



Door System - Check Load 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 relative shear motion between the door's inner and outer panels (also referred to as matchboxing) during check loading, and
- The resultant rise or sag of the door as a result of check loading

1.2 Applicability. This procedure applies to all passenger cars, light duty trucks, and medium duty trucks having conventional swing-open doors. It can also be used for station wagon end gates that pivot about vertical center line hinges.

1.3 Remarks.

1.3.1 A door is secured in **design position** to a rigid fixture, or to a body. With the door in the full-open position, a **check load** force is applied in the outboard direction at the latch opening of the inner panel. During and after loading, the fore/aft relative shear motion between the inner and outer panels is measured on the **belt line** at the center of the moveable glass opening (i.e., **matchboxing**). Door height is also measured before and after the **check load** test (the resulting change in height is the rise/sag). All measurements are recorded in an effort to evaluate the structural integrity of the door when subjected to **check load** type loads.

1.3.2 This test simulates loads that may be applied to the door at the assembly plant or by the customer who purchases the vehicle. Customers' doors may be **check loaded** by a gust of wind when the door is opened with the vehicle parked on a grade, when the door is kicked or thrust open, when a car is pushed out of the snow via an open door, etc.

1.3.3 Check load cycle durability is addressed in GMW15093.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14803 GMW15093

2.3 Additional References.

- CG583 form
- Release Drawings
- Subsystem Technical Specifications (SSTS) – All that apply (see 3.5)
- Vehicle Technical Specifications (VTS)

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3 Resources

3.1 Facilities. Facility equipped with a structural surface plate:

- If performing the test on a fixture or a body slot, with provisions for anchoring body to the floor.
- If performing the test on a body.

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: 3.2.1 and 3.2.2 include fixturing and instrumentation typically used 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. Whether performing this test on a fixture or on a body, the same fixturing will be used, with the exception that the body will replace the hinge mounting plates described in 3.2.1.1, and the rigid hinge pillar fixture in 3.2.1.2 when performing the test on a body. In addition, a body must be rigidly secured to ground using a method similar to that described in 3.2.1.9.

3.2.1.1 Hinge mounting plate(s) (with a **checklink** mount, if applicable) for mounting the door in **design position**, by its hinges and **checklink**, on the structural surface plate (Figure A1).

3.2.1.2 Rigid hinge pillar fixture for securing/mounting the hinge mounting plate(s) in **design position** on the structural surface plate (Figure A1).

3.2.1.3 Rigid fixture to hold the digital linear displacement cable transducer that will measure door height (Figure A2 and Figure A3).

3.2.1.4 Angle plate that maintains the door in the 200 mm open position (Figure A2).

3.2.1.5 Fixtures for measuring the relative shear between the inner and outer panels, (i.e., **matchboxing** fixtures). These fixtures are also used to secure the digital linear displacement probe that is used to record the **matchboxing** measurement (Figure A4).

3.2.1.6 Rigid fixture to hold the servo linear actuator that will be used to apply the specified load (See Figure A5).

3.2.1.7 Semi-spherical, rubber, load applicator approximately 70 mm diameter to apply the specified **check load** to the door's latch area, such as the Blackhawk Manufacturing Company's Flex-Head Number Z539. (See Figure A5 and Figure A6.) This applicator works well because it compresses to conform to the surface of the inner panel without slipping (unlike a hard-tipped accessory).

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

3.2.1.9 When performing the test on a body and measuring door rise/sag 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 (bypass suspension to support vehicle). This is typically achieved by using four turn buckles and appropriate end attachments (one through each shock tower hole on the body). 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.

3.2.2.1 Site controller for conditioning the transducers, controlling the load application, and acquiring the data.

3.2.2.2 Load cell with a capacity to handle the load that will be applied during testing.

3.2.2.3 Servo linear actuator capable of providing the required force (Figure A5).

3.2.2.4 Torque wrench with a capacity of approximately 1.5 times the fastener(s) required torque specification(s). See 3.5.1.6.

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 minimum stroke of 25 mm. This measuring device will be used to measure the **matchboxing** (Figure A4).

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3.2.2.7 Linear measuring device (digital linear displacement cable transducer) with a minimum stroke of 25 mm. This measuring device will be used to measure changes in door height (Figure A2).

3.2.2.8 Linear measuring device for recording how far the door opens during loading. This could be a displacement encoder that is built into the servo linear actuator motor that is used to apply the **check load**. Note that this measurement is recorded in the direction of the load and does not measure the angular displacement of the door (refer to Figures A5 and A6). Also, the door displacement measurement will include compression of the rubber load applicator and any flexing of the column that supports the servo motor. This measurement, therefore, is only an indication of the door movement.

