GM WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW15087

Door System
Torsional 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 when subjected to loads that attempt to twist the door about its “roll” or x-axis (see Figure A1).

1.2 Applicability. This procedure applies to all passenger multi-purpose and commercial vehicles having conventional swing-open doors. It may also be used for other vertically hinged doors. For sliding side door systems, see GMW15844.

1.3 Remarks. A door is secured to a rigid fixture, in approximate **Design Position**, and an outboard direction load is applied to (a) the rearward **belt-line** area of the door, and then to (b) the rear lower corner area of the door. **Deflection** and **set deflection** readings are recorded for each of the two (2) load locations.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15844

2.3 Additional References.

- CG190 Evaluation Report Template
- Global Door Subsystem Technical Specifications (GSSTS), Section 3.2.1.7.2
- Vehicle Technical Specifications (VTS)

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.

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.

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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 A5).

3.2.1.2 Rigid hinge pillar fixture for securing/mounting the hinge mounting plate(s) in approximate **design position** on the structure surface plate (see Figure A5).

3.2.1.3 Rigid fixture to hold the servo linear actuator that will be used to apply the specified load (see Figure A6).

3.2.1.4 Rigid fixture to hold the digital linear displacement probe in place (see Figure A7).

3.2.1.5 Rigid lock pillar fixture with production striker/latch (see Figures A6 and A7).

3.2.1.6 Attachments to connect the load cell to the servo linear actuator and the load application fixturing to the load cell (see Figure A8).

3.2.1.7 Small piece of clay 25 mm cube and a flat thin plate of metal 25 mm square to embed into the clay (see Figure A7).

3.2.1.8 Semi-spherical, rubber, load applicator (approximately 70 mm diameter) to apply the specified load(s) to the door's inner panel (such as the Blackhawk Manufacturing Company's “Flex-Head Number Z539”). See Figure A8. This applicator works well because it compresses to conform to the surface of the inner panel without slipping (unlike a hard-tipped accessory).

Note: Because **deflection** will be measured based on outer panel movement directly opposite of the inner panel load location, localized denting of the inner panel or flexing of the rubber load applicator at the load point will not affect test results.

3.2.2 Instrumentation.

Note: The GMNA Body Test Laboratory has two (2) 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 one of these two (2) consoles and associated equipment.

3.2.2.1 Computer console system.

3.2.2.2 Load cell with a capacity to of approximately 1.5 times the load that will be applied during testing (see Global Door Subsystem Specifications GSSTS).

3.2.2.3 Servo linear actuator capable of providing at least 900 N of linear force (see Figure A6).

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/micrometer, if testing non-metallic parts.

3.2.2.6 Linear measuring device (digital linear displacement probe) with a stroke of at least 25 mm (see Figure A8).

3.2.2.7 Small level for leveling the servo linear actuator and displacement probe in the horizontal direction.

3.2.2.8 Layout dye/spray paint and a scriber suitable for marking the door's flanges/seams/hems that may potentially move or separate during testing. See 4.3.1.3.

3.3 Test Vehicle/Test Piece.

3.3.1 A “**Door-In-White**” is required, including the door hinges, latch/striker, and their 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. For those doors that have an outer panel that is not bonded, e.g., permanently adhered to the inner by means of weld, adhesive, etc., to the inner panel, then the outer panel should be removed. If more than one (1) 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 and fasteners must be obtained for each

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sample tested. It is also recommended that the test parts/assembly be dimensionally certified before testing is started.

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:	3 h
Technician time:	8 h

Note: If door hinge mounting plates do not exist, up to 11 days and 12 additional engineer hours 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 Door Subsystem 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 are 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. Refer to Figure A10 for how to choose the upper load location and Figure A11 and Figure A12 for how to choose the lower load location.

3.5.2 Load magnitudes (per Global Door Subsystem Specifications (GSSTS), Section 3.2.1.7.2).

3.5.3 Maximum allowable door **deflection** at the specified load. A value should be specified for both load locations.

3.5.4 Maximum allowable door **set deflection**. A value should be specified for both load locations.

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

3.5.6 Any critical part thicknesses 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 and will minimize potential for accidents and injuries.

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 sections 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 be included in 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, latch/striker, and the division post assembly. If receiving a door that has no hardware, then install the hinges, latch/striker, and the division post assembly. Use the appropriate fasteners and their respective torque values. **See 4.3.1.2 for hints on torque values.** For those doors that have an outer panel that is not bonded to the inner panel, then the outer panel should be removed.

4.1.3 Facilities and/or Equipment Preparation. Record the instrumentation calibration information on Calibration Data Sheet A1 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). Unless otherwise noted, these conditions are typically 22 °C ± 3 °C, relative humidity of 40% ± 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. Refer to Figures A5 through A12 during this part of the procedure.

