



Oil Canning, Dynamic Dent Resistance and Initial Stiffness of Exterior Body Panels

1 Scope

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 oil canning resistance, Quasi-Static dent resistance and Quasi-Static stiffness of exterior body panels and closure panels which may include, but is not limited to, quarter panels, roofs, and doors. Computer Aided Engineering (CAE) analysis is the preferred method to evaluate body panels for oil canning stiffness, however, physical testing is optional. An automatic fixture controlled indenter should be used for physical testing. Engineering judgment or a manual indenter are also acceptable methods to demonstrate compliance.

1.2 Foreword. This test was developed to ensure that customer expectations are met for a quality panel feel (strong and resist denting and oil canning). Customer usage addressed by this test might include buffing and waxing (15 cm/6 in) pad on electric buffing wheel, roof top carriers (8 cm/3 in) pad on roof-top carriers, items tied to the roof, a person or object leaning against a vehicle, the load from car wash brushes, etc.

1.2.1 Panels are sometimes conveyed by suction cup devices in the production/assembly plants. Deflection testing may provide insight into potential problems in transporting panels with insufficient stiffness. SAE J2575 may be referenced in case more detail is required.

1.3 Applicability. Complete vehicle range. This procedure applies to panels and panel assemblies for all passenger cars, light duty, and medium duty trucks.

2 References

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

2.1 External Standards/Specifications.

SAE J2575

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- CG190 - GM Evaluation Report Template
- Component Technical Specification (CTS)
- Master Process Documents (MPD)
- Subsystem Technical Specification (SSTS)
- Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities. Body Test Laboratory or facility containing the equipment described in 3.2.3.1.1 **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.

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3.2 Equipment.

3.2.1 Fixturing. Locating Jig for Body and Components. A structure large enough to enclose and support the sample and rigid enough so there is minimal deflection or rotation due to its own weight during test loading. Examples include a steel "T" slotted table, big enough to support a body panel and the Quasi-Static dent load/measurement test equipment.

3.2.2 Clamping Devices/Methods. Rigid, mountable clamps, fasteners (i.e., angle iron, flat stock), etc.

Note: Avoid using clamps within 125 mm of any **simple support** point.

3.2.3 Fixturing to secure the vehicle body, if complete Body-In-White (BIW) is to be tested.

3.2.4 Loading device with display and maximum value memory, measuring range 0 N to 500 N, accuracy ± 5 N.

3.2.5 Type I Indenter. This indenter is hemispherical shaped and 25.4 mm in diameter. For Roof Outer Panel oil canning and maximum deflection; for this case, a 100.0 mm diameter flat indenter shall be used.

3.2.6 Ultrasonic thickness tester (or a micrometer).

3.2.7 A measurement system such as a magnetic protractor shall be used to establish loading angle.

3.2.8 Choose the appropriate Indenter size from Table 1.

Table 1: Indenter Sizes

	Method		
	Oil Canning	Oil Canning	Dent Resistance
	Fixtured Indenter	Hand Held Indenter	Hand Held Indenter
Roof	100 mm Die Disk	50 mm or 100 units Diameter Disk	25 mm Diameter Ball
All Other Panels	N/A	50 mm Diameter Disk	25 mm Diameter Ball

N/A = Not applicable

3.2.9 Manual Indenter. Hand-held indenter equipment is shown in Appendix A, Figure A1 and Figure A2.

3.2.10 Additional Hardware Required. Displacement of the panel at the point of loading shall be continuously measured throughout the test using appropriate hardware to digitally store the data for subsequent computer analyses. Data collection at a resolution of at least as large as that of the transducers shall be possible for a minimum travel of 25 mm. The sampling rate shall be sufficient to capture a minimum of 2500 data points for every 25 mm of deflection.

3.2.11 Additional System Performance Requirements. See 3.5.1.

3.3 Test Vehicle/Test Piece.

3.3.1 BIW or body components (door, tailgate, rear lid, hood, side panel, fender, and roof) to be used for dent testing shall receive the production paint process (to cure adhesives and strain harden metal).

3.3.2 Test pieces should include all parts, reinforcements, mastic, gap fillers, and panel stiffening materials that may affect the outer panel structural performance.

3.3.3 The outer body panels must be production intent. Panels produced with the production material, production die lineup and production binders are preferred when making panel comparisons.

3.3.4 Black or dark colored outer body panels are preferred, because dents are more easily seen on dark reflective panels. If a BIW is to be used, a different color may be substituted to coordinate with other tests.

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

3.3.6 When testing roofs, it is recommended that the roof panel have the headliner and/or the structural headliner if the production intent is to incorporate such a design.

