



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

# **NEW CAR ASSESSMENT PROGRAM**

## **REARVIEW VIDEO SYSTEM CONFIRMATION TEST**

**September 2013**

**Office of Crash Avoidance Standards (NVS-120)  
National Highway Traffic Safety Administration  
1200 New Jersey Avenue, SE  
Washington, DC 20590**

# REARVIEW VIDEO SYSTEM CONFIRMATION TEST

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## **1.0 PURPOSE AND APPLICATION**

This New Car Assessment Program (NCAP) laboratory test procedure provides specifications for conducting tests to evaluate the ability of a rearview video system on a passenger vehicle with a gross vehicle weight rating (GVWR) of under 10,000 pounds to present to the driver the specified image of the area behind the vehicle. Current rearview video technology consists of a camera-based system coupled with a display that presents a visual image of the area immediately rearward of the vehicle to the driver.

## **2.0 GENERAL REQUIREMENTS**

This NCAP test procedure evaluates the ability of a rearview video system to present to the driver the specified image of the area behind the vehicle. The test consists of selecting the vehicle's reverse direction and confirming that the appropriately located test objects are displayed and that the image of the objects meets the minimum size specifications.

The requirements of this test procedure must be strictly adhered to. The Contractor's in-house test procedure must have National Highway Traffic Safety Administration (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 Contracting Officer's Representative (COR).

## **3.0 SECURITY**

The Contractor shall provide appropriate security measures to protect test vehicles and equipment during the entire time the test vehicles are in the possession and control of the Contractor, and shall be responsible for all equipment removed from test vehicles before and after the test. Vehicle equipment thefts or acts of vandalism must be reported to the COR. Under no circumstances shall any vehicle components be removed during a visitor inspection unless authorized by the COR. All data developed from the test program shall be protected from premature public disclosure. The release of all data to shall be approved by the COR.

### **Rules for Contractors**

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

- B. All communications with vehicle manufacturers shall be referred to the COR and at no time shall the Contractor release test data without the permission of the COR.
- C. 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 or Contractor personnel.
- D. Test vehicle inspection by the vehicle manufacturer's representative(s) shall be limited to 30 minutes prior to the start of a vehicle test. Post-test inspection shall be limited to 1 hour after Contractor personnel have completed their test tasks.
- E. 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 videotaping of vehicle preparation must be approved by the COR. The Contractor's personnel shall not respond to any questions from the manufacturer's representatives regarding this test program or the specific test. All questions shall be referred to the COR.
- F. The Contractor shall permit public access to and inspection of the test vehicles and related data during the times specified by the COR. 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 COR. The Contractor shall refer all visit requests to the COR. 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 his 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 the COR.

#### **4.0 GOOD HOUSEKEEPING**

The Contractor will 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 test schedule will be set up by the COR, with input from the Contractor. The NHTSA COR 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 COR.

## **6.0 TEST DATA DISPOSITION**

The Contractor shall make all preliminary test data available to the COR within two hours after the test event if so requested by Agency personnel. Under no circumstances shall this preliminary data that has not been quality controlled be furnished to non-Agency personnel.

Additionally, the Contractor shall review and analyze test data to assure that all data required by the test procedure to be recorded has been recorded, that the data recorded falls within ranges that are reasonable to expect in a test conducted under this test procedure, and to determine whether or not the data recorded indicates that the rearview video system tested passes the test procedure. If the data recorded does not fall within ranges that are reasonable to expect in a test conducted under this test procedure, the contractor shall determine whether or not this is due to any malfunction in the recording equipment or process used or it is the result of the inadequacy of the rearview video system that was tested.

The results of this data review, and analysis, the final test data, including digital printouts and computer generated plots (if applicable) shall be available to the COR in accordance with the contract schedule or if not specified, within two working days.

### **6.1 Photos**

The Contractor shall deliver to the COR the final digital photos within one (1) week after the test.

### **6.2 Test Report**

**6.2.1** This test report shall include all of the items shown in the Sample Test Report in section 15 and the data sheets specified in section 16 of this test procedure. The Contractor shall submit two (2) CD's or DVD's 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  
Washington, DC 20590

### **6.2.2 Report Submission**

All test reports including the final version incorporating all COR comments, shall be submitted to the above listed NHTSA office within four (4) weeks from the date of the vehicle test.

### **6.2.3 Text/Data Sheet CD/DVD**

The Contractor shall submit one (1) copy on a CD or DVD of the text and data sheet portion only of the test report in Microsoft Word format within four (4) weeks from the date of the vehicle test.

### **6.3 Test Photographs and Videos**

OCAS shall receive one (1) copy of the color photographs and videos for each test, and the copies shall be mailed directly to the COR within four (4) weeks of the vehicle test. The an original high quality print or data file of each photograph for each of the test photographs shall be retained by the Contractor, but will be made available to the COR upon request. See Section 9.2 for a description of the photograph to be taken during Rearview video System test.

### **6.4 Data Loss**

The Contractor shall exercise reasonable and foreseeable control to ensure that no data is lost or rendered useless.

#### **6.4.1 Conditions for Retest**

The test vehicle is 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 NHTSA's contractual Statement of Work with the contractor as applicable to the test.

The Contracting Officer of NHTSA 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. Reports of Invalidated tests will not be publicly released.

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## **CONDITIONS REQUIRING A RETEST**

**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 tire pressure, fuel loading conditions, vehicle loading conditions, seating position, test object position, and test camera location.**

**The Contractor shall also be responsible for obtaining usable photographs from all instrumentation placed in the vehicle. Failure to produce such data shall be at the expense of the Contractor and shall include vehicle repair or replacement and retest unless the COR and the Contracting Officer determine 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 COR.**

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### **6.4.2 Conditions for Partial Payment**

If some non-critical data and critical 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 agency, reproducible copies of all data, and still photograph negatives or electronic files.

### **6.6 Data Availability to the Public**

The Contractor shall provide interested parties with copies of the test report, test CD's, test data, and test still photographs, at a reasonable cost to the purchaser, but only after the COR has advised the Contractor that the results of that particular test have been released to the public by the Agency.

### **6.7 Indicant Failure Notification**

Any indication of a "test failure" shall be communicated by telephone and e-mail to COR 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 COR's discretion and shall be performed without additional cost.

## **7.0 VEHICLES AND EQUIPMENT**

### **7.1 Acceptance of Test Vehicles**

Unless specified in the contract, the Government shall provide the contractor with test vehicles. The Contractor has the responsibility of accepting leased or NHTSA-provided test vehicles from new car dealers, leasing companies, vehicle owners, or vehicle transporters. In all instances, the Contractor acts on the NHTSA's behalf when signing an acceptance of custody of the test vehicles. Copies of all vehicle transfer documents and transfer logs shall be maintained by the contractor, during the course of this contract. 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 vehicle has been properly prepared and is in running condition.
- E. The spare tire, jack, lug wrench, and tool kit (if applicable) are located in the vehicle cargo area.

