

Tuned Vibration Absorber (TVA) Test Procedure

Table of Contents

1 Introduction 3

 1.1 Purpose. 3

 1.2 Applicability..... 3

 1.3 Remarks. 3

2 References 3

 2.1 External Standards/Specifications..... 3

 2.2 GM Standards/Specifications. 3

 2.3 Additional References. 3

3 Resources 3

 3.1 Facilities..... 3

 3.1.1 Calibration..... 3

 3.1.2 Alternatives. 3

 3.2 Equipment. 4

 3.3 Test Vehicle/Test Piece..... 4

 3.4 Test Time..... 4

 3.5 Test Required Information. 4

 3.5.1 Notification. 4

 3.5.2 Five (5) Phase..... 5

 3.5.3 Product Security..... 5

 3.6 Personnel/Skills. 5

4 Procedure..... 5

 4.1 Preparation. 5

 4.2 Conditions..... 5

 4.2.1 Environmental Conditions. 5

 4.2.2 Test Conditions. 6

 4.2.3 Location Conditions. 6

 4.3 Instructions. 6

 4.3.1 Appearance..... 6

 4.3.2 Mechanical Strength. 7

 4.3.3 Slam Test..... 8

 4.3.4 Environment..... 9

 4.3.5 Compression Load Deflection (CLD) Curve. 9

4.3.6 Vibration Tuning.....	10
4.3.7 Random Vibration.	11
4.3.8 Pothole #1, #2, and #3 Vertical Load Input.	13
4.3.9 Durability.	14
4.3.10 Noise Level at Subsystem.	16
4.3.11 Squeak and Rattle.	17
4.3.12 Corrosion.	18
4.3.13 Identification and Marking.....	19
4.3.14 Press-fit Joint Retention (Mass and Bushing Push-out Test).....	20
4.3.15 Adhesion Test (Bushing).	21
4.3.16 Material Performance Requirements.....	22
4.3.17 Mass Determination.	23
5 Data.....	23
5.1 Calculations..	23
5.2 Interpretation of Results.	23
5.3 Test Documentation.	23
5.3.1 Samples/Components.	23
5.3.2 Test Results.	24
6 Safety.....	24
6.1 Safety Precautions.	25
7 Notes	25
7.1 Glossary.....	25
7.2 Acronyms, Abbreviations, and Symbols.....	25
8 Coding System	26
9 Release and Revisions	26
Appendix A	27
A1 Test Schedule	27
Appendix B: Test Sequence.....	30
Appendix C	31
Appendix D: Test Fixture Examples.....	32

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 validate the Tuned Vibration Absorber (TVA) in either the liftgate, sunroof/shade module or the roof header.

1.2 Applicability. This procedure/standard applies to all passenger vehicles, multipurpose passenger vehicles, trucks, and buses of 4536 kg gross vehicle mass (weight) rating or less with a TVA. The Tuned Vibration absorber is a functional subsystem for automatically reducing the amount of pumping amplitude of a body panel structure during operation of the vehicle. The TVA is a subsystem of the Body or Trim Subsystem. The TVA provides the mechanical force necessary to automatically reduce the amount of panel modal amplitude of the affected body subsystem

1.3 Remarks. This document is the GM Worldwide TVA Testing Standard. Its purpose is to establish a common test methodology for TVA systems to ensure that a high quality world class system is consistently developed and produced. This is a living document and any suggestions or revisions will be reviewed and/or updated annually by the Roof Closures, Front and Rear Closures or Structures Global Subsystem Leadership Team (GSSLT).

2 References

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

2.1 External Standards/Specifications.

ISO 11469	SAE J1344
-----------	-----------

2.2 GM Standards/Specifications.

GMW3059	GMW8518	GMW15272	GMW16156
GMW3116	GMW14089	GMW15576	GMW16331
GMW3232	GMW14264	GMW15719	
GMW3600	GMW14573	GMW15760	
GMW8463	GMW14872	GMW15862	

2.3 Additional References.

- CG180: 5-phase Document (ID).
- Component EMc and ENvironmental Test Database (CEMENT).
- GM Exterior Materials Engineering Material Decision Trees for Noise Abatement Strategy.
- GM Research and Development Report AS-598 Hearing Acuity Standard for Squeak and Rattle Evaluators.
- GM Security Guidelines. <https://gmweb.gm.com/HR/Security/Pages/FutureGuide.aspx>.
- International Commission on Illumination (CIE) Lab Color Coordinates.
- Program specific Component Technical Specification (CTS).
- Subsystem Technical Specifications (SSTS).
- Vehicle Technical Specifications (VTS).

