



Door System Upper Frame Rigidity Structural Test

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To determine the strength and stiffness characteristics of a door upper frame when subjected to outboard loads.

1.2 Applicability. This procedure applies to all passenger, multi-purpose and commercial vehicles having conventional swing-open doors with upper frames. It may also be used for other doors that have an upper frame. For sliding side door systems, see GMW15937.

1.3 Remarks. A door is secured to a rigid fixture, in approximate Design Position, while an outboard load is applied to the upper frame. Upper frame deflection and set deflection reading is recorded for each load in an effort to evaluate the structural integrity of the door's upper frame. These loads can also be thought to represent those applied in the vehicle assembly process and during customer usage, such as in the following examples:

1.3.1 The door upper frame is loaded at the vehicle assembly plant at times when the doors are manually adjusted to meet gap and flushness requirements.

1.3.2 A positive seal force or "overbend" is designed into the door system to minimize potential water leaks and wind/road noise. The upper frame is constantly subjected to this seal force during the times that the door is closed.

1.3.3 When being driven at higher speeds, the vehicle cabin pressure varies from the outside pressure such that forces are applied to the door's header via pressure on the door glass.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15937

2.3 Additional References.

- CG190 Evaluation Report Template
- Global Door Subsystem Technical Specifications (GSSTS), paragraph 3.2.1.7.1

3 Resources

3.1 Facilities.

Major Facility: The facility should contain the equipment described in Minor Facility and 3.2 in addition to providing the conditions in 4.2.

Minor Facility: Structural Surface Plate.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

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3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

Note: The following list(s) include fixturing and instrumentation typically used by the GMNA Body Test Lab to perform this test. Other equipment may be substituted at the discretion of the testing facility as long as it provides the same data and/or data record, with equivalent accuracy as specified herein or by the requestor.

3.2.1 Fixturing.

3.2.1.1 Hinge mounting plate(s) for mounting the door in approximate **design position** on the structural surface plate (see Figure A2).

3.2.1.2 Rigid hinge pillar fixture for mounting the hinge mounting plate(s) in approximate design position on the structure surface plate (see Figure A2).

3.2.1.3 Rigid fixturing to secure the lock pillar end of the door. This can be achieved by attaching clamps along the rear hem-flange (see Figures A3 through A5); using clamps in this way will help isolate any movement to only the door's upper frame.

3.2.1.4 A fixture to apply load to the upper frame. A "U-shaped" bracket (as shown in Figure A6 and Figure A12) has proven to work well (this bracket allows loads to be applied in both directions ("toward the body" and "away from the body") without having to make fixturing adjustments between loads).

3.2.1.5 Rigid fixture to hold the servo linear actuator (see Figure A6 and Figure A7).

3.2.1.6 Rigid fixture to hold the linear displacement digital encoder in place (see Figure A6).

3.2.1.7 Attachments to connect the load cell to the servo linear actuator and the load application fixturing to the load cell (see Figure A6).

3.2.2 Instrumentation.

Note: The GMNA Body Test Laboratory has computer console systems that are designed for and dedicated to door structure testing. Each console is self-contained and operates the required load application motor, load cell, and displacement measuring instrumentation that is used when conducting door structure testing. The GMNA Body Test Lab Instrumentation Department keeps a complete description of the instrumentation equipment and/or software specifications for each of the consoles. The remainder of this procedure is written assuming that the structure testing is performed using these consoles and associated equipment.

3.2.2.1 Computer console.

3.2.2.2 Load cell with a capacity of approximately 1.5 times the load that will be applied during testing.

3.2.2.3 Servo linear actuator (see Figure A7).

3.2.2.4 Torque wrench with a capacity of approximately 1.5 times the fastener(s) required torque specification(s) (see 3.5.5).

3.2.2.5 Ultrasonic thickness tester (for measuring metal panel thickness) or caliper (if testing non-metallic parts).

3.2.2.6 Linear measuring device (digital linear displacement probe) with a stroke of at least 50 mm (see Figure A6.)

3.2.2.7 "Protractor/Angle Finder", Angle measuring instrument.

3.2.2.8 Layout dye or spray paint and a scribe, marking pen, or equivalent suitable for marking the upper frame seams that may move or separate during testing (see 4.3.1.1).