The Contractor shall check for damage that may have occurred during transit or prior use. The COR is to be notified of any deviation from these required items and vehicle damage prior to preparation of the vehicle for testing.

### **7.2 Notification of vehicle receipt to the COR**

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

### **7.3 Government Furnished Equipment (GFE)**

For the Rearview Video System tests, no Government furnished test equipment will be available or provided.

## **8.0 INSTRUMENTATION AND CALIBRATION**

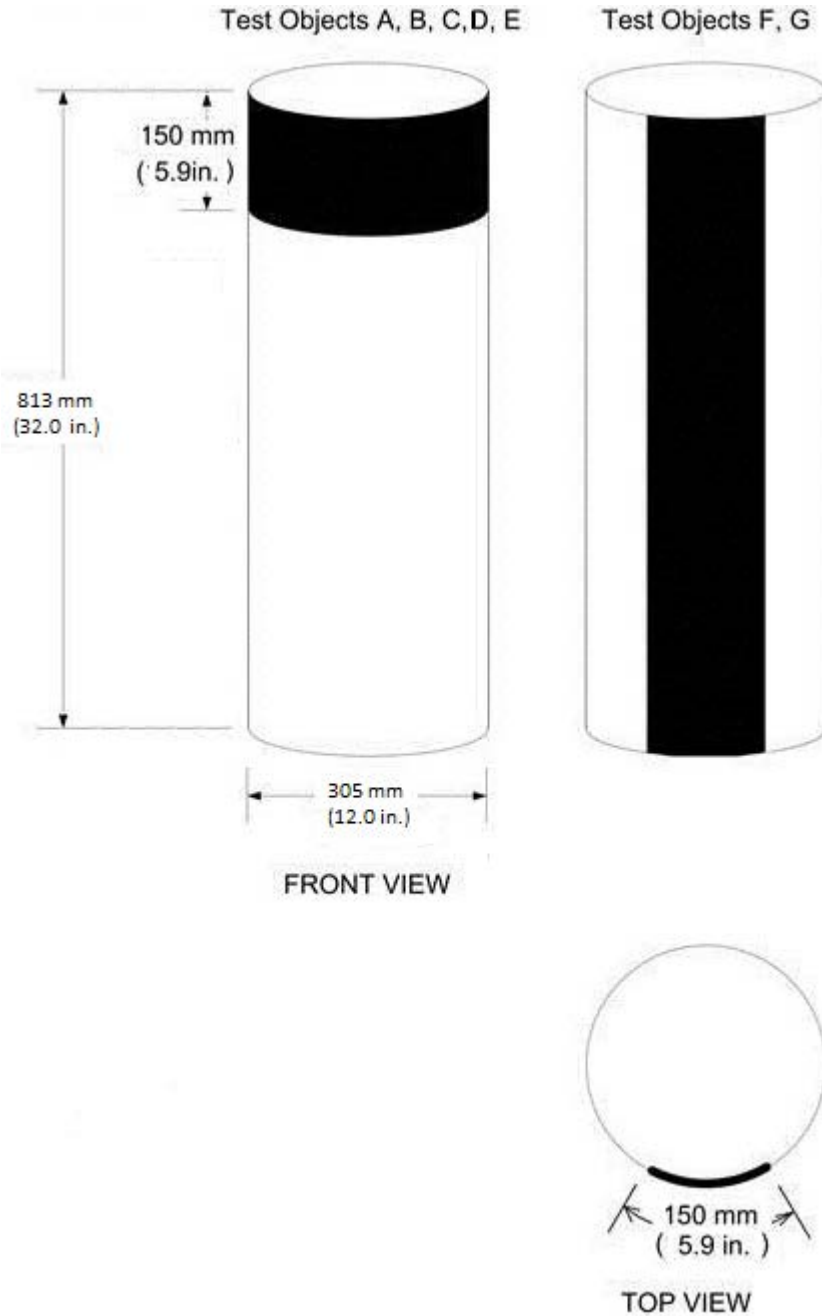
### **8.1 Test Equipment**

- A. Portable tire pressure gauge with an operating pressure of at least 700kPa



(100 psi), graduated increments of 1.0 kPa (0.1 psi) and an accuracy of at least  $\pm 2.0\%$  of the applied pressure.

- B. Illuminance meter with an operating range of at least 500 lux to 20,000 lux and an accuracy of at least  $\pm 5\%$  of the measured value. The meter shall have a relative spectral response within at least 8% of the International Commission on Illumination (CIE) spectral luminous efficiency  $V(\lambda)$ .
- C. Up to five (5) 45 kg weights to be placed on the seat pans of the available seating positions and five (5) 23 kg weights to be placed on the floorboards of the corresponding seating positions. These weights may be subdivided for ease of installation.
- D. A three dimensional SAE Standard J826 JUL95 manikin used for seat adjustment.
- E. Test objects (Figure 1). Each test object is a right circular cylinder that is 0.8 m high and 0.3 m in external diameter. There are seven test objects, designated A through G, and they are marked as follows.
  - (a) Test objects A, B, C, D, and E are marked with a horizontal band encompassing the uppermost 150 mm of the side of the cylinder.
  - (b) Test objects F and G are marked on the side with a solid vertical stripe of 150 mm width extending from the top to the bottom of each cylinder.
  - (c) Both the horizontal band and vertical stripe shall be of a color that contrasts with both the rest of the cylinder and the test area background.



**Figure 1. Test Object Dimensions and Markings**

- F. A 35 mm or larger format still camera, video camera, or digital equivalent with mounting equipment such that the center of the camera's image plane is located at a defined eye location and such that the camera lens can be directed at the center of the display's rearview image.
- G. A ruler no larger than the width of the video screen, adequate in quality for use in a machine shop, to be used in the video image photographs. The

markings on the ruler should be a contrasting color from the surface of the ruler. The finish on the ruler should have a dull or matte finish to eliminate lighting reflection in documentation photographs.

- H. A thermometer to measure and record the ambient temperature of the inside of the vehicle. A digital thermometer is recommended to photographically document the ambient temperature during the test.