(ID) = This document is limited to internal use within General Motors and shall not be accessed outside this company. Contact the GM Lead Engineer for further instructions.

3 Resources

3.1 Facilities. The test facilities shall be accredited to the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) standards or by the International Laboratory Accreditation Cooperation (ILAC).

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.

© Copyright 2020 General Motors Company All Rights Reserved

3.2 Equipment.

3.2.1 Personal Protection Equipment (PPE).

3.2.2 Digital camera.

3.2.3 Torque wrench with a range of approximately 1.5x the required torque specifications.

3.2.4 Holding fixture.

3.2.5 A 9 V to 16 V power supply capable of 20 A and capable of producing the minimum and maximum voltage and current required in the program specific SSTS/CTS.

3.2.6 Magnifying glass.

3.2.7 Voltmeter/Multimeter.

3.2.8 Thermal Chamber. Thermal chamber large enough to contain fully assembled sunroof system. The chamber should also meet the following:

- Temperature Range (-40 °C to +105 °C) and continuously adjustable.
- Controlled humidity.
- Recirculating air temperature cabinet.
- Test room, suitable for the execution of the test.
- Permissible temperature accuracy: ± 3 °C.
- Explosion proof.

3.2.9 Instron or similar tensile machine with the following:

- Load Capacity of 250 N.
- Speed Range of 50 mm/minute to 100 mm/minute.
- Test Area suitable for the required tests.

3.2.10 Force gauge.

3.2.11 Vibration Table see Figure 1.

3.2.12 Slam Test Equipment.

3.2.13 Accelerometers.

3.2.14 Microphone.

3.2.15 Anechoic chamber.

3.2.16 Corrosion chamber.

3.2.17 Salt solution per GM requirements.

3.2.18 Scale to measure weight.

3.3 Test Vehicle/Test Piece.

3.3.1 Test samples shall be of production intent design and material for Design Validation (DV); or, production intent design and materials manufactured with production processes (home line) for Product Validation (PV). Any changes to the components or material, e.g., design, fit, form, function, properties, manufacturing process, and/or location of manufacture require revalidation. GM shall approve validation methods for product/process changes before the supplier is committed to the change. Refer to GMW3600.

3.3.2 All test samples are to be selected using GMW15760 Multivariable Sample Selection.

3.3.3 All components/systems used in testing shall be within drawing specifications and have supporting data prior to start of test (SOT).

3.3.4 All test samples are to be individually marked using a unique numbering system.

3.3.5 All test samples are to have a Bill of Materials (BOM). The BOM is to identify all release levels of the components in the test samples.

3.3.6 All test samples shall have dimensional data and all quality issues identified prior to conducting any testing or evaluation.

3.4 Test Time. See specific procedures in 4.3 for timing.

3.5 Test Required Information.

3.5.1 Notification. GM Validation is to be notified of test failures within 24 h period of occurrence.

© Copyright 2020 General Motors Company All Rights Reserved

3.5.2 Five (5) Phase. Supplier to develop a 5-phase document (CG180) for all test failures. The 5-phase document shall be submitted within 48 h of test failure.

3.5.3 Product Security. Security protocol for the test vehicle must be followed per GM Security Guidelines.

3.6 Personnel/Skills.

3.6.1 Hearing Requirements. It is recommended that all evaluators for customer actuated sound have a hearing test. Any professional hearing test is acceptable, but the following test is given is a reference: GM Research and Development Report AS-598, "Hearing Acuity Standard for Squeak and Rattle Evaluators."

3.6.2 Auditor Skill Level. Evaluators shall have completed 2 to 3 prior Customer Actuated Sounds (CAS) Vehicle Evaluations under the supervision of an experienced CAS Evaluator.

3.6.3 Prior experience in setting up and running similar tests. Experience in the use of the referenced test equipment.

4 Procedure

4.1 Preparation.

4.1.1 Read the proper requirement from the CTS/SSTS.

4.1.2 Thoroughly read this GMW and any other associated GMWs.

4.1.3 Review the TVA Decision Tree in Appendix C, Figure C1 to identify the procedures to run.

4.1.4 Ensure that proper Personal Protection Equipment (PPE) is used during set up and testing.

4.1.5 Ensure that the materials are in compliance to GMW3059 and any regulatory requirements for country of sales.

4.1.6 Confirm Product Security Protocol for the vehicle tested by contacting the Vehicle Performance Manager (VPM). (Vehicles requiring camouflage, etc., must be carefully secured throughout the testing procedure so that no lapse in vehicle security occurs.)