3.3 Test Vehicle/Test Piece.

3.3.1 A "Door-In-White" is required, including the door hinges and appropriate fasteners. If testing a door that has a division post, the post must be installed prior to performing this test. If the stationary glass comes as part of the division post assembly, then install the stationary glass also; if it does not come with the glass, then the division post is sufficient. If more than one sample is being tested, they should all be the same (left hand/right hand) in order to minimize fixture modifications. However, in some cases, it may be desirable to test both right and left-hand parts due to tooling and manufacturing process variations (refer to 3.5). Specifications for hinge locations and bolt torques should be obtained from release drawings. New hinges must be obtained for each sample tested. In addition, it is recommended that the hinge fasteners also be replaced for each door tested. It is also recommended that the test parts/assembly be dimensionally certified before testing is started.

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3.4 Test Time. The following is an estimate of the amount of time (work hours) needed to perform this procedure.

Note: These time estimates are approximate averages. Actual times vary considerably depending on early component failures (and subsequent availability of replacement parts), testing to varying multiples of cycle lives, varying requirements for frequency of environmental test conditions, scheduling problems for test facilities, test equipment malfunctions, scheduling of overtime and/or multiple shifts, scheduling of “witnesses” for tests, actual readiness of test samples upon receipt, unique or additional requests for detailed test information, running multiple samples (times shown are for one (1) system), etc.

These times consider preparation and other downtime, actual test, and analysis of data in capturing a total calendar time. Report writing, approval, processing, etc., are not part of these times.

Calendar time:	1 d
Engineer time:	5 h
Technician time:	8 h

Note: If door hinge mounting plates do not exist, up to eleven (11) days may be added to the testing duration in order to design and fabricate the mounting plates.

3.5 Test Required Information. The requesting engineer is responsible for providing specifications appropriate to the particular vehicle line being tested (reference Global Side Door Subsystem Technical Specifications (GSSTS)).

Testing worst case scenarios may uncover some potential problems. Discuss with the requesting engineer if testing should include some worst case scenarios. Depending on which test is being performed and which level of parts or systems is being tested, consider if any of the following may apply: tolerance stack-ups, build variations, misalignment, minimum/maximum fastener torque(s), lubrication, environmental extremes, location of customer representative load application, symmetry (Left Hand vs. Right Hand), color, mold or die source, etc.

The following specifications or information are required to run this test:

3.5.1 Location(s) for load application. These locations are chosen according to the methods provided in Figures A8 through A11. (See also, Figure A15 and Figure A16.) The exact location on the A-pillar and C-pillar can also be identified using aero pressure loading Computer Aided Engineering (CAE) analysis by locating the place where the maximum deflection occurs on the door window/header.

3.5.2 Load magnitudes (Per Global Door Subsystem Technical Specifications (GSSTS), paragraph 3.2.1.7.1).

3.5.3 Maximum allowable deflection.

3.5.4 Maximum allowable set deflection.

3.5.5 All applicable fastener torque values and description of whether the value is a nominal, minimum, or maximum torque value.

3.5.6 Any critical part thickness and locations where to perform these measurements.

3.5.7 Design position of hinges/door for proper hinge plate selection and/or design.

3.6 Personnel/Skills. Prior experience in setting up and running similar tests and experience in the use of the referenced test equipment are critical to achieving the estimated times shown in 3.4 (Test Time).

4 Procedure

4.1 Preparation.

4.1.1 Sample Inspection.

4.1.1.1 The test and requesting engineers should inspect the test items to insure all material listed in 3.3 is of correct design level and assembled properly.

4.1.1.2 If requested to do so, use the Krautkramer Ultrasonic Thickness Tester (or other suitable measuring tool, such as a micrometer or calipers for non-metal doors) to measure any critical part thicknesses specified by the requesting engineer.

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The locations chosen for thickness measurements should be chosen because they are significant contributors to the door structural performance. Be aware that drawn (stretched) sheet metal paragraphs may be significantly thinner than flat sections of the same part.

Verify thickness measurements with the requesting engineer before beginning the test setup; if parts were made from the wrong stock, or are out of specification, it may be worthwhile to postpone the test until they are corrected.

Note: For the most accurate metal thickness measurements, carefully remove paint, primer, etc., where the thickness measurements will be recorded. Be sure to use non-destructive or non-abrasive means (such as a liquid paint remover) so the thickness of the part being measured is not altered. Do not attempt to remove any plated coatings, e.g., galvanizing. If opting to not remove the paint, then be aware that the paint thickness may influence the measurement, e.g., metallic paints.

