



Door System – Vertical 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 system when subjected to a downward vertical load applied at the latch. This test is to assess the door structure's ability to consistently align the latch and striker.

1.2 Applicability. This procedure applies to all passenger multi-purpose and commercial vehicles having conventional swing-open doors. It can also be used for station wagon endgates. For sliding side door systems, see GMW15939.

1.3 Remarks. A door is secured in **Design Position** to a rigid fixture or on a body, and a downward vertical load is applied at the door latch/striker. Vertical **Deflection** and **Set Deflection** readings are measured at the latch/striker just below the latch/striker opening.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15938 GMW15939

2.3 Additional References.

- CG190 Evaluation Report Template
- Global Door System Subsystem Technical Specifications (GSSTS)

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 specified in Section 4.2.

Minor Facility:

- a. Structural Surface Plate, if testing is conducted on a fixture.
- b. Body Slot or equivalent area, if testing is conducted on a body. Note, however, that the area must have the capability to secure the body to "ground", i.e., to prevent the body from moving relative to the ground.

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.

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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 On Fixture.

3.2.1.1.1 Hinge mounting plate(s) for mounting the door, by its hinges, in design position on the structural surface plate (see Figure A2).

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

3.2.1.2 On Fixture and On Body.

3.2.1.2.1 A fixture to hold the digital linear displacement cable transducer in place when measuring door height (see Figures A3 and A4).

3.2.1.2.2 A slotted sticker or equivalent method for attaching the cable end of the cable transducer to the latch face of the door (see Figure A4).

3.2.1.2.3 Vertical rigidity load bar that enables the door to be loaded in the vertical direction. The GMNA Body Test Lab uses a 2:1 ratio load bar, i.e., for every Newton of force put into the load bar, two (2) times this force is applied at the door. (See Figure A3 and Figure A5).

3.2.1.2.4 Rigid fixture to hold the servo linear actuator that will be used to apply the specified load (see Figure A3).

3.2.1.2.5 Attachments to connect the load cell to the servo linear actuator and the load application fixturing to the load cell (see Figure A5).

3.2.1.2.6 When performing the test on a body and measuring door height values relative to the ground, it is essential that the body be secured to the ground, such that the body height does not change during the test. An example of how this is achieved is shown in Figure A7, where the test body is secured to the surface plate using four (4) turn-buckles and appropriate end attachments, one (1) at each shock tower hole or any equivalent structural attaching location. If the test is performed on a fully built vehicle, then the shock tower holes will not be available, and the body will have to be secured by other methods (straps, jack stands, etc.)

3.2.2 Instrumentation.

Note: The GMNA Body Test Laboratory has computer console systems that are designed for and dedicated to door structure testing. The console is self-contained and operates the required servo linear actuator, (e.g., load application motor), load cell, and displacement measuring instrumentation that is used when conducting door structure testing. The GMNA Warren Primary Tracking Site of the Instrumentation Knowledge Center keeps a complete description of the instrumentation equipment and/or software specifications for the console. The remainder of this procedure is written assuming that the structure testing is performed using this console and associated equipment.

3.2.2.1 Computer console system.

3.2.2.2 Load cell with a capacity to handle the load that will be applied during testing (≥ 450 N).

3.2.2.3 Servo linear actuator capable of providing at least 450 N of linear force (see Figure A3).

3.2.2.4 Torque wrench with a capacity of approximately 1.5 times the fastener(s)' required torque specification(s) (see 3.5.4).

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 cable transducer) with a minimum stroke of 25 mm; this measuring device will be used to measure door height (see Figure A4).

3.2.2.7 Angle measuring instrument, for determining when the cable transducer's cable is vertical (± 1 degree of precision).

3.2.2.8 Tape measure or ruler for measuring the 200 mm door opening position.

3.2.2.9 Layout dye/spray paint and a scribe suitable for marking the door's flanges/seams that may potentially separate during testing (see 4.3.1.1.3).

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3.2.2.10 Height gage (used as a back-up instrument in the event of a cable transducer malfunction) for measuring door height (see Figure A3 and Figure A6).

