



Body Structure Modal Analysis Benchmarking Evaluation Procedure

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. The purpose of this test procedure is to determine the natural frequencies and corresponding mode shapes of a body structure in the 0 Hz to 80 Hz frequency range. Optional to perform the procedure in the 0 Hz to 150 Hz range.

1.2 Applicability. This test procedure is appropriate for benchmarking competitive and GM vehicles in the body structure state, as defined in Definitions Procedure GMW8702.

The testing standards defined in this document are intended to pertain only to work being done for the corporate database and validation. Other testing and analysis methods and interpretations are useful and valid, and should continue to be used for body structure development work where appropriate.

1.3 Remarks. Data from both body structure, trimmed structure, and full vehicle modal surveys are often used as a means of describing the structural performance of GM and competitive vehicles.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW8477

GMW8702

GMW14172

GMW14229

2.3 Additional References.

Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. See GMW8477.

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. See GMW8477.

3.3 Test Vehicle/Test Piece. The test object shall be any body structure of either Body-Frame Integral (BFI) or Body-On-Frame (BOF) construction that represents current release status.

3.3.1 Body-In-White (BIW). The configuration that leaves the paint booth or the basic structural shell of the vehicle including: floor pan, front of dash, door side ring, front radiator support, doors, Front End Sheet Metal (FESM) and deck lid/hatch prior to topcoat paint and trim.

3.3.2 Body Structure: A body structure which includes the following:

- a. **BIW** with non-structural closures removed.

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October 2015

Page 1 of 13



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Note: A Body Structure typically does not include the hood, doors, deck lid/hatch or bolt-on fender outers unless these are assumed to be structural items. The use of closures as structural elements should be defined in the requirements for the vehicle program, and taken into consideration during development and validation testing.

- b. **Paint**, inclusive of Electro-deposition Primer (ELPO); E-Coat, and other properly cured sealers and adhesive(s).
- c. **Properly Bonded Fixed Glass**, such as windshield, backlight or fixed quarter windows, with any trim needed for glass installation and retention.
- d. **All Non-Isolated Structural Bolt-On Parts**. The specific parts included will vary depending on the vehicle design. Examples include: hard-mounted cradles (with braces if appropriate), non-integral FESM, Instrument Panel (IP) beam, pedal support bracket(s), bolt-on radiator supports, rear cross-members, diagonal braces, bumper beam(s) and tunnel straps.
- e. **Sunroof Module(s)**. Generally included if anticipated to contribute to the structural stiffness.

3.3.3 The body structure should also be qualified to ensure that there are no missing welds, poorly executed welds or other processing problems, tears, cracks, or glass adhesion issues, to verify structural adhesive or block adhesion continuity, and bolted on parts at the proper torque specifications.

3.3.4 Deviations shall either be corrected or noted. The requester shall fully describe the condition of the body structure if it features non-standard content.

3.4 Test Time.

Calendar time: 4 days
Test time: 16 hours
Coordination time: 4 hours

3.5 Test Required Information. The trimmed structure should be verified to ensure that there are no system groundouts or extra mass/parts in the interior or in the trunk.

3.6 Personnel/Skills. To complete this test, one (1) technician and/or one (1) engineer skilled in vibration data acquisition, analysis, equipment use, and test setup is required.

4 Procedure

4.1 Preparation.

4.1.1 Obtain body structure description, test data log, and transducer location forms. Data Acquisition Documentation forms are shown in Appendix B, Data Sheets B1 thru B3. Enter appropriate information.

4.1.2 Vehicle Preparation.

4.1.2.1 Thoroughly inspect the test object to ensure that requirements specified in 3.3 and 3.5 are met.

4.1.2.2 Weigh the test object. Record weight in the test object description. Bolted-on structural parts may be weighed separately, then totaled.

Note: Test weight does not include instrumentation.

4.1.2.3 The test object should be washed to ensure clean surfaces for adhesion of transducers.

4.1.2.4 Lift body structure onto air bags using appropriate non-damaging technique. After lowering the body structure on to the air bags, adjust the air pressure to stabilize the body structure. Further adjustments will be made directly prior to testing.