4.1.1.3 Note any areas of metal deformation or irregularities before performing the test. This may aid in analyzing test results.

4.1.1.4 If the doors have not been through the Electrophoretic Priming Operation (ELPO) system, then they must be “baked” before testing in order to fully “cure” the adhesives in the hem, door beam, etc.

4.1.2 Sample Preparation. This test is normally run on the test subject in an “as received” condition. If it is requested to be run in a specifically adjusted condition, follow the applicable procedure(s).

4.1.2.1 If a door has been received that contains hardware, then remove all of the door hardware, with the exception of the hinges, and the division post assembly. If receiving a door that has no hardware, then install the hinges, and the division post assembly. Use the appropriate fasteners and their respective torque values.

4.1.3 Facilities and/or Equipment Preparation. Record the instrumentation calibration information on the attached Data Sheet A1 (Appendix A) or on an equivalent document.

4.2 Conditions.

4.2.1 Environmental Conditions. Unless otherwise specified in this document's text or by the requesting engineer, the typical environmental conditions for this test are the temperature, humidity and pressure at the major test facility (3.1.1). Unless otherwise noted, these conditions are typically $22^{\circ}\text{C} \pm 3^{\circ}\text{C}$, relative humidity of $40\% \pm 20\%$, and atmospheric pressure equivalent to the local barometric pressure (which is variable during any given day and from day to day).

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

Note: For this procedure, any deviations must be brought to the attention of the Global Subsystem Leadership Team (GSSLT) or Closures Technical Integration Engineer (TIE) and agreed upon.

4.3 Instructions.

Note: Unless this test is being performed on a competitive vehicle, analysis data should be available for the test being performed. For correlation purposes, communication between test and analysis personnel must take place to ensure that the loading conditions, restraints, and measurement locations are consistent between the test and analysis procedures.

4.3.1 Set Up Instructions.

4.3.1.1 Using production intent hinges, mount the door in approximate Design Position to the hinge pillar fixture (see Figure A2). Torque all hinge nuts/bolts to specification (see 3.5.5); hinge bolt torque values are typically given as a range. For this test, the maximum value (or greater, within the limits of the fasteners) should be used for the body-side hinge mounting bolts in order to prevent the door from slipping against the mounting plate surface. In contrast, the minimum torque value is typically used for the door side hinge fasteners, as this is the worst case scenario. Scribe or otherwise mark the position of the hinges relative to the door and fixture. If applicable, also scribe along the hem line. This scribing is done to help detect any movement of the hem or hinges that may occur during testing.

4.3.1.2 Secure the lock pillar end of the door by attaching three clamps along the rear edge of the door (see Figures A3 through A5). Clamping the door below the beltline will secure the lower half of the door such that the deflection and set deflection measurements will be isolated only to the upper frame of the door.

Note: When clamping the door, the upper edge of the upper clamp must be $35\text{ mm} \pm 0.5\text{ mm}$ from the C-line (upper edge of beltline) of the outer panel; and the lower edge of the lower clamp must be $35\text{ mm} \pm 0.5\text{ mm}$ from the door's “T-line” (lower edge of the door). See Figures A3 through A5.

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Note: This 35 mm $\pm$ 0.5 mm dimension is the value agreed upon based on investigation of header design and will also be consistent with analytical models. Deviation from the 35mm requirement may be necessary due to unique door designs; these deviations must be agreed upon by the requesting engineer and Computer Aided Engineering (CAE).

4.3.1.3 At this time, locate the points on the upper frame where loading will be applied. Specified load locations should be based on the criteria described in 3.5.1. If specific load locations have not been provided, use the criteria described in Figures A8 through A11 to choose the proper loading locations. Clearly record these locations in the test report for reference and any future test repeatability.

4.3.1.4 Testing must be conducted in the following order:

Front Doors

- a. Outboard Load at Lock Pillar.
- b. Outboard Load at Hinge Pillar.

Rear Doors

- a. Outboard Load at Hinge Pillar.
- b. Outboard Load at Lock Pillar.

Note: Analysis engineering will base any correlation data on the first outboard load only.

Note: In order to perform the following steps, when positioning the fixturing, it will be necessary to move the servo linear actuator.

This is done with the use of the computer console system.

