inside edges shall be at least 12 ft (3.7 m), and the vehicles shall remain in the center of the lane for the duration of the trial.

11.3 Ambient Conditions

11.3.1 Ambient Temperature

The ambient temperature shall be between 32° F (0° C) and 100° F (38° C).

11.3.2 Wind Speed

The maximum wind speed shall be no greater than 22 mph (10 m/s).

11.3.3 Inclement Weather

Tests shall not be performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, and/or ash.

11.3.4 Visibility

The tests shall be conducted during daylight hours with good atmospheric visibility, defined as an absence of fog and the ability to see clearly for more than 3.1 mi (5000 m). The tests shall not be conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera “washout” or system inoperability results.

All tests shall be conducted in an area void of overhead signs, bridges, or other significant structures over or near the testing site. Each trial shall be conducted with no vehicles (as indicted in S11.2), obstructions, or stationary objects within one lane width of either side the vehicle path.

11.4 Instrumentation Required

Each test vehicle shall be equipped with instrumentation and a data acquisition system. Nominal equipment location and weight specifications are presented in Table 1.

Table 1 – Test Equipment Location and Weights

Equipment Description	Typical Location	Nominal Weight
Data Acquisition System	Front passenger-side seat of SV	58 lbs (26 kg)
Integrated Inertial Measurement Unit and GPS (SV)	Antenna(s)[1] mounted to the roof of the SV. IMU/GPS near the center of the vehicle, just behind the front seats. GPS acquisition and ancillary equipment installed/secured on the rear passenger-side seat.	≈15 lbs (6.8 kg)
Programmable Brake Controller	Brake actuator is connected to the SV brake pedal, floor, and seat. The brake controller electronics box is typically secured in the footwell behind the front passenger seat.	Actuator ≈8 lbs (3.6 kg) Electronics Box ≈15 lbs (6.8 kg)
Vehicle-to-vehicle range receiver (SV) *(wireless communication between the SV and POV tow vehicle)*	Antenna mounted to the roof of the SV. Ancillary equipment secured on the rear passenger-side seat.	≈10 lbs (4.5 kg)
Integrated Inertial Measurement Unit and GPS POV tow vehicle)	Antenna(s)[1] mounted to the roof of the POV tow vehicle. IMU/GPS near the center of the vehicle, just behind the front seats. GPS acquisition and ancillary equipment are installed and secured on the rear passenger-side seat.	≈15 lbs (6.8 kg)
Vehicle-to-vehicle range transmitter (POV tow vehicle) *(wireless communication between the SV and POV tow vehicle)*	Antenna mounted to the roof of the POV tow vehicle. Ancillary equipment secured on the rear passenger-side seat.	≈8 lbs (3.6 kg)

[1]Two antennas are necessary if communication with a local base station is used (i.e., to provide real time kinematic correction of GPS position data).

11.4.1 Data Collection

All analog data shall be sampled at 100 Hz. Signal conditioning shall consist of amplification and digitizing. Amplifier gains are shall be selected to maximize the signal-to-noise ratio of the digitized data. Filtering of the data as it is collected is not necessary. However, if a filter is applied to incoming data, it shall be of a low-pass Butterworth specification with nominal cutoff frequencies selected to prevent aliasing. Data collection shall be initiated at least three seconds before the start of the test maneuver.

11.4.2 Sensors and Sensor Locations

An overview of the sensors used for the tests described in this document is provided in Table 2.

Table 2 – Recommended Sensor Specifications

Type	Output	Range	Resolution	Accuracy
Longitudinal Speed Sensor[1]	SV and POV longitudinal speed	0.1 – 62 mph (0.1 -100 km/h)	0.1 mph (0.2 km/h)	+/- 0.25% of full scale
Rate Sensor[1]	SV Yaw Rate	+/- 100 deg/s	0.01 deg/s	+/- 0.25% of full scale
Accelerometer	SV longitudinal deceleration	+/- 2g	+/- 0.001g	+/- 0.01% of full scale
Load Cell	Brake controller actuator force	0-300 lbf (0 – 1.3 kN)	0.25 lbf (1.1 N)	+/- 0.08% of full scale
Rotary Encoder	Brake controller actuator stroke	0 - 8 in (20.3 cm)	3200 pulses per inch	0.04 in (0.5 mm)
Load Cell	Vehicle brake pedal force	0-300 lbf (0 – 1.3 kN)	0.25 lbf (1.1 N)	+/- 0.08% of full scale
Position Sensor	Vehicle brake pedal position	0 - 8 in (20.3 cm)	0.001 in (0.03 mm)	0.01 in (0.4 mm)
Position Sensor	Vehicle throttle position	0 - 100 percent (normalized)	0.1 percent	0.1 percent
Various	Longitudinal position of SV and POV	650 ft (200 m)	2 in (5 cm)	> 3.9 in (10 cm) absolute
Various	Lateral position of SV and POV	650 ft (200 m)	2 in (5 cm)	> 3.9 in (10 cm) absolute
Vehicle Dimensional Measurements	Location of SV and POV tow vehicle GPS antennas; SV, POV, and POV tow vehicle centerlines; front-most SV bumper position; and rear-most POV bumper position	N/A	0.04 in (1 mm)	0.04 in (1 mm)
SV-to-POV static range	Distance between POV tow vehicle reference point (typically the longitudinal CG) and rear-most POV bumper position. Measurement taken with tow line tension determined in S12.1.1.	N/A	2 in (5 cm)	> 3.9 in (10 cm) absolute
POV Moving Platform Load	Tension in rope used to tow the POV and POV moving platform combination	0 – 500 lbf	+/- 0.5 lbf (+/- 2.2 N)	+/- 2.5 lbf (+/- 11.1 N)

[1]Differentially corrected GPS may be used to provide data to calculate vehicle speed and yaw rate in lieu of direct measurement provided the resulting accuracy is comparable.

11.4.2.1 Vehicle Speed

SV and POV longitudinal vehicle speed shall be measured. Use of contact or non-contact based speed sensors is acceptable. Alternatively, GPS based sensors that have an update rate ≥ 100

Hz are acceptable. Sensor outputs are to be transmitted not only to the data acquisition system, but also to a dashboard display unit in the SV. This allows the driver to accurately monitor vehicle speed.