## **8.2 Calibration**

- A. 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 will need the acceptance of the COR before testing commences. The calibration system shall be set up and maintained as follows:
  - B. Standards for calibrating the measuring and test equipment will be stored and used under appropriate environmental conditions to ensure their accuracy and stability.
  - C. All measuring instruments and 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.
  - D. 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 organization and the technician who calibrated the equipment
- E. A written calibration procedure shall be provided by the Contractor to the COR 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

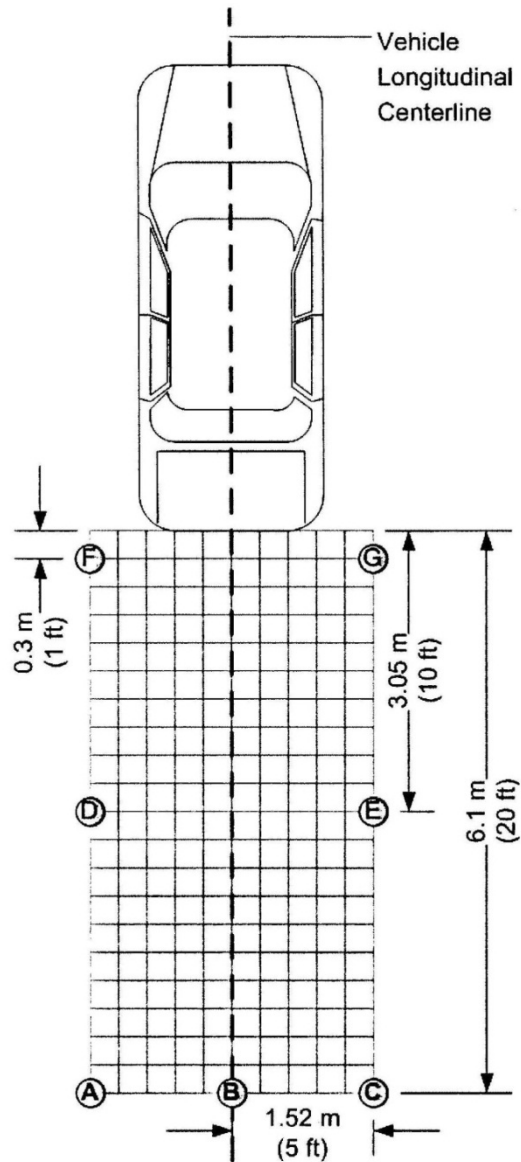
5. Type of standard used to calibrate the equipment (calibration traceability of the standard must be evident)
  6. The actual procedures and forms used to perform the calibrations.
- F. Records of calibration for all test instrumentation shall be kept by the Contractor in a manner that ensures the maintenance of established calibration schedules. All such records shall be readily available for inspection when requested by the COR and shall be included in each final test report.
- G. Test equipment shall receive a pre- and post-test zero check. This check shall be recorded by the test technician(s) and submitted with each final report.

**NOTE:** In the event of a failure to meet an equipment minimum performance requirement, 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 COR's discretion and will be performed without additional cost the OCAS.

### **8.3 Test Vehicle Measurement and Preparation**

- A. The vehicle's tires are set to the vehicle manufacturer's recommended cold inflation pressure.
- B. The fuel tank and all fluids are full.
- C. The vehicle is loaded to simulate the weight of the driver and four passengers or the designated occupant capacity, if less. The weight of each occupant is represented by 45 kg resting on the seat pan and 23 kg resting on the vehicle floorboard placed in the driver's designated seating position and any other available designated seating position.
- D. If the vehicle head restraints obstruct the camera's view of the display, especially rearview video systems mounted rearward of the driver, or if the head restraints hinder the recording of the test, the head restraints may be adjusted or removed prior to testing.
- E. If the vehicle is equipped with a rear hatch or a trunk lid, this vehicle component should be closed and latched in its normal vehicle operating condition.
- F. Adjust the driver's seat to the midpoint of the longitudinal adjustment range. If the seat cannot be adjusted to the midpoint of the longitudinal adjustment range, the closest adjustment position to the rear of the midpoint shall be used. Photograph the seat position by marking the forward most position, the midpoint, and the rearward most position of the seat track.

- G. Adjust the driver's seat to the lowest point of all vertical adjustment ranges present.
- H. Using the three dimensional SAE Standard J826 JUL95 manikin, adjust the driver's seat back angle at the vertical portion of the H-point machine's torso weight hanger to 25 degrees. If this adjustment setting is not available, adjust the seat-back angle to the positional detent setting closest to 25 degrees in the direction of the manufacturer's nominal design riding position.
- I. Place the test objects specified in 8.1E as follows: Measure the distances shown in Figure 2 from one test object to another from the object's cylindrical center (axis) as viewed from above. Each test object is oriented so that its axis is vertical.
  - (a) Place test objects F and G so that their centers are in a transverse vertical plane that is 0.3 m to the rear of a transverse vertical plane tangent to the rearmost surface of the rear bumper.
  - (b) Place test objects D and E so that their centers are in a transverse vertical plane that is 3.05 m to the rear of a transverse vertical plane tangent to the rearmost surface of the rear bumper.
  - (c) Place test objects A, B and C so that their centers are in a transverse vertical plane that is 6.1 m to the rear of a transverse vertical plane tangent to the rearmost surface of the rear bumper.
  - (d) Place test object B so that its center is in a longitudinal vertical plane passing through the vehicle's longitudinal centerline.
  - (e) Place test objects C, E, and G so that their centers are in a longitudinal vertical plane located 1.52 m, measured laterally and horizontally, to the right of the vehicle longitudinal center line.
  - (f) Place test objects A, D, and F so that their centers are in a longitudinal vertical plane located 1.52 m, measured laterally and horizontally, to the left of the vehicle longitudinal center line.



**Figure 2. Object Alignment and Area of Coverage**

- J. Test reference point is intended to simulate the location of a 50<sup>th</sup> percentile male driver's eyes when looking at the rearview image. Obtain the test reference point using the following procedure.
- Locate the center of the forward-looking eye midpoint ( $M_f$ ) illustrated in Figure 3 so that it is 635 mm vertically above the H point (H) and 96 mm aft of the H point.
  - Locate the head/neck joint center (J) illustrated in Figure 2 so that it is 100 mm rearward of  $M_f$  and 588 mm vertically above the H point.
  - Draw an imaginary horizontal line between  $M_f$  and a point vertically above J, defined as J2.
  - Rotate the imaginary line about J2 in the direction of the rearview

image until the straight-line distance between  $M_f$  and the center of the display used to present the rearview image required in this standard reaches the shortest possible value.

- (e) Define this new, rotated location of  $M_f$  to be  $M_r$  (eye midpoint rotated).
- (f) Place CAMERA 1 at the location of  $M_r$ . A camera fixture for the H-point machine may have to be used to place the camera at the correct orientation. A fixture design is described in NHTSA Report Number DOT HS 811 512 titled *Vehicle Rearview Image Field of View and Quality Measurement*.

