



Full Vehicle 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 an entire vehicle structure in the 0 Hz to 50 Hz range.

1.2 Applicability. This test procedure is appropriate for benchmarking competitive and GM passenger vehicles in the full vehicle state. This procedure is valid for use with both Body Frame Integral (BFI) and Body on Frame (BOF) full vehicles.

The testing standards defined in this document are intended to pertain only to work being done for the corporate database and validation. Other testing methods and interpretations are useful and valid, and should continue to be used for normal powertrain mounting system 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 GMW14172 GMW14229

2.3 Additional References.

Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. The test facility may be any interior environment with a hard level surface to mount the full vehicle and test equipment.

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 piece shall be any full vehicle of either BFI or BOF construction that represents current release status. Deviations shall either be corrected or noted. The requester shall fully describe the condition of the full vehicle if it features non-standard in content. The vehicle should also be qualified to ensure that there are no system groundouts or extra mass/parts in the interior or in the trunk.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

October 2015

Page 1 of 11

3.4 Test Time.

Calendar time: 4 to 5 days
Test time: 32 to 40 hours
Coordination time: 8 hours

3.5 Test Required Information. The test property 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 Full Vehicle Description, Test Data Log and Transducer Location Forms (see Appendix B, Data Sheets B1, B2 and B3). Enter appropriate information.

4.1.2 Full Vehicle Preparation.

4.1.2.1 Thoroughly inspect the full vehicle to ensure that requirements specified in 3.3 are met.

4.1.2.2 Fill all fluid reservoirs in the full vehicle, including fuel tank, radiator, overflow tank, brake fluid reservoirs, engine oil, transaxle fluid, power steering reservoir, Urea tank, etc.

4.1.2.3 Weigh the full vehicle. Record weight in the full vehicle description.

Note: Test weight does not include instrumentation.

4.1.2.4 Adjust cold tire pressure to the manufacturer's specifications. (Allow tires to cool if the vehicle has been recently operated.) Record pressures in vehicle description.

4.1.2.5 The vehicle should be washed to ensure clean surfaces for adhesion of transducers.

4.1.3 Component Preparation.

4.1.3.1 Adjust tilt steering columns to mid tilt position. For a telescoping column, locate the column at the midpoint of its travel.

4.1.3.2 Adjust steering wheel to the center position so that the steering wheel rotation is not locked.

4.1.3.3 Set the fore/aft seat adjustments fully rearward.

4.1.3.4 Close all doors, windows and hatches tightly.

4.1.4 Instrumentation Calibration.

4.1.4.1 Transducer System Calibration. See GMW14172.

4.2 Conditions.

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 and Orientation Determination. See Appendix A, Figures A1, A2 and A3.

4.3.1.1 Locate the Shakers. See GMW8477 for recommended locations of two (2) to three (3) shakers for either BFI or BOF structures. Additional shakers at, e.g., powertrain, subframe or cradle are optional.

Fabricate a bracket to horizontally attach the third or fourth shaker (if applicable) to the underside of the powertrain. The purpose of this shaker is to excite rotation about the crank axis, yaw and either fore/aft (transverse mounted powertrain) or lateral (longitudinal mounted powertrain) motion. This bracket must be stiff enough to have inertance comparable or below that of the body structure attachments. The bracket should provide for attachment of a force transducer and a reference accelerometer.

Choose locations based upon:

- Appropriate orientation to excite desired modes.
- Available attachments on powertrain (e.g., unused bosses or flat surfaces for mounting driving point blocks).

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

October 2015

Page 2 of 11

- Ability to locate, orient and secure the shakers.

4.3.1.2 Orient the Shaker Inputs. See GMW8477.

4.3.1.3 Attach Driving Point Blocks. See GMW8477.

4.3.2 Force Level Determination. See GMW8477.

4.3.3 Response Transducer Placement. Transducers should be placed at approximately 100 locations on the body, suspension, powertrain and exhaust systems. The criteria for choosing locations are:

- The animated mode shape should be representative of the vehicle structure (i.e., the shape should look like the vehicle).
- Sufficient points should be included to fully identify the structural modes in the 0 to 50Hz range as well as component modes that may appear as structural modes. A maximum spacing of 100 cm is required between points. The intersection of all structural members should be included.

4.3.3.1 Per Table 1, mark the following locations on the vehicle (using a wax pencil, sticker or other non-permanent technique) for subsequent transducer.

Table 1: Transducer Locations/Placements

Description	Minimum Number 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 Quarters	2 each
Rear Quarters	2 each
Bumpers	3 each
Front Seat Backs ^{Note 1}	2 each
Seat Track	4
Hood	4
Deck Lid	4
Roof	5
Steering Column	2
Steering Wheel	3 (located at 12, 3 and 9 o'clock)
Center Floor Console	4
Powertrain	8
Cradle	4
Exhaust Major Elements	3
Wheel Centers or Spindles	4
Additional Components as required	See GMW8477

Note 1: Response transducers should be attached directly to the seat frame where possible. Otherwise bind the seat back with string or tape and attach the transducer at a firm location.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

October 2015

Page 3 of 11



Documents

Document Sharing Hub

4.3.3.2 Record Geometry. See GMW8477.

4.3.4 Data Acquisition. See GMW8477.

4.3.4.1 Ensure that vehicle has reached ambient temperature. Immediately prior to data acquisition, disconnect the shakers and exercise the front and rear suspensions to remove any "sticktion". Also exercise the powertrain and exhaust mounts by manually shaking the powertrain shaker attachment bracket and the tailpipe(s). Reconnect shakers.

4.3.4.2 Maintain the following acquisition parameters:

- Burst random input signal. ^{Note 1}
- Approximately 80% burst length. ^{Note 2}
- 1% (of time block) trigger delay.
- H1 or HV Frequency Response Function (FRF) estimator.
- Uniform Windows.
- 1024 Block Size (minimum).
- A/C Coupled.
- 0 Hz to 64 Hz Input and Acquisition Range (minimum).
- 0.125 Hz Frequency Resolution (minimum).
- 25 Averages (minimum), 100 Averages (typical).
- 0% Overlap Processing.
- Clear up to the first 1% of Bandwidth.

Note 1: If, due to equipment limitations, another input signal must be used, consult the Noise and Vibration Center (NVC) to determine acceptable alternate acquisition parameters.

Note 2: Response must decay approximately 95% within the acquisition window to prevent leakage.

4.3.5 Test Techniques/Suggestions. See GMW8477.

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 Specifications (SSTS) requirements are achieved.

5.3 Test Documentation. An example summary table is shown in Appendix C, Data Sheet C1. For more details, see 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.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

October 2015

Page 4 of 11



Documents

Document Sharing Hub