11.4.2.2 Yaw Rate

SV yaw rate shall be measured. Alternatively, differentially corrected GPS may be used to provide data to calculate yaw rate in lieu of direct measurement, provided the resulting accuracy is comparable.

11.4.2.3 Programmable Brake Controller Applications

To achieve accurate, repeatable, and reproducible brake applications, a programmable brake controller shall be used to apply all inputs described in this test procedure. The controller presently used by NHTSA consists of an electronically controlled linear actuator attached to the SV brake pedal with a hemispherical joint connected to a small bracket clamped to the pedal. The opposing end of the actuator is attached to an inline load cell, which is then attached to a universal mounting fixture to provide reactionary support.

Note: Brake actuator stroke and application force, measured along a longitudinal axis of the actuator, are data channels typically provided by a programmable brake controller. These data shall be monitored and collected during test conduct to insure the brake controller is operating as commanded. However, due to the articulation of the SV brake pedal with respect to the actuator attachment point, the controller measurements may not be equivalent to the movement seen at the pedal itself.

To maximize consistency, the programmable brake controller shall have the capability to apply constant applications of brake pedal displacement (i.e., pedal travel) or application force. The mode of operation shall be user-selectable.

1. **Constant actuator displacement.** By maintaining constant actuator stroke, the position of the vehicle's brake pedal remains fixed for the duration of the input. To achieve this, the brake controller modulates application force.

2. **Constant actuator force.** By maintaining constant actuator force, the force applied to the center of the vehicle's brake pedal remains fixed for the duration of the input. To achieve this, the brake controller modulates actuator displacement.

11.4.2.4 Vehicle Brake Pedal

Vehicle brake pedal inputs shall be measured to facilitate correlation with those provided by the brake controller actuator. A single axis load cell shall be securely attached to vehicle brake pedal and positioned such that the normal force applied to the center of the brake pedal is measured. Use of a LASER-based linear position sensor shall be used to measure the position of

the vehicle brake pedal horizontal centerline is recommended. This sensor shall be securely installed at a location unaffected by the brake controller hardware or operation.

11.4.2.5 Vehicle Throttle Pedal Position

Vehicle throttle pedal position measurements are required to verify the test input choreography has been correctly executed. Throttle pedal position shall be expressed as a percentage of the wide open throttle (WOT) pedal position.

11.4.2.6 Longitudinal and Lateral Position

Longitudinal and lateral position of the SV and POV can be measured by several different sensors and/or measurement techniques provided they meet the range, resolution, and accuracy specifications provided in Table 2. The longitudinal and lateral positions of the SV and POV shall be reported in the same coordinate system.

12.0 TEST EXECUTION AND TEST REQUIREMENTS

If the SV is equipped with an automatic transmission, all trials shall be performed in ‘‘Drive.’’ If equipped with a manual transmission, the highest gear capable of sustaining the desired test speed shall be used. Manual transmission clutches are to remain engaged during all test trials throughout the validity periods described in S12.3.7 and S12.4.7.

DBS system performance shall be evaluated in accordance with the following test procedures described in S12.3 and S12.4.

12.1 General Vehicle Prep and Pre-Test Conditioning

12.1.1 POV Moving Platform Tow Load Assessment

Since the instrumentation used to assess the POV speed and SV-to-POV headway originates at the POV tow vehicle, it is important that an accurate distance between the POV and POV tow vehicle during test conduct be known.

1. The POV shall be secured to the POV moving platform, and the platform attached to the POV tow vehicle in a manner described in S12.4.1.1 through S12.4.1.5.

2. The POV tow vehicle shall be driven at 20 mph (32.1 km/h), in a straight line, for approximately 350 ft (107 m) over the surface the DBS tests described in S12.4 will be performed. The POV tow vehicle driver shall use smooth throttle modulation to maintain speed with a tolerance of ±1.0 mph (±1.6 km/h).

3. While traveling at a steady 20 mph (32.1 km/h), the force required to pull the POV and POV moving platform combination shall be averaged over a 10 second sampling interval.

This value shall be used for the pre-test tow rope tensioning described in S12.4.1.6 and S12.4.2.3.

12.1.2 SV Brake Conditioning

To insure consistent performance, new brake components shall be conditioned once in the following manner:

1. From a speed of 35 mph (56.3 km/h), conduct ten (10) stops with an average deceleration of approximately 0.5 g per stop.

2. Immediately following the series of 35 mph (56.3 km/h) stops, conduct three additional stops from 45 mph (72.4 km/h) with ABS cycling for the majority of each braking event.

3. Following completion of the final stop, the SV shall be driven at a speed of 45 mph (72.4 km/h) for five minutes to allow brake temperature to stabilize.

12.1.3 Brake Warm-up and Temperature Maintenance

If the SV vehicle remains stationary for longer than 15 minutes any time prior to the conduct of the DBS tests described in S12.2 through S12.4, a series of three brake stops shall be performed with the SV from a speed of 45 mph (72.4 km/h) to warm the brakes. The longitudinal deceleration target of these stops shall be approximately 0.7 g.

A minimum of three (3) minutes must elapse between the completion of the last warm-up stop and the onset of a valid test trial, and between the completion of the individual test trials described in S12.3 and 12.4.

12.1.4 Instrumentation Initialization

All instrumentation shall be secure and properly configured. With all instrumentation off, the SV and POV tow vehicle shall be driven to an outdoor location unobstructed by buildings, overpasses, or other structures capable of interfering with the ability of the GPS equipment to acquire satellite-based position information, and real-time base station corrections (where applicable). At this location, the instrumentation shall be turned on, and static and dynamic GPS initializations be performed.

1. Static initialization

    A. The transmissions of the SV and POV tow vehicle shall be placed in park (automatic transmission) or neutral with the emergency brake enabled (manual transmission).

B. The SV and POV tow vehicle shall remain at rest until transmissions from least six (6) GPS satellites have been obtained and indicated by the vehicle's respective instrumentation.

2. Dynamic initialization

   A. The vehicles shall be driven in a straight line, at a speed of at least 35 mph (56.3 km/h) for at least 350 ft (107 m).

   B. The vehicles shall be driven in three figure eight patterns. The radii of the turns shall be approximately 20 ft (6 m).

   C. Repeat steps 12.1.4.2.A and 12.1.4.2.B until the vehicle's respective instrumentation indicates that the required accuracies for position and heading have been achieved.