- K. Display adjustment. If the display is mounted with a rotational adjustment mechanism, adjust the display such that the surface of the display is normal to the imaginary line traveling through  $M_r$  and J2 or as near to normal as the display adjustment will allow. Any display adjustments should be documented in the report.
- L. Steering wheel adjustment. The steering wheel is adjusted to the position where the longitudinal centerlines of all vehicle tires are parallel to the longitudinal centerline of the vehicle.
- M. The test cylinders may be rotated about their axis in order to facilitate the measurement of the 150 mm width requirements for targets F and G.
- N. The temperature inside the vehicle at the beginning of the Image Response Time test is any temperature between 15°C and 25°C. This should be documented photographically. This temperature range is established to ensure repeatable response times of the video systems.
- O. Measure the vehicle's battery power level at the beginning of the Image Response Test (Section 13.2). The battery power must be within the nominal operating range for the type of vehicle being tested, to ensure the optimal performance of the rearview camera system.
- P. Before testing starts, the parking brake should be set, and at least two of the vehicle's wheels should be chocked, to prevent the vehicle from moving when in gear or in neutral.

## 9.0 PHOTOGRAPHIC DOCUMENTATION

Each vehicle shall be documented on color still pictures. Light glare and shadows must be minimized so that views of the test are visible for visual analysis.

## 9.1 Cameras Required

CAMERA 1: A still camera to execute the test.

CAMERA 2: A still camera to document the vehicle.

VIDEO CAMERA(S): synchronized video camera(s) to document time response measurements.

## 9.2 Vehicle Photographs

The following still photographs (8 x 10 inch or 8<sup>1</sup>/<sub>2</sub> x 11 inch color prints properly focused for clear images) are required for the test:

### Pretest photographs:

- A. Using CAMERA 2, non-instrumented pictures of the test vehicles (front, rear, and four three-quarter pictures)
- B. Using CAMERA 2, instrumented pictures of the test vehicles (driver side with the door open, and pictures of the instrumentation)
- C. Using CAMERA 2, document the steering wheel adjustment mentioned in S8.3, subparagraph L.
- D. Using CAMERA 2, document the driver's seat track position.

### Test photograph:

- E. Using CAMERA 1, follow test procedure described in S12.0 and photograph the image of the visual display.

## 10.0 DEFINITIONS

Rearview video system means the set of devices or components which together perform the function of producing the rearview image.

Rearview image means a visual image, detected by means of a single source, of the area directly behind a vehicle that is provided in a single location to the vehicle operator and by means of indirect vision.

## 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 COR which includes:



- A. A step-by-step description of the methodology to be used that follows the necessary protocols outlined in this document.
- B. 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.
- C. A complete listing of test equipment which shall include instrument accuracy and calibration dates.
- D. 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 off sheets shall be used to document that all requirements and procedures have been complied with for each test. The check off sheets should be kept on file.

There shall be no contradiction between this 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 COR before initiating the test program so that all parties are in agreement.

## **11.2 Ambient Conditions**

### **11.2.1 Ambient Temperature**

The temperature inside the vehicle at the beginning of the Image Response Time test should be between 15°C and 25°C. This should be documented photographically. This temperature range is established to ensure repeatable response times of the video systems.

### **11.2.2 Environmental Conditions.**

The Contractor is required to conduct the test inside a closed building to ensure controlled illumination. The test procedure does not specifically require this building to be heated or air conditioned. The inside of the building should not have any air movement over 22 mph (35 km/h). The tests should not be performed if the inside of the building, around the test vehicle, is being affected by air contamination that affects visibility, such as fog, ash, or dust.

### **11.2.3 Visibility**

The ambient illumination conditions on the exterior of the vehicle and on the test area consists of light that is evenly distributed from above and is at an intensity of between 7,000 lux and 10,000 lux, as measured at the center of the exterior

surface of the vehicle's roof. The lighting source should not cause any problems with photographing or videoing the test. [Note: Fluorescent lighting cycling speed may affect the quality of the test documentation video.]

## **12.0 TEST EXECUTION AND TEST REQUIREMENTS**

### **12.1 Image Field of View Test Procedure**

- A. Using Camera 1:
- a. The vehicle's ignition should be "off"
  - b. Affix a ruler at the base of the rearview image in an orientation perpendicular with a test object cylinder centerline. The ruler may NOT be larger than the video screen, nor bent. If the vehicle head restraints obstruct the camera's view of the display, they may be adjusted or removed.
  - c. Ensure the vehicle's parking brake is on.
  - d. Activate the vehicles ignition to "on"
  - e. Place the vehicle' gearshift selector into the reverse gear position.
  - f. When the image if fully activated, photograph the image of the visual display. Use a timer or remote trigger with the ruler included in the frame and the rearview image displayed. This remote trigger may avoid vehicle movement by the photographer.

### **12.2 Image Size Test Procedure**

The test procedure for Section 12.1, Image Field of View Test Procedure shall be used. The same photographic image may be used for this test.

### **12.3 Image Response Time**

#### **12.3.1 Vehicle Initialization Procedure**

The following steps are to ensure that the rear view camera systems are properly initialized among all makes and models prior to testing for the 2.0-second response time covered in S12.3.2.

The temperature inside the vehicle at the beginning of this test is any temperature between 15°C and 25°C. Immediately prior to commencing the actions listed in subparagraphs A – D of this paragraph, all components of the rearview video system are in a powered off state. Furthermore, the test vehicle's parking brake should be engaged and for automatic transmissions, the transmission gear should be placed in park and in neutral gear for test vehicles with a manual transmission. The doors should be closed and unlocked. The door is closed when fully latched. The visual appearance of the fully latched condition is that the door edge is flush with the exterior body panel at the B-pillar.

- A. Follow manufacturer's guidelines to ensure all components of the rearview video system are in a powered off state.
- B. Open the driver's side door a minimum of 234 mm (9.2 in) (the width of the chest of a 50<sup>th</sup> percentile male), and shut the driver's side door. The driver's side door will be considered open at the first detected movement when the door edge of the driver's door is no longer flush with the exterior body panel at the B-pillar.
- C. Activate the starting system using key as defined by FMVSS No. 114, and
- D. Select the vehicle's reverse direction at any time not less than 4 and no more than 6 seconds after the driver's door is opened.

In some cases, the vehicle may have to be instrumented for the test first, and then left untouched for a period of time such that all components of the rearview video system are in a powered off state. The particular amount of time may be manufacturer dependent. The contractor must provide information based on their observation, or, if applicable, the page numbers in the manual describing how the rearview video system was verified to be in the powered off state.

### 12.3.2 Image Response Time Measurement

Using the synchronized video, determine the response time of the display screen. The response time is the time it takes from the selection of reverse to when the display screen is on. The display screen will be considered ON when the test objects on the screen are discernible and the vertical stripe for objects F and G are distinguishable.

The Contractor must provide evidence that the steps in S12.3.1 and S12.3.2 were followed and the timing for each section was recorded. The Contractor may use but is not limited to, synchronized digital video cameras that capture the following:

- A. The time zero (0),  $T_0$ , at which the driver's side door is opened as defined above,
- B. Time,  $T_1$ , at which the reverse has been selected, and
- C. Time final,  $T_f$ , at which the display is populated with the vehicle's rear view image.