4.3.1.5 Position the servo linear actuator at mid-travel.

4.3.1.6 Select the first load location/condition, as shown in 4.3.1.4, and position the rigid fixture that holds the servo linear actuator such that the U-shaped load applicator almost contacts the upper frame. This may require adjustments in the height of the actuator and the angle position of the actuator. Be sure that the final positioning places the direction of load application normal to the curvature of the upper frame at the area where the loading is occurring (refer to Figures A6 and A7). Use an angle measuring device to determine this angle between the load vector and the horizontal plane. Also, try to align the loading contact point on the upper frame with the center of the load cell in order to minimize bending moments on the load cell (see Figure A12).

4.3.1.7 Secure the servo linear actuator fixture to the structure plate to ensure that it does not move during load application.

4.3.1.8 Position the displacement transducer such that it locates off of the "U-shaped" load application fixture (see Figures A6 and A7). It is essential that the displacement transducer is positioned such that it is measuring the upper frame deflection and set deflection in-line with the load that is being applied.

4.3.1.9 When using one (1) of the door structure console systems to perform the test, the console will check to ensure that the load cell being used is still within calibration parameters.

4.3.1.10 Set the servo linear motor speed such that its travel rate does not exceed 1 mm/s.

4.3.1.11 When beginning the test, the computer console will automatically zero the displacement transducer and load cell.

4.3.2 Test Operation Instructions.

4.3.2.1 Apply the specified load, and graph load vs. deflection; when using the GMNA Body Test Lab door structure consoles. The console will automatically graph load vs. deflection while applying and releasing the load for the test engineer. During loading, it is not uncommon to hear "pop" and crackling noises. If possible, try to verify where on the door these noises came from. Also watch for visible sheet metal separations during loading. Immediately after achieving the desired load, the console will reverse the motor direction and remove the load. Refer to the sample plots contained in Figures A1, A13, and A14 for assistance in interpreting the results. Figures A13 and A14 show some common problems which may occur while performing this test.

4.3.2.2 Continue testing the remaining load locations/conditions described in 4.3.1.4 by repeating steps 4.3.1.6 through 4.3.2.1 (until a total of 2 sets of data have been obtained for each door).

4.3.2.3 If additional doors are to be tested, then follow steps 4.1.1 through 4.3.2.1.

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4.3.3 Post Test Instructions.

4.3.3.1 If applicable, include a sketch or marked drawing showing the part thickness measurement locations.

4.3.3.2 Visually inspect the posttest condition of the test material as it compares to the pretest condition, and note any changes. Record any discrepancies such as metal deformation, hem and/or hinge separation or movement, visible cracks, weld failures, interference between door components, or loss of function on the data sheet.

Note: Every posttest operation/measurement/inspection must typically have a pretest equivalent to have any meaning or significance. A crack detected at end of test means nothing unless there is a pretest documentation verifying no crack existed prior to start of test.

4.3.3.3 Use a paint pen, permanent marker, engraver, etc., to mark the door in a conspicuous location identifying which tests have been performed on it. This is done in cases where the door may be used for mockup, or future testing.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. Record the test information on the attached Data Sheet A2 in Appendix A. Test to be documented consistent with form CG190 located in the General Motors Global Document Management (GDM) database.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Belt-Line/Belt: The lower boundary of the side window daylight opening (D.L.O.) Source: GM Glossary of Terms in Automotive Body Design.

Daylight Opening (D.L.O.): The maximum unobstructed opening through any glass aperture in a given direction. Source: GM Glossary of Terms in Automotive Body Design.

Deflection: Refers to the bending of the door's upper frame in the direction of load application, e.g., toward or away from the body. This measurement is taken as load is being applied to the door's upper frame (see Figure A1).

Design Position: Orientation of a body part in the position it assumes when attached to a built vehicle on level ground.

Door-In-White (D-I-W): The door structural assembly.

Electrophoretic Priming Operation (ELPO): A "paint" process in which the doors and primer have opposite electric charges, and primer is plated onto the doors during immersion in a "bath" of primer.

Overbend: An intentionally designed "over curvature" of the door's upper frame, toward the body centerline, which results in the upper frame deflecting outward as the door closes against the body side frame and weatherstrip (see 1.2.2).

Set Deflection: Refers to the permanent deformation or "plastic" deformation after the specified test load has been applied and removed (see Figure A1).

Upper Frame (Header): The structural member above and along the front and rear edges of the door glass.

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