



Objective Subsystem/Component Squeak and Rattle 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. The purpose of this procedure is to provide instructions for performing objective squeak and rattle subsystem and component testing. This test is intended to subject the subsystem or component to vibration profiles comparable to in-vehicle vibration, and provide an objective measure of squeak and rattle performance.

1.2 Applicability. This procedure is applicable to any automotive subsystem or component where squeaks and rattles are a concern and the vibration environment can be simulated in a laboratory environment.

1.3 Remarks. This test is limited to detecting vibration induced noises excited by inputs above 8 Hz. Squeaks or itches excited only by slow body twist (cross ditches or driveways) will not be addressed by this test. Additionally, impact type vibrations caused by a door, hood or rear compartment lid slam cannot be addressed by this test.

Refer to the appropriate Component or Subsystem Technical Specification (CTS/SSTS) for the vibration test criteria and objective Squeak and Rattle (S&R) Instationary Loudness criteria. For a subjective squeak and rattle test procedure, see GMW7293.

2 References

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

2.1 External Standards/Specifications.

ISO 532

2.2 GM Standards/Specifications.

GMW7293

2.3 Additional References.

- Component Technical Specification (CTS)
- G.R.A.S. (www.gras.dk)
- HEAD acoustics. (head-acoustics.com)
- MB Dynamics. (mbdynamics.com/)
- Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities.

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.

3.1.3 Vibration. The facility must be free of any vibration which may affect the test specimen. Facility vibration levels should not exceed 5% of the test specified input vibration level at any frequency.

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3.1.4 Noise. The facility must be free of noise which may limit the detection or measurement of squeaks and rattles.

When noise measurements are being made, the background N10 Loudness level shall not exceed 1.5 sones. The loudness shall be calculated as described in 5.1, Calculations. Loudness background noise is considered to include:

- Room or test cell ambient noise.
- Equipment noise (shaker amplifiers, computers, and controllers).
- Shaker and fixture noise running the specified random test profile without the test part.

If the 1.5 sones N10 requirement cannot be met, then a quieter facility and/or shaker must be used.

Performing an ambient measurement can provide insight as to whether the shaker or the test cell is too noisy.

3.2 Equipment.

3.2.1 Shaker. A quiet shaker capable of replicating the specified vibration spectrum in the appropriate Subsystem or Component Technical Specification document is required. Dynamic stroke should be at least 2.5 cm, in order to meet the vibration profile requirements. The shaker must be capable of meeting background loudness requirements of 1.5 sones.

(Recommended: MB Dynamics Energizer Series Shakers. If fore-aft or lateral measurements are required, the MB Dynamics horizontal moving table or Multi-directional Universal Test Fixture.)

3.2.2 Fixture. Ideally, fixtures should be rigid, free of resonances in the (0 to 200) Hz range, and free from rattles, creaks and other potentially conflicting noises. Fixture resonances, when excited, can contribute to background noise levels, alter the vibration input to the component, and potentially make test control very difficult. To avoid exceeding the dynamic capability of the shaker, the fixture should also be as light as possible. Magnesium is the material of choice, because of its low mass, high degree of stiffness and damping characteristics. Aluminum is often an acceptable substitute.

Note: Some fixtures depend on the part to contribute to their structural rigidity. In these cases, it is possible for the fixture to make noise when tested without the part, but to be quiet with the part installed. This situation requires engineering judgments as to whether or not to proceed with the test. One must keep in mind that any noise generated by the fixture, shaker, or test cell diminishes the ability of the test part to meet the loudness requirement.

For some large fixtures or configurations of a Universal Test Fixture, it may not be practical to make the fixture resonant free up to 200 Hz. In these cases engineering judgment or further analysis may be required. The use of multiple test control accelerometers and wise placement of the control accelerometers can minimize the effects of resonances below 200 Hz.

If noise measurements are being made on larger subsystems, air bag supports may be used to support the static weight of the component and fixture. A smaller and quieter electromagnetic shaker may then be used to provide the dynamic force to the subsystem.

(Recommended: MB Dynamics Universal Test Fixture for testing Instrument Panel (IP), doors, seats, and other large subsystems.)

3.2.3 Random Controller. A digital controller with random and swept sine control capability is required. The controller must be capable of controlling the shaker:

- In the (5 to 400) Hz range with a minimum of 1 Hz frequency resolution.
- With closed loop control.
- With selectable N-Sigma clipping units or crest factor.

If large subsystems (e.g., instrument panels and doors) are to be tested, the controller is required to have a minimum of four (4) control channels (eight (8) channels recommended).

Note: It is recommended to select a controller capable of adding Time Replication, Shock and Sine-on-Random capabilities for potential future applications.

3.2.4 Accelerometer and Signal Conditioner. An accelerometer and appropriate signal conditioning are required to monitor acceleration input to the test specimen. If a strain gage type accelerometer is used, its nominal acceleration range shall not exceed five (5) times the amplitude of maximum specified input

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acceleration. The accelerometer must not have a resonant frequency less than twice the highest specified test frequency (normally 200 Hz).

(Recommended: Low Mass Integrated Circuit Piezoelectric (ICP) type accelerometer with a minimum sensitivity of 10 mV/(m/s²)).