A video must be submitted along with the data, as well as time stamped still photographs of  $T_0$ ,  $T_1$ , and  $T_f$ .  $T_1$  can be measured by either video recording the reverse using the gear selector PRNDL indicator or by measuring the shifter displacement from park to reverse for automatic transmissions or from neutral to reverse for manual transmissions. Contact switches to measure the door "open"

condition and the time the reverse gear has been selected may also be used.

## 13.0 POST TEST REQUIREMENTS

### 13.1. Required Field of View

Using the photograph captured in section 12.1, the image should contain the following characteristics.

- A. a minimum of a 150-mm wide portion along the circumference of each test object located at positions F and G specified in S8.3I; and
- B. a full width and height of each test object located at positions A through E.

### 13.2 Required Image Size

Using the photograph captured in section 12.2, the image should contain the following characteristics

- A. Using the photograph, measure the apparent length of a 50 mm delineated section of the in-photo ruler, along the ruler's edge, closest to the rearview image and at a point near the horizontal center of the rearview image.
- B. Using the photograph, measure the horizontal width of the colored band at the upper portion of each of the three test objects located at positions A, B, and C in Figure 2.
- C. Define the measured horizontal widths of the colored bands of the three test objects as  $d_a$ ,  $d_b$ , and  $d_c$ .
- D. Obtain scaling factor. Using a photo editing software which provides zoom and pan functions, rotations, and a high resolution XY coordinate system, find the XY positions of the apparent length of the 50 mm portion of the ruler as it appears in the photograph. Using Equation 1 below, where  $(X_1, Y_1)$  and  $(X_2, Y_2)$  are the coordinates in pixels at the endpoints of the 50 mm portion, define the scaling factor,  $S_{scale}$ , in pixels/mm.

$$S_{scale} = \frac{\sqrt{(x_2-x_1)^2+(y_2-y_1)^2}}{50} \quad \text{Equation [1]}$$

- E. Determine viewing distance. Determine the actual distance from the rotated eye midpoint location ( $M_r$ ) to the center of the rearview image. Define this viewing distance as  $a_{eye}$ .
- F. Calculate visual angle subtended by test objects. Use the following equation to calculate the subtended visual angles:

$$\theta_i = 60 \sin^{-1} \left( \frac{d_i}{a_{eye} S_{scale}} \right) \quad \text{Equation [2]}$$

where subscript i can take on the value of each test object A, B, or C, and arcsine is calculated in units of degrees.

- G. The required calculated visual angle subtended by the horizontal width of:
  - a. All three test objects located at positions A, B, and C shall average not

- less than 5.0 minutes of arc; and
- b. Each individual test object (A, B, C) shall not be less than 3.0 minutes of arc.

Note: these final values are not to be rounded but should be truncated to one decimal point.

### **13.3 Required Image Response Time**

The image response time, as defined in section 12.3.2, calculated as  $T_1$  to  $T_f$ , shall be 2 seconds or less.

## **14.0 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.

## **15.0 REPORTS**

### **15.1 Monthly Status Reports**

The Contractor shall submit a monthly Test Status Report and a Vehicle or Equipment Status Report to the COR (both reports shown in this section). The Vehicle Status Report shall be submitted until all vehicles or items of equipment are disposed of.

### **15.2 Test Anomalies**

In the event of an apparent 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 COR's discretion and shall be performed without additional costs to the OCAS.

### **15.3 Final Test Report**

#### **15.3.1 Copies**

The Contractor shall provide the COR with one (1) CD per test. Three items shall be included on each CD: (1) a JPG of the vehicle in its test mode, taken with a resolution of at least 800 x 600 pixels and (2) the test photos, and (3) and electronic copy of each Final Test Report.

The above documentation shall be submitted to the COR according to the

schedule indicated in Section 6.

The Contractor is required to submit one color copy of each Draft Test Report in draft form. DO NOT stamp *preliminary* or *draft* on this report. This draft can be submitted electronically. The COR will review the draft report and notify the laboratory of any corrections that are required. The COR will amend the draft report and prepare a Final Test Report.

### 15.3.2 Requirements

The Final Test Report and 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 COR. 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.

### 15.3.3 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 (001 for the 1st test, 002 for the 2nd test, 003, 3rd test, etc.)

(B) Final Report Title and Subtitle such as

Rearview Video System Confirmation Test  
\*\*\*\*\*

World Motors Corporation  
200X 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, Washington, DC 20590

**First Page After Front Cover** - - A disclaimer statement and an acceptance signature block for the COR 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: \_\_\_\_\_

**Second Page After Front Cover** - - A 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 No. 1 - - REPORT NUMBER**

OCAS-ABC-0X-001

**Block No. 2 - - GOVERNMENT ACCESSION NUMBER**

Leave blank

**Block No. 3 - - RECIPIENT'S CATALOG NUMBER**

Leave blank

**Block No. 4 - - TITLE AND SUBTITLE**

Final Report of Rearview Video System Testing  
of a 201X World XYZ Deluxe 4-door sedan  
NHTSA No. CX0401

**Block No. 5 - - REPORT DATE**

March 1, 20X

**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, MI 48070



**Block No. 10 - - WORK UNIT NUMBER**

Leave blank

**Block No. 11 - - CONTRACTOR GRANT NUMBER**

DTNH22-0X-D-1 2345

**Block No. 12 - - SPONSORING AGENCY NAME AND ADDRESS**

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

**Block No. 13 - - TYPE OF REPORT AND PERIOD COVERED**

Final Test Report  
XXX to XXX, 200X

**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 200X 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 confirmation of a rearview video system performance.

**Block No. 17 - - KEY WORDS**

Rearview Video

**Block No. 18 - - DISTRIBUTION STATEMENT**

Copies of this report are available from the following:

NHTSA Technical Reference Division  
National Highway Traffic Safety Administration  
1200 New Jersey Avenue SE,  
Washington, DC 20590

**Block No. 19 - - SECURITY CLASSIFICATION OF REPORT**

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Add appropriate number

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Leave blank

**15.3.4 TABLE OF CONTENTS ..... PAGE NO.**

Sample Test Report Table of Contents:

- A. Section 1 — Purpose and Summary of Test
- B. Section 2 — Vehicle Information/Data Sheets
- C. Section 3 — Vehicle Photographs
- D. Section 4 — Test Photographs.
- E. Section 5 — Test Equipment and Instrumentation Calibration

**15.3.5 SAMPLE TEST REPORT INFORMATION**

PURPOSE AND SUMMARY OF TEST

PURPOSE

This test is part of the Crash Avoidance program to assess Rearview Video Systems 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 \_\_\_\_\_.