Note: To simulate the ideal free-free boundary condition, the air pressure shall be further adjusted such that the highest rigid body natural frequency is the lower than the following:

- a. Twenty five one hundredths (0.25) times the first flexure natural frequency or
- b. 8 Hz.

4.1.3 Instrumentation Calibration.

4.1.3.1 Transducer System Calibration. See GMW14172.

4.2 Conditions.

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Page 2 of 13



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4.2.1 Environmental Conditions. See GMW8477.

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 Shaker Location Determination. See Appendix A, Figures A1 thru A7. The three (3) shaker arrangement is optional. Typically, locate one (1) shaker on the front rail, one (1) on the rear rail, at opposite corners.

4.3.2 Force Level Determination. See GMW8477. Secure/eliminate all potential squeak and rattles (i.e., cage nuts).

4.3.3 Response Transducer Placement.

4.3.3.1 Transducers should be placed at approximately 75 locations on the body. If the test system has more capability, more response locations may be used to obtain increased mode shape resolution. The criteria for choosing locations are:

- The animated mode shape should be representative of the body structure (i.e., the shape should look like the body structure).
- Sufficient points should be included to fully identify the structural mode shapes in the 0 Hz to 80 Hz range. A maximum spacing of 100 cm (39.37 in) is required between points. The intersection of all structural members should be included.

4.3.3.2 Per Table 1, mark the following locations on the test object (using a wax pencil, sticker, or other non-permanent technique) for subsequent transducer placement:

Table 1: Transducer Locations/Placements

Description	Minimum Number of Points
Midrails/Longitudinals	4 each
Rockers	3 each
Rear Rails	4 each
A-Pillars	3 each
B-Pillars	2 each
C-Pillars	2 each
Headers	3 each
Front Upper Rails	3 each
Cowl/Instrument Panel (IP) Beam	4
Upper Tie Bar	3
Lower Tie Bar	3
Rear Shelf and Seat Back	3
Underbody Lateral Members (Bars)	3 each
Tunnel	8
Rear Quarter	4 each
Glass	4 each
Cradle (Hard-mounted)	4
Integral Bumper Beam	3 each
Sunroof Opening (if applicable)	6

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October 2015

Page 3 of 13

4.3.3.3 Prepare the Transducer Location form with the relative locations of each transducer attachment point in a global coordinate system (see Appendix B, Data Sheet B3). Measurements should be accurate to 5 cm (1.97 in). More accuracy may be required if the results are used for geometric correlation with analytically generated geometry.

4.3.4 Data Acquisition. See GMW8477. Maintain the following acquisition parameters:

- Burst Random Input Signal.
Note: If, due to equipment limitations, another input signal must be used, consult the Noise and Vibration Center (NVC) to determine acceptable alternate acquisition parameters.
- Approximately 60% Burst Length.
Note: Response must decay approximately 95% within the acquisition window to prevent leakage.
- H_1 or H_v Frequency Response Function (FRF) Estimator.
- Uniform Windows.
- 1024 Time Block Size (minimum).
- A/C Coupled.
- 0 Hz to 128 Hz Input and Acquisition Range (minimum).
- 0.125 Hz Frequency Resolution (maximum).
- 25 Averages (minimum), 100 Averages (typical).
- 0% Overlap Processing.
- Clear up to the First 1% of Bandwidth.

5 Data

5.1 Calculations.

5.1.1 Create Geometry. See GMW8477.

5.1.2 Sums and Mode Indicator Functions (MIF). See GMW8477.

5.1.3 Parameter Estimation. See GMW8477.

5.1.3.1 Check for Normal/Real Modes Necessity. See GMW8477.

5.1.4 Verify Poles. See GMW8477.

5.1.5 Save Results. Store the natural frequency and mode shape information.

5.1.6 Compare Experimental Data to Synthesized Data. See GMW14229.

5.1.7 Independently Inspect/Describe Each Estimated Mode Shape. See GMW14229.

5.2 Interpretation of Results. Verify whether the Subsystem Technical Specification (SSTS) requirements are achieved.

5.3 Test Documentation. An example summary table is shown in Appendix C, Data Sheet C1. See also GMW8477.

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. See GMW8702.

7.2 Acronyms, Abbreviations, and Symbols.

AWD All Wheel Drive

BFI Body-Frame Integral

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Page 4 of 13



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