4.3.1.1 Using production intent hinges, mount the door in approximate **Design Position** to the hinge pillar fixture (see Figure A5).

4.3.1.2 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. The maximum value (or greater, within the limits of the fasteners) should also be used for the latch/striker fasteners on the door to prevent any latch/striker movement while the door is loaded. In contrast, the minimum torque value is typically used for the door side hinge fasteners, as this is the worst case scenario.

4.3.1.3 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/slipping of the hem or hinges that may occur during testing.

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4.3.1.4 Move the door to the fully closed position. Adjust the rigid latch/striker fixture accordingly, and latch the door onto this fixture (see Figure A7). Secure the rigid latch/striker fixture to the structural surface plate.

4.3.1.5 This test involves applying the specified load at 2 different locations on the door inner panel. These locations are historically at the (a) upper rear area of the inner panel at approximately **belt-line** height and on the primary (J-line) sealing surface (see Figure A10) and; (b) lower rear area of the inner panel, once again on the primary (J-line) sealing surface (see Figure A11and Figure A12). Using Figures A10 through A12 as a guide, locate and mark these points at this time.

4.3.1.6 Loading at the upper rear area of the inner panel will occur first. Move the servo linear actuator to approximately the mid-travel position, and position the servo linear actuator fixture such that the load cell and rubber load applicator are positioned as shown in Figures A6, A8, and A9.

Note: When testing the second load location, align the servo linear actuator using the same concepts as described in Figures A6, A8, and A9.

4.3.1.7 Once proper alignment of the loading fixture has been established, secure this loading fixture to the structural surface plate.

4.3.1.8 Adjust the inboard/outboard stroke position of the servo linear actuator such that the rubber load applicator is very close to the point on the panel where loading will occur, but do not touch the panel (approximately 2 mm).

4.3.1.9 Move the digital linear displacement probe into approximate position and secure its fixturing to the structural surface plate (see Figure A7).

4.3.1.10 Fine tune the position of the digital linear displacement probe against the door's outer panel as shown in Figures A7, A8, and A9. The probe should be positioned to measure the door **deflection** in-line with the load application direction. Since most outer panels are curved, the displacement transducer will slide along the curved surface as the load is applied, thus causing erroneous displacement readings. This can be eliminated by using a piece of clay and small thin piece of metal to build the surface “up” to a flat surface (see Figure A7 and Figure A8). For those doors that have had the outer panel removed, clay and a small thin piece of metal can be used to form a flat surface that the probe can be located against. Make sure that the final positioning of the displacement transducer allows for enough travel during the test (at least 20 mm of the 25 mm probe should be available for recording data).

4.3.2 Test Operation Instructions.

4.3.2.1 When using one 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 tolerances.

4.3.2.2 Set the servo linear actuator speed to 1 mm/s.

4.3.2.3 When beginning the test, the computer console will automatically zero the digital linear displacement probe and load cell before any loading begins.

4.3.2.4 Upon pressing the start button on the console, the console will automatically apply and release the specified load while recording the door's torsional displacement vs. the applied load. Also during the loading, it is not uncommon to hear “pop” and crackling noises. If possible, try to verify where on the door these noises are coming 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.

4.3.2.5 Refer to the sample plots contained in Figures A2, A3, and A4 for assistance in interpreting the results. If a problem appears to have occurred during the test, then Figure A3 and Figure A4 provide an example of what these problems have typically been in the past.

4.3.2.6 Repeat steps 4.3.1.6 through 4.3.2.5 for the 2nd load location (lower rear area of the door).

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 post test condition of the test material as it compares to the pre-test condition, and note any changes. Record, in the comment section of the load vs. **deflection** graph, any discrepancies such as metal deformation, hem and/or hinge separation or movement, visible cracks, cracked or broken welds, interference between door components, or loss of function.

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Note: Every post test operation/measurement/inspection must typically have a pre-test equivalent to have any meaning or significance. A crack detected at end of test means nothing unless there is a pre-test 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 mock-up, 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 Data Sheets A1 and A2. 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 movement of the door at the load location in the direction of load application (see Figure A2).

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.

Set Deflection: Refers to the permanent deformation or “plastic deformation” of the door at the load location (measured in the direction of load application) after the specified load has been applied and removed (see Figure A2).

7.2 Acronyms, Abbreviations, and Symbols.

D-I-W	Door-In-White
D.L.O.	Daylight Opening
ELPO	Electrophoretic Priming Operation
GDM	Global Document Management
GSSLT	Global Subsystem Leadership Team
GSSTS	Global Subsystem Technical Specification
TIE	Technical Integration Engineer
VTS	Vehicle Technical Specification

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