12.1.5 DBS System Initialization

Before DBS system performance can be properly assessed, some vehicles require a brief period of initialization. During this time, diagnostics to verify functionality and sensor calibrations are performed. If system initialization is required by a particular DBS system, the OVSC will obtain the appropriate procedure from the respective vehicle manufacturer, and provide it to the Contactor. The Contractor shall perform any OVSC-provided initialization schedule prior to performing the tests specified in S12.3 and S12.4.

12.2 Foundation Brake System Characterization

Foundation brake system characterization is used to objectively quantify the brake response of a vehicle without the contribution of advanced technologies such as DBS, brake assist, etc.

12.2.1 General Requirements

For an individual trial to be valid, the following must hold true throughout the test:

1. The SV driver seatbelt must be latched.

2. The front passenger seatbelt must be unlatched.

3. The SV shall be driven at the in the center of the travel lane.

4. The driver shall use the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period specified in S12.2.5. Use of abrupt steering inputs or corrections shall be avoided.

5. The yaw rate of the SV must not exceed ±1.0 deg/s during the validity period specified in S12.2.5.

6. The lateral distance between the centerline of the SV, relative to the centerline of the roadway, in road coordinates, shall not exceed 1 ft (0.3 m) during the validity period specified in S12.2.5.

12.2.2 Nominal SV Speed

1. All foundation brake system characterization tests shall be initiated using a nominal SV speed of 45 mph (72.4 km/h).

2. The validity of the nominal SV speed shall be assessed at the instant the brake pedal application is initiated.

The SV speed shall not deviate more than ±1.0 mph (±1.6 km/h) during a time from two (2) seconds prior to the brake application, to the instant the brake application is initiated.

12.2.3 Throttle Pedal Inputs

1. For all tests the SV driver shall modulate the throttle, using smooth inputs, to maintain a constant SV speed for two (2) seconds prior to smoothly releasing the throttle. Abrupt throttle inputs shall be avoided.

2. The throttle pedal shall be fully released at least one (1) second before the brake pedal applications described in S12.2.4 are input. Throttle pedal release rate is unrestricted.

12.2.4 Brake Pedal Inputs

1. The SV brakes shall be brought up to operating temperature using the methods described in S12.1.3.

2. Choreography

    A. Each test trial shall begin with the brake pedal in its natural resting position, with no preload or position offset.

    B. For each test trial, the SV brakes are applied at least one (1) second after the throttle is released.

    C. The onset of the brake application occurs when the brake actuator has applied 2.5 lbf (11 N) of force to the brake pedal.

D. The brake application force shall be measured by a load cell that measures the force applied by the brake controller actuator. Due to the articulation of the SV brake pedal with respect to the actuator attachment point, the force applied by the controller may not be equivalent to the force acting perpendicular to the pedal itself.

E. The validity of the throttle release-to-brake application choreography shall be assessed from the instant the brake pedal application is initiated.

3. Application Magnitude

   A. For each test trial, the brake pedal displacement necessary to realize a deceleration of at least 0.7g shall be applied in conjunction with the application rate specified in S12.2.4.4.

   B. If the SV cannot achieve a deceleration of 0.7g, the brake pedal displacement need to realize maximum deceleration shall be applied during each test trial.

4. Application Rate

   A. The SV brake pedal application rate shall be 1 to 2 in/s (25 to 51 mm/s).

   B. Application rate is defined as the slope of a first order linear regression line applied to brake pedal position data over a range from 25 to 75% of the commanded input magnitude.

12.2.5 Validity Period

1. The valid test interval begins two (2) seconds prior to the SV throttle release.

2. The valid test interval ends when either the SV comes to a stop.

12.2.6 End of Test Instructions

1. For each test trial, after the validity period specified in S12.2.5 is complete, the SV driver shall manually apply force to the brake pedal, disengage the programmable brake controller, and place the transmission in park (automatic transmission) or neutral (manual transmission).

2. The brake system characterization test trial is complete.

12.2.7 Number of Test Trials

A total of eight (8) valid trials shall be performed for brake system characterization.

12.2.8 Brake System Characterization Output

Brake system characterization data shall be used to calculate the brake pedal input magnitudes needed for the tests described in S12.3 and S12.4. In the context of this test procedure, input magnitude are defined in two ways: brake pedal displacement and brake pedal application force.

The stringency of the test procedures described in S12.3 and S12.4 is believed to be similar, regardless of how the brake pedal input magnitude and application rate are defined. However, for some vehicle implementations, realizing proper DBS system performance may depend on what brake application control logic is specified. For this reason, an OCAS representative will specify to the Contractor which programmable brake controller feedback loop shall be used for a vehicle's respective evaluation.

1. Brake Pedal Displacement

    A. For each test trial, a first order regression line shall be applied to brake pedal position versus SV deceleration data from 0.25 to 0.55 g (2.5 to 5.4 m/s^2).

    B. For each test trial, the equation of the regression line shall be used to calculate what brake pedal position magnitude produced a deceleration of 0.3g

    C. An average brake pedal position magnitude shall be calculated from the eight individual test trial results produced in S12.2.8.1.B.

2. Brake Pedal Application Force

    A. For each test trial, a first order regression line shall be applied to brake pedal application force versus SV deceleration data from 0.25 to 0.55 g (2.5 to 5.4 m/s^2).

    B. For each test trial, the equation of the regression line shall be used to calculate what brake pedal application force magnitude produced a deceleration of 0.3g

    C. An average brake pedal application force magnitude shall be calculated from the eight individual test trial results produced in S12.2.8.2.B.

12.3 Subject Vehicle Encounters a Stopped Principal Other Vehicle on a Straight Road

This test evaluates the ability of the DBS system to detect, and respond to, a stopped lead vehicle in the immediate forward path of the SV. Should the SV foundation brake system be unable to prevent an SV-to-POV impact for a given test condition, the DBS system shall automatically provide supplementary braking intended to prevent an SV-to-POV collision.

12.3.1 POV Placement

1. The POV shall be positioned in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge, and the POV facing the same direction as the front of the SV, so the SV approaches the rear of the POV.

2. The POV shall be secured to the ground such that its position relative to the roadway remains constant for the duration of each test (i.e., up to the instant where SV-to-POV contact occurs).