3.3 Test Vehicle/Test Piece.

3.3.1 A “Door-In-White” is required, including the door hinges, door 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. 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 (see 3.5.4) should be obtained from release drawings. New hinges and fasteners must be obtained for each sample tested. It is 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.

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 Load magnitude as specified in 3.2.1.7.3 of the Global Door System Specifications (GSSTS).

3.5.2 Maximum allowable **Deflection**.

3.5.3 Maximum allowable **Set Deflection**.

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

3.5.5 Any critical part thicknesses and locations where to perform these measurements.

3.5.6 If a reverse load to return the door to a zero set condition is required (see 4.3.3.2).

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.

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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 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.

Thickness measurement locations 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 **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, the latch and/or striker, and the division post assembly. If receiving a door that has no hardware, then install the hinges, the door latch and/or striker, and the division post assembly. Use the appropriate fasteners and their respective torque values (see 4.3.1.1.2 for guidance on torque values).

4.1.2.2 If testing is to be conducted on a body, perform the Door System - Alignment to Body procedure (GMW15938) and make necessary adjustments so the door is in the correct **Design Position** prior to the start of testing.

4.1.3 Facilities and/or Equipment Preparation. Record the instrumentation calibration information on Data Sheet A1 or 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, then documented prior to test start.

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4.3.1 Set Up Instructions.

4.3.1.1 On Fixture Set Up Instructions. For testing conducted on a body, proceed to 4.3.1.2. **Refer to Figures A2, A3, A4, A5, and A6 during this part of the procedure.**

4.3.1.1.1 Using production intent hinges, mount the door in **Design Position** to the hinge pillar fixture (see Figure A2).

4.3.1.1.2 Torque all hinge nuts/bolts to specification (see 3.5.4); hinge bolt torque values are typically given as a range. For testing conducted on a fixture, 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.

4.3.1.1.3 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 undesired movement/slipping of the hem or hinges that may occur during testing.

4.3.1.1.4 Perform any functional/operational tests/evaluations as requested or as may be referenced in Section 2 References. As applicable, note any irregular sounds or erratic operation indicating a potential problem with design, manufacture, or assembly and verify observations with the requesting engineer.

4.3.1.1.5 Move the door to approximately the 200 mm open position, measured at the latch/striker area of the door (the door's zero open position is when the door is in the fully closed position).

4.3.1.1.6 Adjust (rotate) the end of the vertical rigidity load bar such that the side of the load bar is parallel to the door's latch/striker mounting face (see Figure A4).

4.3.1.1.7 Adjust the load bar up or down on the stanchion so that it will be horizontal when the striker is fully engaged into the latch; latch the door onto the load bar.

Note: Do not attempt to adjust the load bar up or down with the load bar already latched to the door. This will introduce vertical loads to the door before the test has even begun.

4.3.1.1.8 Fine-tune adjust the load bar stanchion so the door is in the 200 mm open position. Make sure the striker remains properly engaged into the latch.

4.3.1.1.9 As shown in Figure A4, attach the cable end of the cable transducer to the latch/striker mounting face of the door, and position the body of the transducer below the latch/striker mounting face such that the cable is perpendicular to "ground", i.e., vertical to the structural surface plate. This cable transducer will be used to record the door's height before, during, and after testing, and report these results back to the computer console.

4.3.1.1.10 Using the angle measuring instrument in 3.2.2.7, position the servo linear actuator so that its shaft is vertical; also, move the shaft to approximately the mid-travel position. Align the hook accessory with the load location on the load bar. Secure the servo linear actuator fixture to the structural surface plate (see Figure A5).

4.3.1.1.11 As a suggested backup method for measuring the door's **set deflection**, use a height gage and scribe a very fine line in the same area of the latch face that the cable transducer is connected to (see Figure A6). Record this initial height value on Data Sheet A2. If testing on a body, then also scribe a very fine line on the body in order to verify that the body did not move as a result of the vertical load application. Record this initial body height value on Data Sheet A2. Data Sheet A3 is provided as an example of a properly "filled-out" data sheet.