## **16.0 DATA SHEETS**

### **SUMMARY**

#### **DATA SHEET NO. DESCRIPTION**

1. Test Summary
2. General Test and Vehicle Parameter Data
3. Photographs

**DATA SHEET NO. 1**

TEST SUMMARY

Vehicle NHTSA No.: \_\_\_\_\_

Test Date: \_\_\_\_\_ Time: \_\_\_\_\_ Temperature: \_\_\_\_\_ °C

Make/Model/Body Style/Trim/Option \_\_\_\_\_

Model year: \_\_\_\_\_

Vehicle Test Weight: \_\_\_\_\_ kg

**Pass/Fail?**

Field of View (pass/fail?)

Minimum visible, F and G, (150 mm or more): \_\_\_\_\_

Full width/height visible A through E?: \_\_\_\_\_

Image Size:

Angle, Object A: \_\_\_\_\_

Angle, Object B: \_\_\_\_\_

Angle, Object C: \_\_\_\_\_

Average Angle, A, B, and C: \_\_\_\_\_

Response Time: \_\_\_\_\_

**Data:**

Field of View (visible -yes/no?)

Minimum visible (150 mm on object)

Object F: \_\_\_\_\_

Object G: \_\_\_\_\_

Full width/height of A through E visible:

Object A visible: \_\_\_\_\_

Object B visible \_\_\_\_\_

Object C visible \_\_\_\_\_

Object D visible \_\_\_\_\_

Object E visible \_\_\_\_\_

Image Size (minutes of arc):

Specific image angle (not less than 3 minutes of arc)

Test Object A: \_\_\_\_\_

Test Object B: \_\_\_\_\_

Test Object C: \_\_\_\_\_

Average image angle (A,B&C) (not less than 5 minutes of arc):

Average: \_\_\_\_\_

Image Response time (2 seconds or less)(seconds):

T<sub>i</sub>: \_\_\_\_\_

T<sub>f</sub>: \_\_\_\_\_

Response time: \_\_\_\_\_

**DATA SHEET NO. 2**

GENERAL TEST AND VEHICLE PARAMETER DATA

TEST VEHICLE INFORMATION:

Year/Make/Model/Body Style: \_\_\_\_\_  
NHTSA No.: \_\_\_\_\_; VIN: \_\_\_\_\_; Color: \_\_\_\_\_  
Engine Data: \_\_\_\_\_ cylinders; \_\_\_\_\_ CID; \_\_\_\_\_ Liters; \_\_\_\_\_  
Transmission Data: \_\_\_\_\_ speeds; \_\_\_\_\_ Manual; \_\_\_\_\_ Automatic; \_\_\_\_\_ Over drive  
Final Drive: \_\_\_\_\_ Rear Wheel Drive; \_\_\_\_\_ Front Wheel Drive; \_\_\_\_\_ Four Wheel Drive  
Date Received: \_\_\_\_\_; Odometer Reading \_\_\_\_\_ miles

**DATA FROM VEHICLE'S CERTIFICATION LABEL:**

Vehicle Manufactured by: \_\_\_\_\_  
Date of Manufacture \_\_\_\_\_  
GVWR: \_\_\_\_\_ kg; GAWR: \_\_\_\_\_ kg FRONT; \_\_\_\_\_ kg REAR

**DATA FROM TIRE OR TIRE PLACARD:**

Tire Pressure with Maximum Capacity Vehicle Load: \_\_\_\_\_ kpa FRONT  
\_\_\_\_\_ kpa REAR  
Load Index & Speed Symbol: \_\_\_\_\_  
Recommended Tire Size: \_\_\_\_\_  
Recommended Cold Tire  
\* Pressure: \_\_\_\_\_ kpa FRONT; \_\_\_\_\_ kpa REAR  
Tire Grades: \_\_\_\_\_  
Treadwear; \_\_\_\_\_ Temperature; \_\_\_\_\_ Traction  
Size of Tires on Test Vehicle: \_\_\_\_\_; Manufacturer: \_\_\_\_\_