3. The POV securing method shall allow the POV to easily break away from the restraints after SV-to-POV contact occurs. Fasteners used to secure the POV to the ground shall be nonmetallic or flush with the roadway surface.

4. Determine the position of the stationary POV.

12.3.2 Static Instrumentation Calibration

Calibration data shall be collected to assist in resolving uncertain test data.

1. The SV and POV shall be centered in the same travel lane.

2. The orientation of the SV and POV shall be the same (i.e., each must face the same direction).

3. The front-most location of the SV shall be positioned such that it just makes contact with a vertical plane that defines the rearmost location of the POV. This is the "zero position."

4. The zero position shall be documented prior to, and immediately after, conduct of a test series.

    A. If the "zero position" reported by the data acquisition system differs by more than ±2 in (±5 cm) from that actually measured during collection of the pre-test static calibration data file, the pre-test longitudinal offset shall be adjusted to output zero and another pre-test static calibration data file collected.

    B. If the "zero position" reported by the data acquisition system differs by more than ±2 in (±5 cm) from that actually measured during collection of the post-test static calibration data file, the Stopped POV tests performed between collection of that post-test static calibration data file and the last valid pre-test static calibration data file shall be repeated.

5. Static data files shall be collected prior to, and immediately after, conduct of the test series described in S12.3.3 through S12.3.9. The pre-test static files shall be reviewed prior to test conduct to confirm all data channels are operational and have been properly configured.

12.3.3 SV Approach to the Stopped POV

For an individual trial to be valid, the following must hold true throughout the test:

1. The SV driver seatbelt must be latched.

2. The front passenger seatbelt must be unlatched.

3. The SV shall be driven at one of the two nominal speeds specified in S12.3.4, in the center of the lane of travel, toward the stationary POV.

4. The driver shall use the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period specified in S12.3.7. Use of abrupt steering inputs or corrections shall be avoided.

5. The yaw rate of the SV must not exceed ±1.0 deg/s during the validity period specified in S12.3.7.

6. The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, shall not exceed 1 ft (0.3 m) during the validity period specified in S12.3.7.

7. The SV driver shall not manually apply force to the brake pedal during the validity period specified in S12.3.7. All braking shall be performed by the programmable brake controller at the TTC specified in S12.3.6.1.

12.3.4 Nominal SV Speeds

1. All Stopped POV test trials are performed using an SV speed of 25 mph (40.2 km/h)

2. SV speed shall not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 4.1 seconds to TTC = 2.1 seconds.

    A. When the SV test speed is 25 mph (40.2 km/h), TTC = 4.1 seconds is taken to occur at an SV-to-POV distance of 150 ft (45.8 m).

    B. When the SV test speed is 25 mph (40.2 km/h), TTC = 2.1 seconds is taken to occur at an SV-to-POV distance of 77 ft (24 m).

12.3.5 Throttle Pedal Inputs

1. For all tests the SV driver shall modulate the throttle, using smooth inputs, to maintain a constant SV speed for two (2) seconds prior to smoothly releasing the throttle. Abrupt throttle inputs shall be avoided.

2. At TTC = 2.1 seconds (see S12.3.4.2), the throttle pedal position shall be zero (i.e., fully released).

3. The throttle pedal shall be fully released at least one (1) second before the brake pedal applications described in S12.3.6 are input. Throttle pedal release rate is unrestricted.

12.3.6 Brake Pedal Inputs

1. Choreography

    A. For each test trial, the SV brakes shall be applied at TTC = 1.1 seconds.

    B. TTC = 1.1 seconds is taken to occur at an SV-to-POV distance of 40 ft (12 m).

    C. Each test trial shall begin with the brake pedal in its natural resting position, with no preload or position offset.

    D. The onset of the brake application occurs when the brake actuator has applied 2.5 lbf (11 N) of force to the brake pedal.

    E. The brake application force shall be measured by a load cell that measures the force applied by the brake controller actuator. Due to the articulation of the SV brake pedal with respect to the actuator attachment point, the force applied by the controller may not be equivalent to the force acting perpendicular to the pedal itself.

    F. The validity of the throttle release-to-brake application choreography shall be assessed from the instant the brake pedal application is initiated.

2. Application Magnitude

Brake application magnitude is defined in one of two ways, depending on which of the programmable brake controller's control feedback loops is specified:

    A. Brake Pedal Displacement Feedback

        i. The commanded input magnitude shall be based on brake pedal position.

ii. The commanded magnitude shall be that calculated in S12.2.8.1.C.

B. Brake Pedal Application Force Feedback

i. The commanded input magnitude shall be based on the force applied to the brake pedal.

ii. The commanded magnitude shall be that calculated in S12.2.8.2.C.

3. Application Rate

A. The SV brake pedal application rate shall be 5 to 7 in/s (127 to 178 mm/s).

B. When the programmable brake controller is configured to use Brake Pedal Displacement Feedback, application rate is defined as the slope of a first order linear regression line applied to brake pedal position data over a range from 25 to 75% of the commanded input magnitude.

C. When the programmable brake controller is configured to use Brake Pedal Application Force Feedback,

i. The brake pedal position at the instant the commanded brake pedal force is first realized is determined.

ii. Application rate is defined as the slope of a first order linear regression line applied to brake pedal position data over a range from 25 to 75% of the magnitude determined in S12.3.6.3.C.i.

12.3.7 Validity Period

1. The valid test interval begins when the SV-to-POV TTC = 4.1 seconds (see S12.3.4.2.A)

2. The valid test interval ends when either of the following occurs:

A. The SV comes in contact with the POV.

B. The SV comes to a stop before making contact with the POV.

12.3.8 End of Test Instructions

1. For each test trial, after the validity period specified in S12.3.7 is complete, the SV driver shall manually apply force to the brake pedal, disengage the programmable brake controller, bring the vehicle to a stop (if necessary), and place the transmission in park (automatic transmission) or neutral (manual transmission).

2. The Stopped POV trial is complete.

12.3.9 Number of Test Trials

Since only one of two brake controller feedback loops will be utilized per vehicle, a total of eight (8) valid trials per test speed and brake application combination shall be performed for the Stopped POV test scenario, as shown in Table 3.

Table 3. Stopped POV Test Trial Requirement.