4.1.7 Ensure that all components are at the proper release level and signed off by the DE and VE prior to testing.

4.1.8 Ensure that all torques have been confirmed before test.

4.1.9 Ensure that all critical bolts have been marked before test.

4.1.10 Ensure that the fixture is in proper working order – proper representation of the body, no damage from previous test.

4.1.11 Ensure that all equipment is in proper working order, equipment is calibrated, and counters are working properly.

4.1.12 Document environmental conditions (temperature, humidity, wind speed and direction, time and date) before, during, and end of test (EOT).

4.1.13 All test samples are to be properly labeled using a permanent unique identifier. The numbering system shall be used in all phases of testing including DV, PV, PVA, Development and any test incident retesting.

4.1.14 All test samples shall have a BOM that indicates release levels of the subsystem and components.

4.2 Conditions. All conditions specified shall be targeted toward the specified value with any given ($\pm$) tolerance used to compensate for variation. During testing, conditions specified shall not be readjusted within the tolerance unless it is to maintain the particular test condition within the specified tolerance. If such an adjustment is made, it shall be approved by the appropriate GM engineer prior to the start of any testing. Unless otherwise specified, perform the tests in the as-received condition without any special preconditioning.

Deviations from the requirements of this standard shall have been agreed upon and approved by the GM Subsystem Validation Engineer (SVE) or Validation Engineer (VE) and Design Engineer (DE). Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.1 Environmental Conditions. The following conditions apply to all tests unless otherwise specified in the program specific SSTS/CTS:

- Ambient temperature: $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.
- Voltage: $V_{\text{nom}} \pm 0.3\text{ V}$ at motor terminals.
- Humidity shall be 50% to 75% for all tests unless otherwise specified.
- T_{min} is $-40\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ unless otherwise specified.

- T_{max} is $+85\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ unless otherwise specified.
- 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.

4.2.3 Location Conditions.

Table 1: Vehicle Location Conditions

	Liftgate	Header	Roof Module	Other
High Temperature Note 1	80 °C	85 °C	90 °C	See program specific location requirements
Low Temperature Note 1	-30 °C	-30 °C	-30 °C	See program specific location requirements
Slams	1200	0	0	See program specific location requirements
Corrosion	Interior Mid	Interior High	Interior High	See program specific location requirements
UPC	1C6K	2C	2C	See program specific location
FNA	1261A	--	1620A	See program specific location
Description	REINFORCEMENT ASM-L/GATE PNL VIBRATION DPNR	--	DAMPENER ASM- RF PNL	See program specific location requirements

Note 1: All Temperatures have a tolerance of $\pm 3\text{ }^{\circ}\text{C}$.

4.3 Instructions.

4.3.1 Appearance.

4.3.1.1 Purpose. To ensure that the TVA meets program specific requirements for appearance after exposure and testing. This evaluation shall be done when the TVA is exposed to the customer under any normal conditions. If the TVA is never visible, this evaluation may not be required. GM Product Development Team (PDT) to make final determination if the evaluation is required.

4.3.1.2 Test Equipment.

4.3.1.2.1 PPE.

4.3.1.2.2 Digital camera.

4.3.1.2.3 Magnifying glass.

4.3.1.3 Test Samples. Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.

4.3.1.4 Test Time.

Calendar time:	1 d
Test time:	4 h
Coordination time:	4 h

4.3.1.5 Test Preparation. See 4.1.

4.3.1.6 Test Conditions. See 4.2.

4.3.1.7 Test Procedure.

4.3.1.7.1 All test samples shall be properly marked so they can be identified.

4.3.1.7.2 Conduct Design Review Based on Test Results (DRBTR) on all test samples after each test in the ADVP&R unless agreed not to run by the GM and Supplier Team.

4.3.1.7.3 Photograph any appearance issues or any potential “buds of problems”.

4.3.1.7.4 Document all observations and measurements in the test report.

4.3.1.7.5 If the evaluation identifies boundary samples, the boundary samples are to be signed by GM validation, engineering, supplier quality and the supplier representative.

4.3.1.8 Test Requirements or Acceptance Criteria.

4.3.1.8.1 Refer to the program specific CTS/SSTS for strength requirements.

4.3.1.8.2 Ensure that the TVA meets location specific requirements.

4.3.1.8.3 There shall be no visible signs of unacceptable degradation of the rubber or metal components of the TVA after any of the validation testing in the ADVP&R.

4.3.2 Mechanical Strength.

4.3.2.1 Purpose. To ensure that the TVA meets program requirements for strength.

Note: The TVA shall be tested separately as a component and has location specific requirements.