3.2.2.9 Angle measuring instrument, for measuring door opening angles.

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

3.2.2.11 Marker or paint pen suitable for marking the door's flanges/seams/hinges/**checklink**/hems that may potentially move or separate during testing (4.3.1.3).

3.2.2.12 Height gauge (used as a back-up instrument in the event of a cable transducer malfunction) for measuring door height.

3.2.2.13 White spray paint or stencil ink for coating stressed areas of door in order to more easily detect cracks.

3.3 Test Vehicle/Test Piece.

3.3.1 A Door-In-White is required, including the door hinges, **checklink** (if not already integral to the hinges), latch (for on body test), and their fasteners. If testing a rear 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 to show the hinge hole pattern (body side) and the hinge-to-body reference locations (will be needed to make door hinge mounting plates, in order to mount the door in **design position**) when performing tests on a fixture. When performing on-fixture testing on a door that has weld-on hinges, discuss with the requesting engineer as to how the door should be attached to the hinge mounting plates. New hinges and fasteners must be obtained for each door 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 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 hours:	15 h
Technician hours:	8 h

Note: If door hinge mounting plates do not exist, extra time 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 VTS/SSTS, if applicable. The paragraphs include: 3.2.2.3.1.3 (Deflection **Check Load** Strength), of 55.02, the Rear End Door Subsystems SSTS; 3.2.1.7.4 (Door **Check Load** Rigidity), of 55.01, the Front and Rear Side Door SSTS.

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

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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.

3.5.1 The following specifications or information are required to run this test.

3.5.1.1 Location for **check load** application. This location should be at the latch opening on the inner panel (i.e., latch fish mouth), or in those cases where the striker is located on the door, load at the striker location.

3.5.1.2 Check load magnitudes.

3.5.1.3 Maximum allowable door rise/sag as a result of the **check load**.

3.5.1.4 Maximum **matchboxing set**. Note that the specifications are different depending on whether the test is performed on a body or a rigid fixture (reference the SSTs).

3.5.1.5 All applicable fastener torque values and a description of whether the value is a nominal, minimum, or maximum torque value. Fasteners are typically torqued to nominal value for validation.

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

3.5.1.7 Nominal door angles for the door's full-open and check positions. (Reference SSTs section 3.2.2.1.3).

3.5.1.8 Hold-open detent efforts (GMW14803), if requested to be measured before and after the **check load** test.

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.

4.1.1.1 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.

4.1.1.2 If requested to do so, use an 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.

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 (i.e., 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.

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 latch, outside handle, hinges, **checklink**, and on rear doors, the division post assembly. If receiving a door that has no hardware, then install the hinges, **checklink**, latch (on body test) and for rear doors, also the division post assembly. Use the appropriate fasteners and their respective torque values (4.3.1.2 for hints on torque values).

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

4.2 Conditions.

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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.

Note: For this procedure, any deviations must be brought to the attention of the Global Subsystem Leadership Team (SSLT) 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 Setup Instructions.

On-Fixture Setup Instructions. For testing conducted on a body, refer to 4.3.1.8.

4.3.1.1 Using production intent hinges, mount the door in **design position** to the rigid hinge pillar fixture (Figure A1). If the door has a separate check system (a **checklink** not integral to the hinges), this must also be mounted on the hinge pillar fixture in **design position**. For systems that have a **checklink** that is not part of the hinges, the **checklink** mounting surface location (supplied by requesting engineer) is critical in order for this test to produce meaningful data. For example, some hinges are designed with a built-in check-stop that is intended to assist the **checklink** only after the **checklink** has been engaged for at least three degrees of additional door open travel beyond the already full-open position. If the **checklink** mounting surface is not correct, the hinges may assist the **checklink** at a load less than what is intended, i.e., too early, or on the other extreme, not early enough.

4.3.1.2 Torque and mark all hinge nuts/bolts to specification (3.5.1.6); hinge bolt torque values are typically given as a range. For testing conducted on a fixture, bolts/nuts are torqued to nominal values unless otherwise specified.

4.3.1.3 Mark the position of the hinges relative to the door and fixture. If applicable, also mark along the hem line. This marking is done to help detect any movement/slipping of the hem or hinges that may occur during testing.

4.3.1.4 Document hinge check stop angle without **checklink** body side attachment degrees.

4.3.1.5 Document hinge check stop contact order (upper, lower, both) on checklist (Data Sheet A2). After this measurement is performed, install body side **checklink** fastener. If body side **checklink** attachment uses a fastener with Loc-Tite or other adhesive, a new production intent fastener must be used for durability testing.