4.3.1.2 On Body Set Up Instructions.

4.3.1.2.1 Secure the body such that the body cannot move relative to "ground", i.e., the floor. If possible, turn-buckles may be used to secure the body to the floor, one (1) end of each turn-buckle attaches to the body at the shock-tower hole and the other end to the floor (see Figure A7). If the test is performed on a fully built vehicle, then the shock tower holes will not be available, and the body will have to be secured by other methods (straps, jack stands, etc.)

4.3.1.2.2 Torque all hinge nuts/bolts to specification (see 3.5.4); hinge fastener values are typically given as a range. For testing conducted on a body, the minimum torque value is typically used for all fasteners, as this is typically the worst-case scenario.

4.3.1.2.3 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 undesired movement/slipping of the hem or hinges that may occur during testing.

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4.3.1.2.4 Perform any functional/operational tests/evaluations as requested or as may be referenced in Section 2 References. As applicable, note any irregular sounds or erratic operation indicating a potential problem with design, manufacture, or assembly and verify observations with the requesting engineer.

4.3.1.2.5 Move the door to approximately the 200 mm open position, measured at the latch/striker area of the door. The door's zero open position is when the door is in the fully closed position.

Note: Unlike testing on a fixture, the vertical rigidity load bar cannot be positioned/located perpendicular to the door's inner panel, i.e., the body is in the way. For on-body testing, the load bar extends off the end of the door in a direction parallel to the door's inner panel, not perpendicular.

4.3.1.2.6 Adjust the end of the vertical rigidity load bar such that the striker and latch are aligned properly.

4.3.1.2.7 At this point, setup on a body is conducted in the same manner as on a fixture, therefore, follow steps 4.3.1.1.8 through 4.3.1.1.11 to complete the on-body test setup.

4.3.2 Test Operation Instructions. Test Operation - On Fixture and On Body.

Note: When using the door structure console system to perform the test, the console will guide the test engineer through the required steps necessary to operate the console.

4.3.2.1 When using the door structure console system 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 cable transducer and load cell before any loading begins, i.e., the initial door height measure is set to zero.

4.3.2.4 Upon pressing the start button on the console, the console will automatically apply and release the specified load as specified in 3.2.1.7.3 of the Global Door Subsystem Technical Specifications (GSSTS), while recording the door's vertical displacement vs. the applied vertical load. Also during the loading, it is not uncommon to hear "popping" 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, and, for testing conducted on a body, watch for contact between the front edge of the door being tested and adjacent body/door panels. Immediately after achieving the desired load, the console will reverse the actuator direction and remove the load.

4.3.2.5 As a back-up for measuring the door's **set deflection** with the cable transducer, use the height gage and determine the new height of the original scribed line (record this height on Data Sheet A2). The **set deflection** of the door is the difference between the original height of the scribe and the final height of the scribe line. This value should be equal or within ± 0.10 mm to the value measured by the cable transducer. The value measured by the cable transducer is the value that should be reported in the test report, unless it has been determined that the cable transducer malfunctioned during the test.

4.3.2.6 If testing was conducted on a body, then also use the height gage to verify that the body did not rise/sag during the test.

Note: The body should not have moved during the test. If it did move, however, then there is no way of equating this movement into the door rise/sag value, as there is no way to determine about what axis the body rotated. The only option would be to re-run the test on a new body and door.

4.3.2.7 Refer to the sample plots contained in Figure A1, Figure A8, and Figure A9 for assistance in interpreting the results. If a problem appears to have occurred during the test, then Figure A8 and Figure A9 provide an example of what these problems have typically been in the past.

Note: If testing is performed at a location other than the GMNA Body Test Laboratory, the test engineer will not have the use of a console system. If so, then use the attached Data Sheet A2 to record the **Deflection, Set-Deflection**, and body height values. Data Sheet A3 provides an example of a data sheet that has been properly filled out.

4.3.3 Post Test Instructions.

4.3.3.1 Visually inspect the post test condition of the test material as it compares to the pre-test condition, and note any changes. Record, on Data Sheet A2, 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.

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 pre-test documentation verifying no crack existed prior to start of test.

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