Pre-Crash Scenario	Brake Controller Configuration		Number of Trials
	Displacement Feedback	Application Force Feedback	SV: 25 mph POV: 0 mph
Stopped POV	✓	--	8
Stopped POV	--	✓	8

12.3.10 Stopped POV Test Choreography Summary

As a courtesy to the Contractor, Table 4 presents a summary of the choreography used to perform the Stopped POV tests. Specifically, the TTCs and their respective distances to the POV are provided. The choreography shown in Table 4 is applicable for both brake pedal application magnitudes described in S12.3.6.2.

Table 4. Nominal Stopped POV DBS Test Choreography.

Test Speeds		Throttle Inputs				Brake Application Initiated *(for each application magnitude)*	
		Held Constant		Released			
SV	POV	TTC (seconds)	SV-to-POV Distance	TTC (seconds)	SV-to-POV Distance	TTC (seconds)	SV-to-POV Distance
25 mph (40.2 km/h)	0	4.1 → 2.1	150 → 77 ft (46 → 24 m)	2.1	77 ft (24 m)	1.1	40 ft (12 m)

12.4 Subject Vehicle Encounters a Slower Principal Other Vehicle on a Straight Road

This test evaluates the ability of the DBS system to detect, and respond to, a slower moving lead vehicle, traveling at a constant speed in the immediate forward path of the SV. Should the SV foundation brake system be unable to prevent an SV-to-POV impact for a given test condition, the DBS system shall automatically provide supplementary braking intended to prevent or mitigate an SV-to-POV collision.

12.4.1 POV Placement

1. The POV moving platform (described in S7.5) shall be placed on the POV lateral restraint track (described in S7.6) in the center of a travel lane.

2. The POV shall be positioned on the POV moving platform with its longitudinal axis oriented parallel to the roadway edge, and the POV facing the same direction as the front of the SV, so that the front of the SV approaches the rear of the POV.

3. The POV shall be secured to the POV moving platform such that its position relative to platform remains constant for the duration of each test (i.e., up to the instant where SV-to-POV contact occurs).

4. The POV securing method shall allow the POV to easily break away from the restraints in the event SV-to-POV contact occurs. Fasteners used to secure the POV to the POV moving platform shall be nonmetallic or flush with the roadway surface.

5. The front of the POV moving platform shall be attached to the rear of the POV tow vehicle using the hardware described in S7.5.

6. The tow vehicle shall be slowly driven forward to establish tow rope tension at the magnitude determined in S12.1.1 and stopped.

12.4.2 Static Instrumentation Calibration

Calibration data shall be collected to assist in resolving uncertain test data.

1. The SV, POV, POV moving platform, and POV tow vehicle shall be centered in the same travel lane.

2. The orientation of the SV, POV, and POV tow vehicle shall be the same (i.e., each must face the same direction).

3. With the POV tow rope tension at the magnitude determined in S12.1.1, the front-most location of the SV shall be positioned such that it just makes contact with a vertical plane that defines the rearmost location of the POV. This is the “zero position.”

4. The zero position shall also be documented prior to, and immediately after, conduct of a test series.

    A. If the zero position reported by the data acquisition system differs by more than ±2 in (±5 cm) from that actually measured during collection of the pre-test static calibration data file, the pre-test longitudinal offset shall be adjusted to output zero and another pre-test static calibration data file collected.

B. **If the zero position reported by the data acquisition system differs by more than ±2 in (±5 cm) from that actually measured during collection of the post-test static calibration data file, the Slower POV tests performed between collection of that post-test static calibration data file and the last valid pre-test static calibration data file shall be repeated.**

6. Static data files shall be collected prior to, and immediately after, conduct of the test series described in S12.4.3 through S12.4.9. The pre-test static files shall be reviewed prior to test conduct to confirm all data channels are operational and have been properly configured.

12.4.3 SV Approach to the Slower POV

For an individual trial to be valid, the following must hold true throughout the test:

1. The SV driver seatbelt must be latched.

2. The front passenger seatbelt must be unlatched.

3. The SV shall be driven at one of the two nominal speeds specified in S12.4.4, in the center of the lane of travel, toward the slower POV.

4. The driver shall use the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period specified in S12.4.7. Use of abrupt steering inputs or corrections shall be avoided.

5. The yaw rate of the SV must not exceed ±1.0 deg/s during the validity period specified in S12.4.7.

6. The lateral position of the POV moving platform shall not deviate more than ±1 ft (0.3 m) from the center of the travel lane.

7. The lateral distance between the centerline of the SV, relative to the centerline of the POV and POV tow vehicle, in road coordinates, shall not exceed 1 ft (0.3 m) during the validity period specified in S12.4.7.

8. The SV driver shall not manually apply force to the brake pedal during the validity period specified in S12.4.7. All braking shall be performed by the programmable brake controller at the TTC specified in S12.4.6.1.

12.4.4 Nominal SV and POV Speeds

1. Tests are performed using two combinations of SV and POV speeds:

A. SV: 25 mph (40.2 km/h), POV: 10 mph (16.1 km/h).

B. SV: 45 mph (72.4 km/h), POV: 20 mph (32.2 km/h).

2. SV and POV speed tolerances

   A. The SV speed shall not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by a TTC = 4 seconds to a TTC = 2 seconds.

      i. When the SV test speed is 25 mph (40.2 km/h) and the POV = 10 mph (16.1 km/h), TTC = 4 seconds is taken to occur at an SV-to-POV distance of 88 ft (27 m).

      ii. When the SV test speed is 45 mph (72.4 km/h) and the POV = 20 mph (32.2 km/h), TTC = 4 seconds is taken to occur at an SV-to-POV distance of 147 ft (45 m).

      iii. When the SV test speed is 25 mph (40.2 km/h) and the POV = 10 mph (16.1 km/h), TTC = 2 seconds is taken to occur at an SV-to-POV distance of 110 ft (34 m).

      iv. When the SV test speed is 45 mph (72.4 km/h) and the POV = 20 mph (32.2 km/h), TTC = 2 seconds is taken to occur at an SV-to-POV distance of 198 ft (60 m).

   B. The POV speed shall not deviate more than ±1.0 mph (±1.6 km/h) during the validity period specified in S12.4.7.

12.4.5 Throttle Pedal Inputs

1. For all tests the SV driver shall modulate the throttle, using smooth inputs, to maintain a constant SV speed for two (2) seconds prior to smoothly releasing the throttle. Abrupt throttle inputs shall be avoided.