3.3.7 Any other related components (roof bows, overhead consoles, visors, clothes-hanger hooks, assist handles, moldings, etc., should be installed as required by the requesting engineer).

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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. 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.

Technician Resource: 12 hours

Engineering Resource: 12 hours

Calendar Duration (total): 2 days

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

3.5.1 System Performance.

3.5.1.1 The system must be sufficiently rigid to minimize deflection at a load of 222 N. If the test frame stiffness is suspect, then an external reference point must be used for panel deflection measurements.

3.5.1.2 The test system shall be capable of recording the total load displacement curve, both the loading and unloading segments. If desired, recording of the unloading segment may be terminated after sufficient data is obtained to identify the true end of the loading cycle.

3.5.1.3 The angle of load input to the panel shall be perpendicular to the surface at the point of first contact within 2.5 degrees, and continue on this angle throughout the test without shifting or skidding along the surface of the panel.

3.5.1.4 To minimize bending loads placed on the load cell, the distance between the load cell and the panel shall be as small as practical.

3.5.1.5 Loading device must be capable of controlled rate of load application. This procedure recommends an indenter velocity of approximately 50 mm/minute used during both the loading and unloading portions of the test.

Note: For regions or laboratories that do not have a specific roof fixture fabricated, an alternative wood or metal fixture is acceptable, provided that the product engineer, validation engineer, and test laboratory agree that compliance to the SSTS or program specific requirements can be demonstrated. (For example, a roof panel can be tested out of vehicle position.)

3.5.2 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 versus right hand)
- Color, mold or die source, etc.

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

3.5.2.1.1 Maximum allowable deflection, if specified.

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3.5.2.1.2 Minimum allowable stiffness.

3.5.2.1.3 Load locations and any desired sequence of testing. See Appendix A, Figure A3 for standard load locations. Long roofs may require additional load locations. Special roof designs may require unique load locations. Some test requests may require special locations relative to roof bows, sunroofs, etc.

3.5.2.1.4 Test Locations for Other Panels. Sample test locations for Hoods, Doors, Decklids and Fenders are shown in Appendix A, Figure A11 through A16 and Appendix A, Table A2 and Table A3.

3.5.2.1.5 Load to which roof will be subjected and any sequence or incremental steps.

3.5.2.1.6 Whether headliner and structural headliner should be installed or removed.

3.5.2.1.7 Time required for headliner adhesives, if applicable, to cure.

3.5.2.1.8 Critical part thickness and desired measurement locations.

3.5.3 Roof Test Fixturing.

3.5.3.1 For Full vehicle or BIW testing. Set up vehicle as shown in Appendix A, Figure A4. The fixtures include two (2) vertical stanchions firmly bolted to the "T" slot plate. Additionally, the vehicle should be supported in a stable manner as shown in Appendix A, Figure A5 and Figure A6.

3.5.3.2 For individual panels or partial body sections such as quarter panels, affix the panel securely to a substantial plate or stiff sheet as shown in Appendix A, Figure A10. An example of the quarter panel dent resistance test is shown in Appendix A, Figure A11.

3.5.3.3 For dent resistance, attach a steel load head in the shape of a spherical ball of approximately 25 mm diameter to be attached to the load cell. See Appendix A, Figure A5.

3.5.3.4 For roof deflection, attach a **100 mm** flat steel disk with 2 mm thick piece of vinyl fabric. See Appendix A, Figure A7.

Note: The disk is 5 mm thick and has a concave indentation at the center of the top face. The spherical load head and the disk's indentation form a swivel interface, so that the disk is parallel to the radius of curvature of the roof, and that the centerline of the disk is perpendicular to this curvature. The direction of load is vertical (downward).

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation. Refer to 3.5 as needed throughout the procedure for additional test required information regarding system performance and further detailed setup information.

4.1.1 Sample Inspection. The test and requesting engineers shall inspect the test items to ensure all material listed are of correct design level and assembled properly. Check for cracks, paint chips, dents, etc., and document any variation/deviation in assembly, etc.

4.1.1.1 Ensure all panels, parts, and reinforcements are present and assembled properly.

4.1.1.2 Visually inspect the entire test panel for any dents or other surface irregularities, and record observations for posttest comparison.

4.1.1.3 Use an ultrasonic thickness tester or other suitable measuring tool, such as a micrometer for non-metal panels to measure critical part thicknesses if specified by the requesting engineer. Typical measurements include three (3) or more randomly selected locations on each roof. Verify thickness measurements with the requesting engineer before beginning 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, Electrophoretic Priming Operation (ELPO), etc., where the thickness measurements will be recorded. Be sure to use non-destructive, non-abrasive means (such as liquid paint remover) so the thickness of the part being measured is not altered.