4.3.2.2 Test Equipment.

4.3.2.2.1 PPE.

4.3.2.2.2 Digital camera.

4.3.2.2.3 Holding fixture.

4.3.2.2.4 Instron Machine of force gauge.

4.3.2.2.5 Thermal chamber.

4.3.2.3 Test Samples. Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.

4.3.2.4 Test Time.

Calendar time:	1 d
Test time:	4 h
Coordination time:	2 h

4.3.2.5 Test Preparation. See 4.1. Ensure that the load profile is provided several weeks before SOT.

4.3.2.6 Test Conditions. See 4.2.

4.3.2.7 Test Procedure.

4.3.2.7.1 Place the test sample into the holding fixture.

4.3.2.7.2 Photograph the test setup and include in the test report.

4.3.2.7.3 Apply a load in the x, y, and z direction. The load shall be specified for the specific program.

4.3.2.7.4 Document the observations in each direction.

4.3.2.7.5 Repeat for all test samples.

4.3.2.7.6 Continue testing each sample to failure – one sample in each of the 6 directions. (+x, +y, +z, -x, -y and -z).

4.3.2.7.7 Document the peak load and the failure mode.

4.3.2.7.8 Repeat for any environmental conditions (cold, hot, humid, etc.,) stated in the CTS/SSTS.

4.3.2.7.9 Repeat for all samples.

4.3.2.8 Test Requirements or Acceptance Criteria.

4.3.2.8.1 Refer to the program specific CTS/SSTS for requirements.

- 4.3.2.8.2 Ensure that the TVA meets location specific requirements.
- 4.3.2.8.3 There shall be no failures when loaded to the required force in each direction.
- 4.3.2.8.4 Document the failure modes in the test report.
- 4.3.2.8.5 Create a force-displacement graph of the part loaded to the specified maximum stress.
- 4.3.2.8.6 The permanent compression amount is the change in length of the part measured at 50% of the maximum force after loading and unloading.
- 4.3.2.8.7 The permissible permanent compression shall be:
- 0.15 mm maximum for a clamping length of ≤ 30 mm.
 - 0.5% maximum of shrink length for a clamping length of ≥ 30 mm.
- 4.3.2.8.8 The TVA shall withstand vehicle shocks with no effect on the performance of the parts or the lift gate system. The maximum g force to be tested is per Appendix A, per program specific requirements or provided by GM CAE.
- 4.3.2.8.9 **Pass/Fail Criteria.** No degradation or change in operational performance is allowed in the post-test measurements. After testing, parts must be disassembled and components inspected. Any damage or deformation of parts is considered a failure of the test.

4.3.3 Slam Test.

4.3.3.1 **Purpose.** To ensure that when exposed to closure slams, the TVA will not lose performance. This test is location specific. Confirm with the GM PDT for loading requirements for the specific location.

4.3.3.2 Test Equipment.

4.3.3.2.1 PPE.

4.3.3.2.2 Digital camera.

4.3.3.2.3 Holding fixture.

4.3.3.2.4 Thermal chamber.

4.3.3.2.5 Slam Test setup.

4.3.3.3 **Test Samples.** Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.

4.3.3.4 Test Time.

Calendar time:	4 d
Test time:	32 h
Coordination time:	6 h

4.3.3.5 **Test Preparation.** See 4.1. Ensure that the load profile is provided several weeks before SOT.

4.3.3.6 **Test Conditions.** See 4.2.

4.3.3.7 Test Procedure.

4.3.3.7.1 Place the test sample in the slam buck. See Appendix D for examples.

4.3.3.7.2 Photograph the test setup and include in the test report.

4.3.3.7.3 Start the slam cycles - refer to GMW16156.

4.3.3.7.4 Set the thermal chamber at $80\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

4.3.3.7.5 Move the test setup to thermal chamber. Allow test setup to soak for 4 h or until setup reaches desired thermal condition.

4.3.3.7.6 Continue the slam cycles.

4.3.3.7.7 Set the thermal chamber to $-30\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$.

4.3.3.7.8 Move the test setup to thermal chamber. Allow test setup to soak for 4 h or until setup reaches desired thermal condition.