2. At TTC = 2 seconds (see S12.3.3.2.A), the throttle pedal position shall be zero (i.e., fully released).

3. The throttle pedal shall be fully released at least one (1) second before the brake pedal applications described in S12.4.6 are input. Throttle pedal release rate is unrestricted.

12.4.6 Brake Pedal Inputs

1. Choreography

    A. For each test trial, the SV brakes shall be applied at TTC = 1.0 seconds.

        i. When the SV test speed is 25 mph (40.2 km/h) and the POV = 10 mph (16.1 km/h), TTC = 1 second is taken to occur at an SV-to-POV distance of 22 ft (7 m).

        ii. When the SV test speed is 45 mph (72.4 km/h) and the POV = 20 mph (32.2 km/h), TTC = 1 second is taken to occur at an SV-to-POV distance of 37 ft (11 m).

    B. Each test trial shall begin with the brake pedal in its natural resting position, with no preload or position offset.

    C. The onset of the brake application occurs when the brake actuator has applied 2.5 lbf (11 N) of force to the brake pedal.

    B. The brake application force shall be measured by a load cell that measures the force applied by the brake controller actuator. Due to the articulation of the SV brake pedal with respect to the actuator attachment point, the force applied by the controller may not be equivalent to the force acting perpendicular to the pedal itself.

    C. The validity of the throttle release-to-brake application choreography shall be assessed from the instant the brake pedal application is initiated.

2. Application Magnitude

Brake application magnitude is defined in one of two ways, depending on which of the programmable brake controller's control feedback loops is specified

    A. Brake Pedal Displacement Feedback

        i. The commanded input magnitude shall be based on brake pedal position

        ii. The commanded magnitude shall be that calculated in S12.2.8.1.C.

    B. Application Force Feedback control logic is used,

        i. The commanded input magnitude shall be based on the force applied to the brake pedal

ii. The commanded magnitude shall be that calculated in S12.2.8.2.C.

3. Application Rate

   A. The SV brake pedal application rate shall be 5 to 7 in/s (127 to 178 mm/s)

   B. When the programmable brake controller is configured to use Brake Pedal Displacement Feedback, application rate is defined as the slope of a first order linear regression line applied to brake pedal position data over a range from 25 to 75% of the commanded input magnitude

   C. When the programmable brake controller is configured to use Brake Pedal Application Force Feedback,

      i. The brake pedal position at the instant the commanded brake pedal force is first realized is determined

      ii. Application rate is defined as the slope of a first order linear regression line applied to brake pedal position data over a range from 25 to 75% of the magnitude determined in S12.4.6.3.i

12.4.7 Validity Period

1. The valid test interval begins when the SV-to-POV TTC = 4 seconds (see S12.3.4.2.A)

2. The valid test interval ends when either of the following occurs:

   A. The SV comes in contact with the POV.

   B. 1 second after the velocity of the SV becomes less than that of the POV.

12.4.8 End of Test Instructions

1. For each test trial, after the validity period specified in S12.4.7 is complete, the SV driver shall manually apply force to the brake pedal, disengage the programmable brake controller, bring the vehicle to a stop (if necessary), and place the transmission in park (automatic transmission) or neutral (manual transmission).

2. For each test trial, after the conditions in S12.4.8.1 have been satisfied, the POV tow vehicle driver shall apply the brakes and bring the vehicle to a stop.

3. The Slower Moving POV trial is complete.

12.4.9 Number of Test Trials

Since only one of two brake controller feedback loops will be utilized per vehicle, a total of sixteen (16) valid trials, eight (8) per test speed and brake application combination, shall be performed for the Slower Moving POV test scenario, as shown in Table 5.

Table 5. Slower Moving POV Test Trial Requirement.

Pre-Crash Scenario	Brake Controller Configuration		Number of Trials	
	Displacement Feedback	Application Force Feedback	SV: 25 mph POV: 10 mph	SV: 45 mph POV: 20 mph
Slower Moving POV	✓	--	8	8
Slower Moving POV	--	✓	8	8

12.4.10 Slower Moving POV Test Choreography Summary

As a courtesy to the Contractor, Table 6 presents a summary of the choreography used to perform the Slower POV tests. Specifically, the TTCs and their respective distances to the POV are provided. The choreography shown in Table 6 is applicable for both brake pedal application magnitudes described in S12.4.6.2.

Table 6. Nominal Slower Moving POV DBS Test Choreography.

Test Speeds		Throttle Inputs				Brake Application Initiated *(for each application magnitude)*	
		Held Constant		Released			
SV	POV	TTC (seconds)	SV-to-POV Distance	TTC (seconds)	SV-to-POV Distance	TTC (seconds)	SV-to-POV Distance
25 mph (40 km/h)	10 mph (16 km/h)	4.0 → 2.0	88 → 44 ft (27 → 13 m)	2.0	44 ft (13 m)	1.0	22 ft (7 m)
45 mph (72 km/h)	20 mph (32 km/h)	4.0 → 2.0	147 → 73 ft (45 → 22 m)	2.0	73 ft (22 m)	1.0	37 ft (11 m)

12.5 Diagnostic Trouble Codes (DTC)

Repeatedly impacting the POV may result in a diagnostic trouble code (DTC) being set by the SV's DBS system. Activation of a DTC, typically reported via illumination of a telltale within the SV instrument cluster, indicates a plausibility check has failed or that a system malfunction has been detected. In the event a DTC is presented, the Contractor must cease the respective test series and decipher what error the DTC has identified. If no damage has actually occurred to any DBS component, the DTC shall be cleared to bring the SV DBS system back online and initialized using the methods described in S12.1.5 (if applicable).

The OVSC will obtain the appropriate procedures for deciphering and/or clearing DTCs from the SV from the respective vehicle manufacturer, and will provide it to the Contactor in the event a DTC occurs. If this process requires specialized equipment from the SV manufacturer, the OVSC will provide it to the Contactor as Government Furnished Equipment (GFE) or make arrangements for technical support to be present during SV test conduct.

12.6 DBS Performance Requirements

No SV-to-POV impact shall occur for any valid test trial described in S12.3 and S12.4.