4.1.2 Fixation.

4.1.2.1 Fix components on clamping device free from slip and internal strain.

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4.1.2.2 Fix body at jacking points.

Note: Manually apply lateral loads of approximately 20 N at each of the clamped points of the panel to ensure the panel will not move relative to the fixture.

4.1.3 Identify Test Locations.

4.1.3.1 Identify points of maximum displacement by performing analysis or by subjective hand application of loads.

4.1.3.2 Identify high usage concern areas where denting is probable due to palm printing, elbow marks, sit marks, plant handling, etc.

4.1.3.3 Mark the loading points on the panel.

4.1.3.4 Wipe the test location(s) using a clean cloth to remove any extraneous dirt from the test location.

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%/-0% 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.

4.3.1 Instructions for Initial Stiffness, Maximum Displacement and Oil-Canning.

4.3.1.1 Align the actuator to the point to be tested, and move the actuator so that the indenter's centerline appears to be perpendicular (as close to it as possible) to the panel's loading point surface. Readjust in the X-Y plane as necessary to realign the indenter with the desired contact point. Secure the actuator in this position.

4.3.2 Apply 10 N load and release to settle part.

4.3.3 Verify data recorders are active and set at zero (0).

4.3.4 Apply load at controlled rate from zero (0) to highest load value of interest (133 N) and release.

4.4 Instructions for Quasi-Static Dent Resistance (For Reference Only).

Note: This procedure requires a subjective visual inspection to determine first visible dent or alternately a high resolution measuring system not in common use today due to high cost and availability.

4.4.1 Apply a series of loads in 20 N increments returning to zero (0) load point following each incremental load until the first visible dent is observed, until a maximum (210 N typical) load is achieved. See Appendix A, Figure A9.

Note: 0.06 mm is the target called **First Visible Dent** (for metal panels only).

4.5 Additional Instructions for Roof Test. Refer to 3.5.3 for additional fixturing setup information as needed.

4.5.1 Establish and mark nine (9) load locations on the roof panel (as shown in Appendix A, Figure A3, and sample chart in Appendix A, Table A1). The locations will be in a rectangular grid (three (3) rows of three (3)). Measure the shortest longitudinal dimension of the roof (usually the side edge) and the narrowest lateral dimension of the roof. Divide each of these by two (2) and of the two (2) dimensions by four (4) to get the perpendicular distances from the center load location to the side rows, respectively. As necessary, use the grease pencil to mark the locations as they are determined.

Note: Alternate or additional locations may be appropriate to correlate to analytical studies or expected customer usage. Points may also be different on vehicles with sunroofs or permanently attached roof-top cargo carriers.

4.5.2 When testing panels other than roofs, select load locations to be tested. Locations may be tested in any order unless specified by the requesting engineer. Position the load cell so the spherical ball is directly over the selected location.

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4.5.3 Center the flat disk under the spherical ball and lower the sphere until it almost contacts the disk; (the load is still zero (0)).

4.5.4 Calibrate and reset to zero (0) the recording device for the linear displacement transducer and load cell.

4.5.5 Using a ram travel rate of approximately 1 mm/s, apply the specified downward load, and graph load versus deflection.

4.5.5.1 Release the load immediately after obtaining the specified load, but do not change the ram travel rate. See Appendix B, Figure B1. To meet a stiffness specification, all points of a graph must be above the line that represents the specification.

4.5.6 Repeat 4.3.1 through 4.3.4 until all load locations have been tested.

4.6 Posttest Instructions. Note any observations while doing a posttest visual inspection of the dent test areas.

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.

4.6.1 Include a sketch or marked drawing showing the part thickness measurement locations, and load locations.

5 Data

5.1 Calculations.

5.1.1 Determine Initial Stiffness. The initial stiffness shall be determined by a linear least squares fit to the load displacement data from loads between 10 N and 25 N, inclusive, on the 50 N loading cycles (Appendix A, Figure A8 and Figure A9).

5.2 Interpretation of Results. Determine maximum deflection at the maximum deflection load value, reference SSTs. The values shall be noted in the corresponding data sheets. Buy-in must be obtained from program team, deflection performance to be deemed acceptable. An example of results can be seen in Appendix B, Figure B2, Sample Load Deflection Curve when Stiffness Falls Below Desired Slope.

5.3 Test Documentation. With reference to this test procedure, the results of the measurements shall be presented in a test report.