4.3.3.7.9 Continue the slam cycles.

4.3.3.7.10 Document any observations, failures or “buds of problems” in the test report.

4.3.3.8 Test Requirements or Acceptance Criteria.

- 4.3.3.8.1** Refer to the program specific CTS/SSTS for requirements.
- 4.3.3.8.2** Ensure that the TVA meets location specific requirements.
- 4.3.3.8.3** No loss of function, objectionable appearance, degradation in the rubber or metal bracket.
- 4.3.4 Environment.**
- 4.3.4.1 Purpose.** To ensure that the TVA still performs to program requirements when exposed to operating environmental conditions. Operating Conditions can be found in the program specific CTS/SSTS. Tuned Vibration Absorber/Damper subsystem shall be able to withstand any combination of environmental conditions that it may be exposed to over its lifetime.
- 4.3.4.2 Test Equipment.**
- 4.3.4.2.1** PPE.
- 4.3.4.2.2** Digital camera.
- 4.3.4.2.3** Thermal chamber.
- 4.3.4.2.4** Holding fixture.
- 4.3.4.3 Test Samples.** Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.
- 4.3.4.4 Test Time.**
- | | |
|--------------------|---|
| Calendar time: | See specific program requirement for test time. |
| Test time: | See specific program requirement for test time. |
| Coordination time: | See specific program requirement for coordination time. |
- 4.3.4.5 Test Preparation.** See 4.1.
- 4.3.4.6 Test Conditions.** See 4.2.
- 4.3.4.6.1** Refer to Table 2 for Environmental Conditions the TVA may be exposed.

Table 2: Ambient Environment Definition

Temperature	Humidity	Classification
+80 °C ± 3 °C for Lift Gate	5% ± 5%	Hot
+95 °C ± 3 °C for Roof System		
+20 °C ± 3 °C	Room Ambient	Ambient
-30 °C ± 3 °C	Room Ambient	Cold
+38 °C ± 3 °C	95%	Hot and Humid

- 4.3.4.7 Test Procedure.**
- 4.3.4.7.1** Identify the proper operating conditions for the TVA based on the location in the vehicle.
- 4.3.4.7.2** Set thermal chamber to the high temperature.
- 4.3.4.7.3** Soak for 4 h.
- 4.3.4.7.4** Document any observations.
- 4.3.4.7.5** This procedure is to evaluate the TVA after all G3 Tests.
- 4.3.4.7.6** If the TVA is never visible to the customer, most appearance criteria is not a requirement.
- 4.3.4.8 Test Requirements or Acceptance Criteria.**
- 4.3.4.8.1** Refer to the program specific CTS/SSTS for requirements.
- 4.3.4.8.2** Ensure that the TVA meets location specific requirements. Some appearance requirements may not be applicable based on the TVA location in the vehicle.
- 4.3.5 Compression Load Deflection (CLD) Curve.**

4.3.5.1 Purpose. Supplier is responsible for providing a load deflection curve in the primary tuning direction and one perpendicular direction.

4.3.5.2 Test Equipment.

4.3.5.2.1 PPE.

4.3.5.2.2 Digital camera.

4.3.5.2.3 Force gauge or similar.

4.3.5.3 Test Samples. Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.

4.3.5.4 Test Time.

Calendar time:	1 d
Test time:	4 h
Coordination time:	2 h

4.3.5.5 Test Preparation. See 4.1.

4.3.5.6 Test Conditions. See 4.2.

4.3.5.7 Test Procedure.

4.3.5.7.1 Place the TVA in the holding fixture.

4.3.5.7.2 Apply a load of 5 N to the rubber material.

4.3.5.7.3 Measure the deflection for the load conditions.

4.3.5.7.4 Increase the load by 1 N. Record the displacement.

4.3.5.7.5 Repeat for all load conditions up to the Maximum Load + 20 N (See program specific CTS for Maximum Load) until an accurate CLD curve is developed.

4.3.5.7.6 Repeat for all samples.

4.3.5.7.7 Calculate averages and standard deviations.

4.3.5.7.8 Create the Compression Load Deflection Curve and provide to GM.

4.3.5.7.9 GM CAE to develop the acceleration profile to be used in the vibration test.

4.3.5.8 Test Requirements or Acceptance Criteria.

4.3.5.8.1 Refer to the program specific CTS/SSTS for requirements.

4.3.5.8.2 Ensure that the TVA meets location specific requirements.

4.3.5.8.3 A complete Load/Deflection profile.

4.3.6 Vibration Tuning.

4.3.6.1 Purpose. To ensure that the TVA is within design requirements of the natural frequency of the TVA. The Tuned Vibration Absorber/Damper shall be tuned at the prescribed frequency ($\pm 8.0\%$) as plotted on a frequency response diagram.

4.3.6.2 Test Equipment.

4.3.6.2.1 PPE.

4.3.6.2.2 Digital camera.

4.3.6.2.3 Holding fixture.

4.3.6.2.4 Vibration table.

4.3.6.2.5 Accelerometers.

4.3.6.3 Test Samples. Unless otherwise specified, 6 samples are to be used. Use GMW15760 to select the test samples.

4.3.6.4 Test Time.

Calendar time:	1 d
Test time:	6 h
Coordination time:	1 h

© Copyright 2020 General Motors Company All Rights Reserved