



Door System Belt Line 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 deflection of the door inner and outer panels. This measurement is recorded at the center of the belt line.

1.2 Applicability. This procedure applies to all passenger, multi-purpose and commercial vehicles having dropping window systems, such as conventional side doors and station wagon end gates.

1.3 Remarks. A door is secured in body position and a horizontal load is applied at the belt line on the inner and outer panel. The lateral deflections of the inner and outer panels are measured at the center of the belt line.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- CG190 Evaluation Report Template
- Master Process Documents (MPD)
- Release Drawings

3 Resources

3.1 Facilities.

Major Facility: The facility should contain the equipment described in 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 Rigid hinge pillar fixture for mounting the door by its hinges, in approximate design position, on the structure surface plate (see Figure A2)

3.2.1.2 Door Hinge Mounting Plate(s): Steel plate(s) used to attach the door's hinges to the rigid hinge pillar fixture. The plate(s) use(s) standard attaching holes for the hinge pillar and specific holes for the door hinges.

3.2.1.3 Hemispherical rubber, load applicator (approximately 15 mm diameter) to apply a specified load to the door's inner and outer panels (such as Blackhawk Manufacturing Company's "Flex-Head Number Z539"; see Figures A4, A5, and A6). This adapter works well because it compresses to conform to the surface of the panel without slipping (unlike a hard tipped accessory). For unique door panel shapes at the belt line, other load applicators may be needed in order to load the door panel and prevent slippage of the load head and localized bending of the inner and outer panel.

3.2.1.4 Rigid fixture to secure the lock pillar end of the door. This can be achieved by attaching clamps along the rear hem-flange (see Figure A3); clamping the door will reduce the reaction to the torsional loads introduced to the door when loading at the belt line. When clamping the door along the rear hem flange, it is best not to clamp the door at a height above the outside handle opening so as not to restrict movement at the hem flange at the rear of the belt line.

3.2.1.5 Light-weight fixture to clamp on either the inner panel or the outer panel at the belt and hold a deflection instrument that will measure the deflection (refer to Figure A4 and Figure A5).

Note: The fixture's design must attach as close as possible to the loading centerline to minimize error in the readings. Similarly the height of the device should be minimum to reduce rotational discrepancies.

3.2.1.6 Rigid fixture to hold the servo linear actuator (see Figure A3).

3.2.2 Instrumentation.

3.2.2.1 Unit console which includes an x-y plotter, bridge amplified meter, a variable resistance calibration box, and a servo linear motor controller.

3.2.2.2 Load cell with a capacity approximately 1.5 times the maximum specified load to be applied to the door's inner and outer panels.

3.2.2.3 Servo linear actuator.

3.2.2.4 Torque wrench(s) with a capacity approximately 1.5 times the maximum specified fastener torque(s).

3.2.2.5 Instrument capable of measuring linear displacement with a linear measuring range equal or greater than the gap between the inner and outer panels, measured at the center of the belt line.

3.2.2.6 Krautkramer Ultrasonic thickness tester (for measuring metal panel thickness or caliper (for measuring non-metal panel thickness)).

3.3 Test Vehicle/Test Piece. A door assembly is required (preferably without trim and window systems), including hinges and their respective fasteners. Unless specifically requested, the door should have been "baked" per the production paint process to cure all adhesives, deadeners, etc. If more than one (1) sample is being tested, they should all be the same "hand" in order to minimize fixture modifications, e.g., all left-hand or all right-hand doors. However, in some cases it may be desirable to test both right and left-hand parts due to tooling and manufacturing process variations. Specifications for hinge mounting locations and bolt torques should be obtained from release drawings or Master Process Documents (MPD). 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 test details, running multiple samples (times shown are for one (1) system), etc.

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

Calendar time: **Note 1** 1 d

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Engineer time: ^{Note 1} 4 h

Technician time: 8 h

Note 1: If hinge plates have to be designed and built, add 11 h to the "Engineer time" and 11 d to the "Calendar time".

3.5 Test Required Information. The requesting engineer is responsible for providing specifications appropriate to the particular vehicle line being tested (see 2.2).

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 magnitudes, rates and directions.

3.5.2 Maximum allowable deflection.

3.5.3 All applicable fastener torques.

3.5.4 Any critical part thicknesses.

3.5.5 Location for load application.

3.5.6 Type of load applicator.

3.5.7 Addition or deletion of structural members.

3.5.8 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.

4 Procedure

4.1 Preparation.

4.1.1 Sample Inspection. The test and requesting engineers should inspect the test items to ensure all material listed in 3.3 is of correct design level and assembled properly.

4.1.1.1 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. Typical measurements include three (3) randomly selected locations on each of the following parts: Door Outer Panel and Door Inner Panel.

Note: Additional locations may be requested depending on whether or not additional door structure tests will be performed.

Note: The previously listed locations are of particular interest because they are significant contributors to the door structural performance. Be aware that sheet metal drawn (stretched) sections may be significantly thinner than flat sections of the same part.

4.1.1.2 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: To avoid erroneous ultrasonic metal thickness measurements, carefully remove paint, primer, etc., where the thickness measurements will be made. 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.