\*Tire pressure used for test

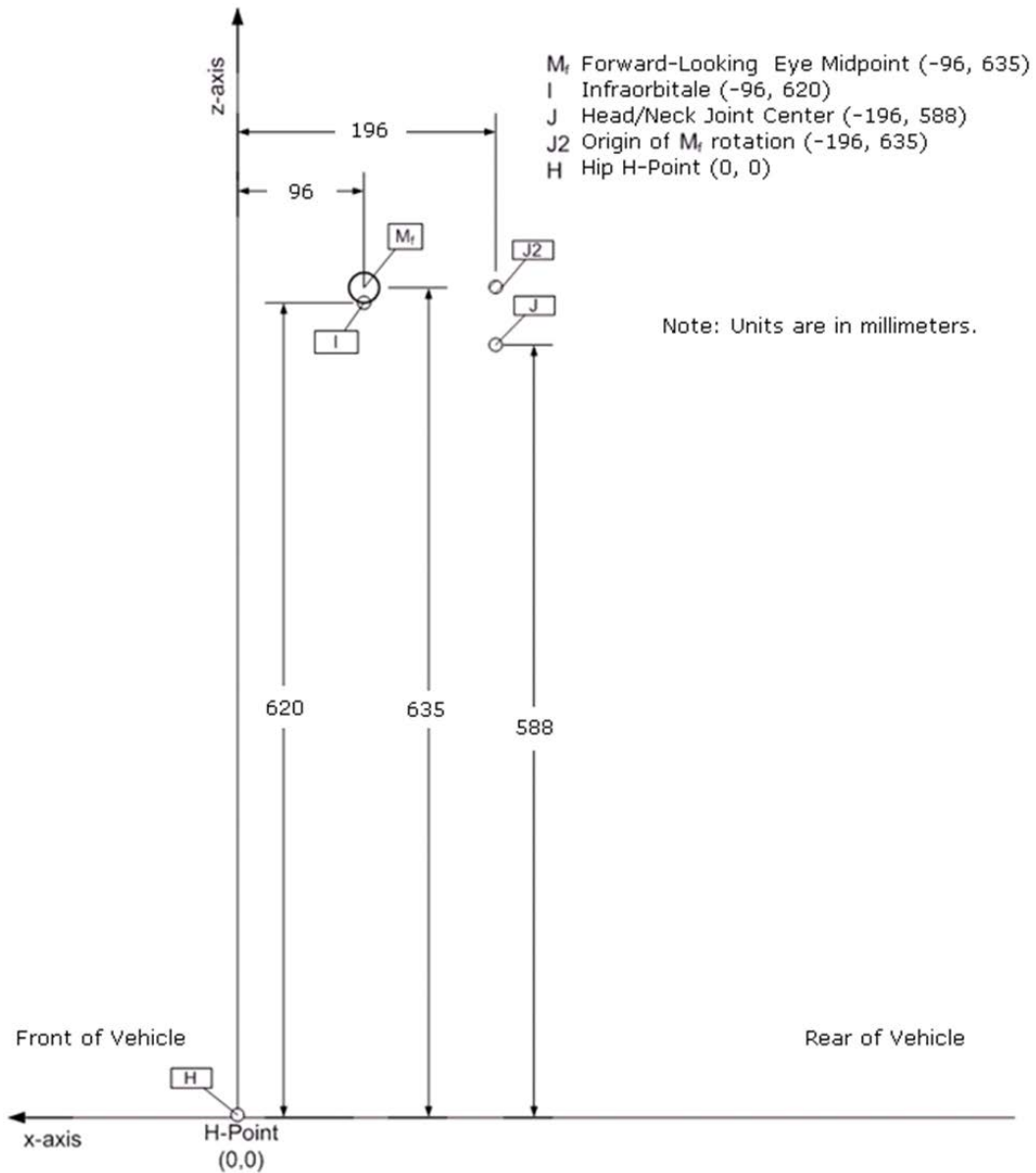
**FUEL SYSTEM DATA :**

Fuel System Capacity From Owner's Manual = \_\_\_\_\_ liters  
Test Volume Range (100% of Usable Capacity) = \_\_\_\_\_ (gage reading)

**DATA SHEET NO. 3**

**PHOTOGRAPHS**

## 17.0 FIGURES



**FIGURE 3. Eye Midpoint Location ( $M_f$ ) in the Mid-Sagittal Plane with respect to H Point for Forward-Looking 50<sup>TH</sup> Percentile Male Driver Seated with 25 Degree Seat back Angle**

## 18.0 DERIVATION OF SUBTENDED VISUAL ANGLE EQUATION

**Assumption 1:** The plane upon which the image is displayed (may be a mirror, a video display, or some other surface) is, at least locally, flat. (This works, even for convex mirrors, because the image being analyzed is small compared to the radius of curvature of the mirror, video display, or other surface.)

**Assumption 2:** The plane upon which the image is displayed (may be a mirror, a video display, or some other surface) is perpendicular to the driver's line of sight at some point. While this is not in general exactly true, the difference from perpendicularity has been typically small in systems that NHTSA has tested to date.

Figure 4 shows the geometry of the situation and defines the symbols used.

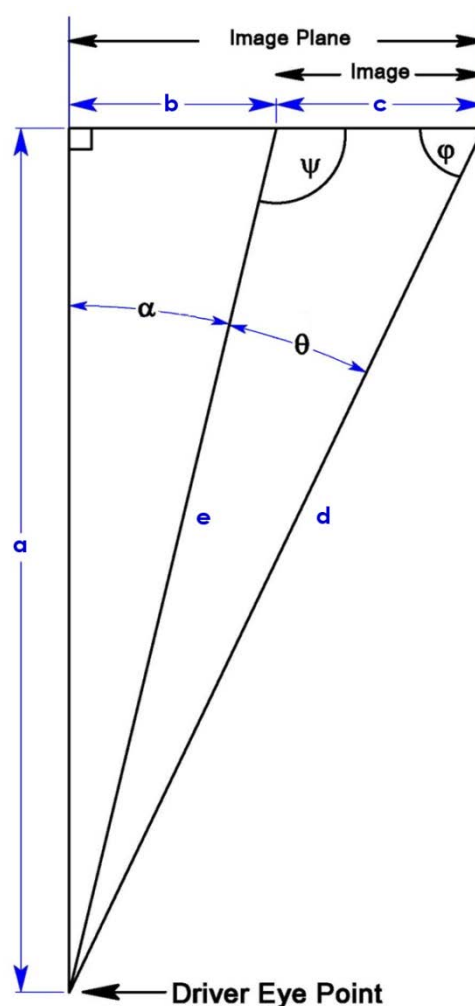


Figure 4. Geometry Used to Derive Subtended Visual Angle Equation



**Definitions:**

In the figure,  $c$  is the width of the actual image in the Image Plane,  $a$  is the perpendicular distance from the Driver's Eyepoint to the Image Plane, and Greek letters denote angles. The subtended visual angle that is to be determined is denoted by  $\theta$ .

**Case 1: One Edge of Image at Perpendicular Point**

This is a special case in which one edge of the image is at the point in the Image Plane that is intersected by the perpendicular line emanating from the Driver's Eyepoint. In the figure, this corresponds to the angle,  $\alpha$ , and the distance,  $b$ , being zero. For this case, using the standard trigonometric definition of tangent,

$$\tan \theta = \frac{c}{a} \quad [3]$$

Equation (3) can be rearranged to:

$$\theta = \tan^{-1} \frac{c}{a} \quad [4]$$

**Case 2: One Edge of Image Not at Perpendicular Point**

This is a more general case in which an edge of the image is no longer assumed to be at the point in the Image Plane that is intersected by the perpendicular line emanating from the Driver's Eyepoint. Then, from the Law of Sines, the following equation is true:

$$\frac{\sin \theta}{c} = \frac{\sin \Psi}{d} = \frac{\sin \varphi}{e} \quad [5]$$

Where

$$e = \sqrt{b^2 + a^2} \quad [6]$$

$$d = \sqrt{(c + b)^2 + a^2} \quad [7]$$

$$\Psi = 90^\circ + \alpha \quad [8]$$

$$\alpha = \tan^{-1} \frac{b}{a} \quad [9]$$

$$\varphi = 90^\circ - \alpha - \theta \quad [10]$$

Using Equations (8) and (10), Equation (5) can be reduced to:

$$\frac{\sin \theta}{c} = \frac{\cos \alpha}{d} = \frac{\cos(\alpha + \theta)}{e} \quad [11]$$

It is difficult to determine the exact point on the Image Plane that is precisely perpendicular to the line emanating from the Driver's Eyepoint. Therefore, it is practically impossible to accurately measure the distance  $e$ . To allow for an approximate solution of Equation (11), two additional assumptions will be made:

**Assumption 3:** The distance  $c$  is much smaller than the distance  $a$ . Therefore, the angle  $\theta$  will be small (less than 1 degree for the situations being considered).

**Assumption 4:** The distance  $b$  is much smaller than the distance  $a$ . Therefore,

the angle  $\alpha$  will be small (less than 1 degree for the situations being considered).

Using Assumptions 3 and 4, the quantity  $(b + c)$  is also much smaller than the distance  $d$ .

Assumptions 3 and 4 were used to simplify the  $\cos \alpha/d$  term in Equation (11). Each part of this term was expanded in a Maclaurin series in powers of  $c/a$  and  $b/a$  and second order, or higher, terms deleted as too small to matter.