1. When the SV test speed is 25 mph (40.2 km/h), the POV = 0 mph, and TTC = 1.1 seconds, crash avoidance requires an effective deceleration[1] of approximately 0.52g (5.1 m/s^2).

2. When the SV test speed is 25 mph (40.2 km/h), the POV = 10 mph (16.1 km/h), and TTC = 1.0 seconds, crash avoidance requires an effective deceleration[1] of approximately 0.34g (3.4 m/s^2).

3. When the SV test speed is 45 mph (72.4 km/h), the POV = 20 mph (32.2 km/h), and TTC = 1.0 seconds, crash avoidance requires an effective deceleration[1] of 0.57g (5.9 m/s^2).

13.0 POST TEST REQUIREMENTS

13.1 Vehicle Data and Test Documentation

The Contractor shall collect all data necessary to complete the final test report data sheets and provide details of any problem areas.

13.2 Post Test Vehicle Inspection

The Contractor shall inspect the test vehicle after all testing is completed. Any vehicle modifications or damage shall be restored to the as-delivered condition or the vehicle shall be declared "totaled" and shall be disposed of as a totally destroyed vehicle. Disposition of the vehicle shall be determined by the Government. Any damage incurred to the vehicle during the actual tests, except damage caused by negligence of the Contractor, shall be the responsibility of the Government.

14.0 REPORTS

14.1 Monthly Status Reports

The Contractor shall submit a monthly Test Status Report and a Vehicle or Equipment Status Report to the COTR (both reports shown in this section). The Vehicle Status Report shall be

[1]Provided for informative purposes only. Effective deceleration interval is calculated over the entire brake pedal application interval, and does not consider the effects of brake system latency, rise time, precharge, etc.

submitted until all vehicles or items of equipment are disposed of.

14.2 Final Test Report

14.2.1 Copies

The Contractor shall provide the OCAS with two (2) CDs or DVDs, each including (1) a JPEG of the vehicle in its test mode, taken with a resolution of at least 800 x 600 pixels, and (2) test video footage.

In addition to the CD or DVD, the Contractor shall provide the OCAS with one paper copy of each Final Test Report.

The above documentation shall be submitted to the COTR according to the schedule indicated in S6.0.

Contractors are required to submit one color copy of each Final Test Report in draft form. DO NOT stamp *preliminary* or *draft* on this report. The COTR will review the draft report and notify the laboratory of any corrections that are required. If the COTR agrees to make changes to the test report, the Contractor shall mail the appropriate (the changed) pages to the COTR. The new pages will be inserted into the preliminary test report. At the end, the preliminary test report will be accepted with the inserted pages as the final test report.

14.2.2 Requirements

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

The Contractor should use detailed descriptions of all test events. Any events that are not directly associated with the test program 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 below for the purpose of standardization.

14.2.3 First Three Pages

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:

(A) Final Report Number such as OCAS-ABC-0X-001

Where:

OCAS is the Office of Crash Avoidance Standards,
ABC are the initials for the laboratory,
0X is the Fiscal Year of the test program,
001 is the Group Number (00 1 for the 1st test, 002 for the 2nd test, 003 for the 3rd test, etc.)

(B) Final Report Title and Subtitle such as

Final Report of Dynamic Brake Support Tests
****
World Motors Corporation
201X XYZ 4-door sedan
NHTSA No. CX0401

(C) Contractor's Name and Address such as

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

NOTE: DOT SYMBOL WILL BE PLACED BETWEEN ITEMS (C) AND (D)

(D) Date of Final Report completion

(E) The words “FINAL REPORT”

(F) The sponsoring agency's name and address as follows

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
Mail Code: NVS-120
1200 New Jersey Avenue SE, Room W43-478
Washington, DC 20590

First Page After Front Cover – A disclaimer statement and an acceptance signature block for the COTR shall be provided as follows:

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Prepared By: _____

Approved By: _____

Approval Date: _____

FINAL REPORT ACCEPTANCE BY OCAS:

_____

Manager, NHTSA, Office of Crash Avoidance Standards

Date: _____

_____

COTR, NHTSA, Office of Crash Avoidance Standards

Date: _____

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:

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OCAS-ABC-0X-001

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Leave blank

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Leave blank

Block No. 4 – TITLE AND SUBTITLE

Final Report of Dynamic Support Tests
of a 201X World XYZ Deluxe 4-door sedan
NHTSA No. CX0401

Block No. 5 – REPORT DATE

March 1, 201X

Block No. 6 – PERFORMING ORGANIZATION CODE

ABC

Block No. 7 – AUTHOR(S)

John Smith, Project Manager
Bill Doe, Project Engineer

Block No. 8 – PERFORMING ORGANIZATION REPORT NUMBER

ABC-DOT-XXX-001

Block No. 9 – PERFORMING ORGANIZATION NAME AND ADDRESS

ABC Laboratories
405 Main Street
Detroit, Ml 48070

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DTNH22-0X-D-1 2345

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Block No. 13 – TYPE OF REPORT AND PERIOD COVERED

Final Test Report
XXX to XXX, 201X

Block No. 14 – SPONSORING AGENCY CODE

NVS-120

Block No. 15 – SUPPLEMENTARY NOTES

Leave blank

Block No. 16 – ABSTRACT

These tests were conducted on the subject 201X World XYZ 4-door sedan in accordance with the specifications of the Office of Crash Avoidance Standards Test Procedure No. TP-OCAS-XX for the evaluation of a Dynamic Brake Support (DBS) system.

Block No. 17 – KEY WORDS

Dynamic Brake Support system, DBS

Block No. 18 – DISTRIBUTION STATEMENT

Copies of this report are available from the following:

NHTSA Technical Reference Division
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14.3.4 TABLE OF CONTENTS.....PAGE NO.

Sample Test Report Table of Contents:

Section 1 — Purpose and Summary of Test

Section 2 — Vehicle Information/Data Sheets

Section 3 — Photographs

Section 4 — Vehicle data traces

Section 5 — Test Equipment and Instrumentation Calibration

14.2.4 SAMPLE TEST REPORT INFORMATION

PURPOSE AND SUMMARY OF TEST

PURPOSE

This test is part of the Crash Avoidance program to assess Dynamic Brake Support (DBS) system performance, sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No._____. The purpose of this test was to obtain vehicle crash avoidance performance data for _____.