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

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).

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4.1.2.1 As applicable, remove all non-fixed windows and related hardware, unless otherwise directed by the requesting engineer. However, if the door has a division post, check with the requesting engineer to determine whether or not it should be installed/removed before testing; it may add stiffness to the belt line section of the door. Be sure to note in the final report whether or not a division post was present during testing.

4.1.2.2 The door must have hinges and door latch(es) along with appropriate fasteners.

4.1.2.3 Check with the requesting engineer(s) to determine if adhesive (if applicable) should be fully cured or not before testing. If doors have not been through the ELPO system, then they must be "baked" before testing in order to "set" the adhesives in the hem, door beam, etc.

4.1.3 Facilities and/or Equipment Preparation. Record the instrumentation calibration information on Data Sheet A1 (Appendix A) 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 $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$, 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.

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 A2, A3, A4, and A5 during this part of the procedure.

4.3.1.1 Mount the door, with production-intent hinges, to the hinge pillar fixture in approximate body position (see Figure A2). Torque all hinge nuts/bolts to specification (see 3.5.3). Scribe or otherwise mark along the door's hem line. This scribing is done to help detect any movement of the hem flange during testing. Scribing or marking the position of the hinges relative to the door and fixture may also be done. This, however, should not be necessary, because if the hinges slip slightly during the test, this should not affect the relative displacement measurements. The hinge pillar fixture is clamped to the surface plate at some point during this process. When and where is at the discretion of the test engineer.

4.3.1.2 Secure the lock pillar end of the door by attaching three (3) clamps along the rear edge of the door. Clamping the door below the belt line will secure the lower half of the door (see Figure A1).

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 belt line) 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 Figure A1).

Note: This $35\text{ mm} \pm 0.5\text{ mm}$ dimension is the value agreed upon based on investigation of header design and will also be consistent with analytical models.

4.3.1.3 Clamping the door along the lower rearward edge will reduce the reaction to the torsional loads introduced when loading at the Belt Line. When clamping the door along the rear hem flange, it is best not to clamp the door at a height above the outside handle opening so as not to restrict movement at the hem flange at the rear of the belt line.

4.3.1.4 The load will be applied at the center of the belt line (see Figure A3). To find the center, measure the length, from front to rear, of the moveable glass opening at the belt line. Divide this length by 2, to find the center of the belt line and mark this location at the belt line on both the inner and outer panels.

4.3.1.5 Loading of the inner panel and outer panel should be applied independently.

4.3.1.5.1 The load will be applied at the center of the belt line (as determined in step 4.3.1.4). The lateral load should be applied independently at the middle of the inner panel box section (see Figure A4) and the outer panel in an outboard and an inboard direction, respectively. The outer panel should be loaded in line with the load application point on the inner panel box section. Record load locations, orientations, directions, etc., on data records.

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4.3.1.5.2 Position the load applicator and servo linear actuator to load the inner panel in the direction and the location determined in 4.3.1.4. Secure the fixture that holds the servo linear actuator to the structure plate.

Note: The hemispherical rubber load applicator is not the only applicator that may be used, but it is the preferred applicator. Other adapters, such as a knife edge accessory, may be needed to apply the load.

4.3.1.5.3 The purpose of the test is to measure the deflection of the inner and outer panels when subjecting to a specified load. At this time, instrumentation, similar to what is shown in Figure A4 and Figure A5, needs to be installed to measure this deflection at the location where the load is being applied, e.g., the center of the belt line.

Note: Try to keep the attachment point and all displacement measurement as close as possible to the centerline of the load application vector.

Note: It is understood that different doors have different belt line configurations, thus it may be difficult to clamp a fixture to the inner or outer panel. The end result, however, is that the deflection of the inner and outer panels must be measured. Alternate methods of measurement may include using a string potentiometer, a dial indicator, or a linear variable displacement transducer.

Note: Outer panel shapes, at the belt line, vary considerably; some have a flange, some are rounded, etc. Discuss with requesting engineer exactly where to load on the outer panel.

4.3.2 Test Operation Instructions. Apply and release the specified (see 3.5.1) load on the door inner panel and then the outer panel belt at the established location and in the direction determined in 4.3.1.4 and 4.3.1.5.1, and graph load vs. panel deflection. Use a pre-labeled graph similar to that shown in Figure A6 to record deflection and set deflection. Adjust the ram travel rate to be approximately 1 mm/s. Refer to the sample plots contained in Figures A6, A7, and A8 for assistance in interpreting the results. Figure A6 shows what a typical graph will look like when performing the belt line rigidity structural test. Figure A7 and Figure A8 show some common problems which may occur while performing the test.

4.3.3 Post Test Instructions.

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 pretest documentation verifying no crack existed prior to start of test.

4.3.3.1 Include a sketch or marked drawing showing the part thickness measurement locations (if measured), load application locations and directions, and deflection measurement locations.

4.3.3.2 Note posttest areas of visible metal deformation, hem and/or hinge separation or movement, panel cracks, or interference between door components.

4.3.3.3 Use a paint pen or permanent marker 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 Data Sheet A2. (Refer to 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.

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