5.3.1 Observe Load Displacement Curve For Hard Oil-Canning. As the indenter is pressed into a panel, after some initial deflection, a drop in the load required for a further deflection may occur (Appendix B, Figure B1). This is referred to as **hard** or **snap-through** oil can. The oil canning load is defined by the point where the slope of the load displacement curve (that is, the instantaneous stiffness) first reaches a value of zero (0).

5.3.2 Test Report Format. The final test report shall be presented in a format consistent with Appendix B, Table B1 and Table B2.

5.3.2.1 Page 1 and Page 2: CG190 Template, GM Evaluation Report, as shown in Appendix B, Table B1, and Table B2.

5.3.2.2 Page 3: Sample Load Deflection Curve Example, Appendix B, Figure B1.

5.3.2.3 Page 4: Sample Load Deflection Curve when Stiffness Falls Below Desired Slope, Appendix B, Figure B2 and Example Roof Test Results Chart in Appendix B, Table B3. The Sample Load Deflection Curve shall include a note stating "**Buy-in must be obtained from program team for deflection performance to be deemed acceptable**", as shown in Appendix B, Figure B2. If more than one (1) page is required to include all roof test data, continue using next pages as needed. An additional test result sample for a hood test is also shown in Appendix B, Table B4.

Note: Test Work Order number shall be replaced with Activity Request number if Test Work Order number is unavailable for Sample Load Deflection Curve header information.

5.3.2.4 Page 5. Graph Soft and Hard Oil Canning Functions as shown in Appendix B, Figure B3. For Roof Tests, include all loads versus deflection graphs performed.

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6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Dent: A permanent plastic deformation, resulting from an external load localized at the point of loading.

Dent Resistance: The ability of a panel to withstand a localized load before taking a permanent plastic deformation.

Oil Canning: Recoverable, localized reversal of panel curvature, which may be accompanied with audible sound.

Oil Canning Hard: The type of oil canning that occurs when the panel curvature reverses at a speed faster than that at which the indenter is traveling. As a result, a drop in applied load is observed. The slope of the load-deflection curve becomes negative (Appendix A, Figure A8 and Figure A9).

Oil Canning Load: Load at which the load versus deflection curve changes from a positive slope to a near zero slope (Appendix A, Figure A8 and Figure A9), but where the deflection is fully recoverable (no set occurs).

Oil Canning Soft: The type of oil canning that occurs when the panel curvature reverses at a slow rate, the panel and the indenter are in continuous contact and no drop in applied load is observed. The slope of the load-deflection curve does not have a value < 0 . See Appendix A, Figure A8 and Figure A9.

On Body Outer Body Panel Assemblies: Body outer panel assemblies that are assembled on a vehicle body/buck, resulting in large/heavy/difficult to handle test parts.

Off Body Outer Body Panel Assemblies: Body outer panel assemblies that are not assembled on a vehicle/body/buck, resulting in smaller/lighter/relatively easy to handle test parts.

Post Load: A load applied after completion of dent resistance testing to determine dent depth. For automotive panel testing 10 N is recommended.

Quasi-Static Denting: A process of producing a dent at a low rate of loading. The loading rate would be, at most, 127 mm/minute. This procedure recommends an indenter velocity of approximately 50 mm/minute.

Stiffness, Initial: The ability of a panel to withstand an applied load elastically Slope of the initial linear portion of the load-displacement curve of a given panel. Initial Stiffness is always a positive slope. See Appendix A, Figure A8 and Figure A9.

7.2 Acronyms, Abbreviations, and Symbols.

AR	Activity Request
BIW	Body-In-White
CAE	Computer Aided Engineering
CTS	Component Technical Specification
ELPO	Electrophoretic Priming Operation
EWO	Engineering Work Order
Int.	Internal
Loc	Location
MPD	Master Process Document
N/A	Not applicable
No.	Number
PIMREP	Project Incident Monitoring and Resolution Process
PRTS	Problem Resolution and Tracking System
Pt	Part Number

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RPO	Regular Production Option
SSTS	Subsystem Technical Specification
UPC	Uniform Parts Classification
VIA	Vehicle Integration Area
VPP	Vehicle Partitioning and Product
VTs	Vehicle Technical Specification

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14284

9 Release and Revisions

This standard was originated in August 2005. It was first approved by the Global Body Structures Testing Sub-Team in August 2006. It was first published in December 2006.

Issue	Publication Date	Description (Organization)
1	DEC 2006	Initial publication.
2	AUG 2008	Roof panel information added and reformatted to current GMW Template. (Global Body Structures Testing Sub-Team)
3	DEC 2013	Updated to current template. (Structures/Sealers and Adhesives Global Subsystem Leadership Team)

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