SUMMARY

DATA SHEET NO. DESCRIPTION

1. Test Summary
2. General Test and Vehicle Parameter Data
3. Post test Data
4. Test Vehicle Information
5. Vehicle Measurements

15.0 DATA SHEETS

DATA SHEET NO. 1

TEST SUMMARY

General Vehicle Information	
NHTSA Vehicle No.	Test Date
Vehicle Make/Model/Body Style	

General Test Facility Information	
Facility Designation (e.g., "Skid Pad Lane #4")	Test Surface (e.g., asphalt, concrete, etc.)
Surface Condition	

Pretest Conditions			
Time	Ambient Temperature (ºC)	Wind Speed (km/h)	Wind Direction
Test Vehicle-to-POV Distance During Static Cal, Measured (mm)		Test Vehicle-to-POV Distance During Static Cal, Displayed (mm)	

Post-test Conditions			
Time	Ambient Temperature (ºC)	Wind Speed (km/h)	Wind Direction
Test Vehicle-to-POV Distance During Static Cal, Measured (mm)		Test Vehicle-to-POV Distance During Static Cal, Displayed (mm)	

DATA SHEET NO. 2

FOUNDATION BRAKE SYSTEM CHARACTERIZATION INPUTS

Pedal Magnitude (in.)	Application Type (✓ if applicable)	
	Used To Produce SV Deceleration ≥0.7g	Use To Produce Maximum SV Deceleration[1]

FOUNDATION BRAKE SYSTEM CHARACTERIZATION OUTPUT SUMMARY

Test Trial	Regression Line Slope (Foundation Brake Gain)		Regression Line Coefficient		Application Magnitude at 0.3g Deceleration	
	Brake Pedal Displacement vs. SV Deceleration (in/g)	Applied Brake Pedal Force vs. Deceleration (lbf/g)	Brake Pedal Displacement vs. SV Deceleration	Applied Brake Pedal Force vs. Deceleration	Brake Pedal Displacement (in)	Applied Brake Pedal Force (lbf)
1						
2						
3						
4						
5						
6						
7						
8						
Series Mean						

DATA SHEET NO. 3

TEST SUMMARY

DBS Speed Reduction Summary (mph; km/h). If no SV-to-POV contact occurred, enter "NC".				
Trial #	**Brake Application Control Feedback (Indicate "Displacement" or "Force")**	**Test Condition**		
		Stopped POV	**Slower POV**	
		SV: 25 mph POV: 0 mph	**SV: 25 mph POV: 10 mph**	**SV: 45 mph POV: 20 mph**
1				
2				
3				
4				
5				
6				
7				
8				
Series Mean				

DATA SHEET NO. 4

VEHICLE DATA

NHTSA Vehicle No.		VIN	
Vehicle Make/Model/Body Style		Vehicle Test Weight (kg)	Exterior Color
Date of Manufacture		Date Received	
Pretest Odometer Reading	Post-test Odometer Reading	Fuel System Capacity (l) (from manual)	Allowable Fuel Level Range (l) (75 to 100% of fuel system capacity)

GVWR (kg)	Front GAWR (kg)	Rear GAWR (kg)

Engine Data			Drivetrain Data		
Cylinder Count	Displacement (l)	Fuel type	Configuration (Rear, Front, or Four Wheel Drive)	Transmission: (Manual, Automatic, CVT, etc.)	Final Drive Ratio

Advanced Technology References From Owner's Manual (provide page number)			
Forward Collision Warning	Crash Imminent Braking	Adaptive Cruise Control	Advanced Braking (incl. DBS)

Placard Information					
Cold Pressure*		With Max Capacity		Speed Rating	Load Index
Front (kPa)	Rear (kPa)	Front (kPa)	Rear (kPa)		

*Tire pressure used for NHTSA DBS tests.

Tire Information			
Recommended Size (front)	Recommended Size (rear)	Size As Installed (front)	Size As Installed (rear)

Manufacturer	Load Index	Speed Rating

Treadwear Grade	Temperature Grade	Traction Grade

DATA SHEET NO. 5

TEST VEHICLE PREPARATION

Driver Seatbelt Buckled?	Front Passenger Seatbelt Buckled?
Airbags Disabled?	
Method To Disable Airbag(s)?	
Airbag Squibs Installed?	Airbag Squib Resistance (ohms)

PRINCIPAL OTHER VEHICLE (POV) INFORMATION

POV Description	POV Moving Platform Material
POV Tow Vehicle Make/Model/Body Style	POV Tow Rope Length (m)
Distance From Rearmost Location of POV Tow Vehicle to Rear Most Location of POV **Note: Tow rope tension must be at the magnitude specified in S12.1.1.3 for this value to be accurate.**	

DATA SHEET NO. 6

TEST VEHICLE INSTRUMENTATION LOCATION MEASURMENTS

All Measurements Are Relative to the Test Vehicle Inertial Measurement Unit (IMU)				
Description	**Mnemonic**	**Longitudinal Orientation (m) (x-axis)**	**Lateral Orientation (m) (y-axis)**	**Vertical Orientation (m) (z-axis)**
IMU centroid	C_RT_TRUE_CENTER	0	0	0
GPS antenna location on roof	M_ANTENNA_CENTER			
Front Bumper	M_FRONT_MOST_POINT			
Rear Bumper	M_REAR_MOST_POINT			
Rear Axle Midpoint	C_REAR_AXLE_MID_POINT PROJECTED TO SURFACE			

POV TOW VEHICLE INSTRUMENTATION LOCATION MEASURMENTS

All Measurements Are Relative to the Test Vehicle Inertial Measurement Unit (IMU)				
Description	**Mnemonic**	**Longitudinal Orientation (m) (x-axis)**	**Lateral Orientation (m) (y-axis)**	**Vertical Orientation (m) (z-axis)**
IMU centroid	C_RT_TRUE_CENTER	0	0	0
GPS antenna location on roof	M_ANTENNA_CENTER			
Front Bumper	M_FRONT_MOST_POINT			
Rear Bumper	M_REAR_MOST_POINT			
Rear Axle Midpoint	C_REAR_AXLE_MID_POINT PROJECTED TO SURFACE			

DATA SHEET NO. 7

PHOTOGRAPHS