Start with simplifying Equation (7):

$$d = a \sqrt{1 + f^2} \quad [12]$$

Where,

$$f = \frac{b+c}{a} \quad [13]$$

As stated above,

$$f \ll 1 \quad [14]$$

To expand  $c$  in a Maclaurin series, the first two derivatives of  $c$  with respect to  $f$  need to be calculated and evaluated at  $f = 0$

$$\frac{dd}{df} = \frac{fa}{\sqrt{1+f^2}} \quad [15]$$

$$\left. \frac{dd}{df} \right|_{f=0} = 0 \quad [16]$$

$$\frac{d^2d}{df^2} = \frac{a}{\sqrt{1+f^2}} - \frac{f^2 a}{\sqrt{(1+f^2)^3}} \quad [17]$$

$$\left. \frac{d^2d}{df^2} \right|_{f=0} = a \quad [18]$$

$$d = a + \frac{a}{2} f^2 + \text{Higher Order Terms} \quad [19]$$

Neglecting all terms of order  $f^2$  or higher, compared to  $a$ , yields

$$d \cong a \quad [20]$$

Next, simplify Equation (9) using the standard Maclaurin series expansion for arctangent:

$$\alpha = \tan^{-1} \frac{b}{a} = \frac{b}{a} - \frac{1}{3} \left( \frac{b}{a} \right)^3 + \text{Higher Order Terms} \quad [21]$$

Neglecting all terms of order  $(b/a)^2$  or higher yields

$$\alpha \cong \frac{b}{a} \quad [22]$$

Using the standard MacLaurin series expansion for cosine:

$$\cos \alpha = 1 - \frac{1}{2} \left(\frac{b}{a}\right)^2 + \text{Higher Order Terms} \quad [23]$$

Neglecting all terms of order  $(b/a)^2$  or higher yields

$$\cos \alpha \cong 1 \quad [24]$$

The  $\cos \alpha/d$  term in Equation (11) therefore can be simplified, based to the assumptions made, to  $1/a$ . The first two terms in Equation (11) have, therefore, been reduced to:

$$\frac{\sin \theta}{c} = \frac{1}{a} \quad [25]$$

or

$$\theta = \sin^{-1} \frac{c}{a} \quad [26]$$

Two equations, Equations (4) and (26), have now been developed for the subtended visual angle  $\theta$ . Equation (4) is exact but only applies to the special case in which one edge of the image is at the point in the Image Plane that is intersected by the perpendicular line emanating from the Driver's Eyepoint. Equation (26) applies to the more general case in which one edge of the image is **not** at the point in the Image Plane that is intersected by the perpendicular line emanating from the Driver's Eyepoint, however, it relies on small angle approximations. Note that for small angles, both Equations (4) and (26) are identical since

$$\sin^{-1} \theta \cong \tan^{-1} \theta \cong \theta \quad [27]$$

Therefore, both Equations (4) and (26) reduce, for small angles to:

$$\theta = \frac{10800}{\pi} \times \frac{c}{a} \quad [28]$$

Where  $10800/\pi$  is the correct constant to convert  $c/a$  into minutes of arc. Equation (28) provides a third equation for determining the subtended visual angle.

Each of Equations (4), (26), and (28) was used to calculate a subtended visual angle for a given  $c/a$  value. The  $c/a$  value used was 0.00145444053054153000. The resulting values of  $\theta$  were 4.999994711511520 minutes of arc from Equation (4), 5.000000000000000 minutes of arc from Equation (26), and 4.999998237167900 minutes of arc from Equation (28).

The above calculations demonstrate two things:

1. For the angles of interest, there is a minimal difference in the subtended visual angle that was calculated with a maximum difference of 0.000005288488482 minutes of arc. This sixth decimal place difference is well beyond the accuracy of the procedures used to measure  $a$  and  $d$ . Therefore, from an accuracy point of view, it does not matter which of these equations is used.
2. Equation (26), which utilized the arcsine function, calculated the largest value of  $\theta$ . Therefore, this is the equation that helps the most when trying to fare well in an image quality assessment based on a minimum subtended visual angle.

Based on the above discussion, the preferred equation for calculating the subtended visual angle is:

$$\theta = \sin^{-1} \frac{c}{a} \quad [26]$$

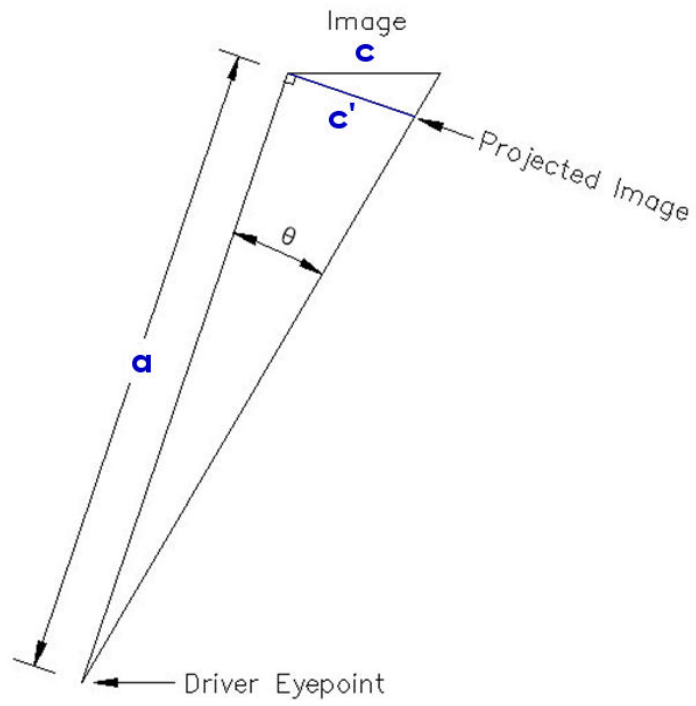
In the case where Assumption 2 is not true (the plane upon which the image is displayed is not perpendicular to the driver's line of sight, the subtended angle will be calculated based on the apparent size of the object in the plane in which the image is displayed. As the ultimate goal of measuring subtended angles is to determine how much area the reflected object occupies in the driver's field of view, the apparent size is the correct measurement. Define  $e$  as zero and the projection of  $\alpha$  onto a plane perpendicular to the line of sight will be designated as  $c'$  (see Figure 4). In this case Equation (4) can be used:

$$\theta = \tan^{-1} \frac{c'}{a} \quad [29]$$

Using the small angle approximation, Equation (29) becomes:

$$\theta = \sin^{-1} \frac{c'}{a} \quad [30]$$

Which is the same as Equation (26) with  $c'$  substituting for  $\alpha$ .



**Figure 5. Calculation of Subtended Visual Angle for Case Where Plane in Which Image is Displayed is Not Perpendicular to Driver's Line of Sight**

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