4.3.1.6 Measure the door's open angle with the door in the last detent position. If different than the full open position, also measure the door's open angle when the door begins to check (3.5.1.8). Record these angles on Data Sheet A2.

Note: Exactly when the door begins to check can be a subjective measurement depending on the stiffness of the door system when in the check position. For these cases, it will be more repeatable to measure the door's open angle at check position if a 40 N pre-load is applied to the door, at the latch location, when the angle is measured (4.3.1.6).

4.3.1.7 Using the angle plate, open the door to 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).

4.3.1.8 As shown in Figures A2 and A3, slide an angle plate up against the inner panel of the door and secure the angle plate to the structure plate. This allows the door to be brought back exactly to the 200 mm open position each time the door height is measured. For body testing, instead of the angle plate described above, use a bar that attaches to the latch and striker to locate/hold the door in the 200 mm open position.

4.3.1.9 As shown in Figures A2 and A3, attach the cable end of the cable transducer to the latch face of the door, and position the body of the transducer below the latch face such that the cable is perpendicular to **ground**

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(i.e., vertical). This cable transducer will be used to determine the door's height before and after the test and report these results back to the computer console.

4.3.1.10 Determine the center of the moveable glass opening at the **belt-line**. As shown in Figure A4, there will be two fixtures mounted to this area. These two fixtures will be used for measuring **matchboxing**.

4.3.1.11 Mount, to the door's outer panel **belt-line**, the fixture that the digital linear displacement probe locates against (Figure A4). If the outer panel has a **belt-line** flange, then this fixture just clamps onto this flange at the beltline midpoint. If the door does not have a surface that can be easily mounted to, then the test engineer will have to be creative as to how to mount the fixture. Typically, the indicator is shifted away from the midpoint to where it is possible to clamp it, yet as close to the midpoint as possible. The direction and distance away from the midpoint in which the indicator is clamped should be recorded for repeatability.

4.3.1.12 Mount the displacement probe portion of the **matchboxing** fixtures to the inner panel **belt-line** flange, with the probe pointing in the forward direction and resting against the fixture that is attached to the door's outer panel (Figure A4). The probe direction should be parallel to the door's **belt-line**. The probe stroke length should be at the mid-travel position before starting the test, as the panel could move in either direction during testing. Making sure that the probe points in the forward direction is important when deciphering the directions of the panel movement (i.e., inner panel moves rearward relative to outer panel, etc.) When the fixtures are setup as shown in Figure A4, then a positive displacement means that the outer panel moved rearward relative to the inner panel.

4.3.1.13 The door should be in the 200 mm open position. At this time, record the initial door height; **matchboxing** = 0.

4.3.1.14 As a suggested backup method for measuring the door height, use a height gage and mark a very fine line in the same area of the latch face that the cable transducer is connected to. Record this initial height value on Data Sheet A2. If testing on a body, then also mark a very fine line on the body in order to verify that the body did not move during the **check load** application (make a note of the initial body height).

4.3.1.15 Remove the cable end of the cable transducer from the door latch area and carefully swing the door to the full open position without disturbing the **matchboxing** fixtures.

Note: During the next part of the test setup, ensure that nothing comes in contact with the door height measuring equipment.

4.3.1.16 Fully retract the servo linear actuator.

4.3.1.17 With the door open, move the servo linear actuator into its loading position (Figures A5 and A6). Position the actuator so that the load is applied to the inner panel latch opening/striker mount at the rear of the door. The load direction should be parallel to ground (horizontal direction) and applied such that the **attack** angle to the door equals 102 degrees $\pm$ 2 degrees at the start of the **check load**. This **attack** angle is the angle between the force application direction and the plane created by the door's inner panel (Figure A6).

On-Body Setup Instructions.

Note: The body will need to be secured to the ground in order to prevent the body from moving relative to the ground. In the event that the door height can be measured relative to the body, securing the body to ground is not necessary.

4.3.1.18 Mount the door, with production-intent hinges, to the body.

Note: If the door has a separate check system (a **checklink** not integral to the hinges), this must also be installed.

4.3.1.19 Torque all hinge and **checklink** nuts/bolts to specification (see 3.5.1.6). Hinge bolt torque 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. Mark the position of the hinges relative to the door and body. If applicable, also mark along the hem line. This marking is done to help detect any movement of the hem or hinges that may occur during testing.

4.3.1.20 At this point, setup on a body is conducted in the same manner as on a fixture; therefore, follow 4.3.1.2 thru 4.3.1.17 to complete the test setup.

4.3.1.21 Measure and mark door to fender gaps and/or front door to rear door gaps.

4.3.1.22 For rear door **check load** rigidity test, the front door should be in the latched position.

4.3.2 Test Operation Instructions.

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