3.2.5 Sound Recorder and Analyzer. Due to the lack of standards used in calculating Instationary Loudness, it is necessary to require either the use of a HEAD acoustics Artemis Analyzer system (available from HEAD acoustics) for all loudness measurements or demonstrate correlation of any other system to the Artemis system. The analysis method used will be loudness versus time. The calculation method should be set to Filter/ISO 532, the sound field should be set on free field, the scale should be set to Sone, and a 6th order filter should be selected.

3.2.6 Microphone and Power Supply. A 13 mm free field microphone with a frequency range of (3.15 to 20) kHz is recommended. The microphone should also have a dynamic range from (15 to 146) dB Sound Pressure Level (SPL). A 13 mm preamplifier should be used in conjunction with the microphone and have a frequency range from (2 to 20) kHz. It should also have a very low inherent noise level of < 2.5 μ V_{rms}. A power supply for use with the selected microphone type is required. The power supply should also have selectable gain and filtering.

(Recommended: microphone (13 mm free field) with a model type 26AJ preamplifier. G.R.A.S. model 12AA power module.)

3.2.7 Calibrator. A 94 dB 1000 Hz calibrator is needed to perform a calibration of the microphone system before each test.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Vehicle. No test vehicle is used for the laboratory vibration test in this procedure.

3.3.2 Test Piece. Test components/subsystems should be of the latest revision level available. Full documentation shall be provided with the material including:

- Supplier part number.
- Vintage (i.e., mule, integration, etc.)
- Change level.
- Description of any unique features.

3.4 Test Time.

Calendar time: (1 to 3) days

Test hours: (1 to 8) h

Coordination hours: (2 to 8) h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. A skilled technician or an engineer can perform this test procedure. Test personnel shall have a working knowledge of:

- Specific shaker being used and its amplifier or controller.
- Specific Digital Random Controller being used.
- HEAD acoustics Artemis Analyzer and Recorder or equivalent analyzer.
- Accelerometers (selection, mounting and calibration).
- Fixturing for vibration testing.
- Squeak and rattle root source analysis methods.
- A general knowledge of the product being tested.

4 Procedure

4.1 Preparation.

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4.1.1 Fixture and Test Specimen Mounting. All subsystems and components should be mounted in vehicle position with design intent fasteners and hardware. Careful attention shall be paid to installation torques, harness, belt and cable routing, and clearances and adjustments. See Appendix C of this procedure for detailed microphone locations and subsystem and component configurations. The sample must be mounted such that the shaker will not bottom out or hit any internal stops, which may induce an impact to the test specimen or create unwanted noise. The shaker should also be attached at the center of gravity of the fixtured part, so as not to introduce any rotational motions (overturning moments) into the test specimen or induce side loading or moments on the shaker. The shaker should be mounted to a reaction mass or bedplate of sufficient size as to avoid generating noise in the building, floor and/or other supporting structure.

4.1.2 Control Accelerometer. For small parts with relatively rigid fixtures, a single control accelerometer is adequate and location is usually not critical. However, for larger parts, especially when there are fixture resonances lower than 200 Hz, multiple control accelerometers should be used. Ideally, place a control accelerometer at each interface (or attachment) of the test part to the fixture. If not enough control channels are available, locate the control accelerometers to cover as many interfaces to the fixture as possible, attempting to achieve uniform spacing between them. If only two (2) control channels are available, try to locate them at the part-to-fixture interfaces where the fixture is the most rigid and where it is least rigid. It is not recommended to attempt a test on a large test part with only one (1) control accelerometer.

4.1.3 Random Controller. The random controller shall be set up with the random profile specified in the SSTS/CTS and the appropriate meter per second squared (m/s^2) Root Mean Square (RMS) vibration level. N-Sigma clipping should be set for three (3) unless otherwise stated in the CTS or SSTS.

4.1.4 Calibration. The recording system shall be calibrated by recording a 94 dB 1000 Hz calibration tone for 10 s. The calibration file shall be saved with the data and the calibration value shall be recorded on the provided Instrument Calibration Data Sheet (Appendix A, Data Sheet A1) or entered into the appropriate database.

4.2 Conditions. A background loudness measurement shall be taken with only the fixture mounted on the shaker (no product) and excited with the random input specified in the CTS/SSTS. The fixture may be ballasted with a rigid mass if desired. The microphone shall be positioned in the same location used to make the product measurements. When multiple product measurements are being made, place the microphone at the position judged to have the highest background noise. The N10 value for the background noise shall be recorded on the Subsystem/Component Evaluation Worksheet (Appendix B, Data Sheet B1) provided. Note any noises that are heard on the Evaluation Worksheet.

The subsystem or component shall be tested in the configurations specified in Appendix C with the subsystem or component mounted in vehicle position. Fore-aft and lateral tests shall be performed with an MB Dynamics horizontal moving table.

The background noise requirement of 1.5 sones N10 must be met when loudness measurements are being made. If any extraneous noises are heard, the measurement should be repeated.

4.2.1 Environmental Conditions. Not applicable.

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 Random Test. Start the random controller. The random controller should be allowed to ramp up and stabilize to the profile specified in the CTS/SSTS.

Perform loudness measurements in accord with the microphone locations for each of the subsystem/component configurations described in Appendix C. The microphone should be positioned 15 cm from the measurement surface in the orientation also pictured in Appendix C (Figures C20 thru C33).

If the measured Zwicker Loudness exceeds the performance requirement, identify each individual squeak and rattle, root source and document. Proceed with the development of corrective action for each squeak and rattle.

The following measurement parameters should be used for the recording of the product noise.

Recording:

- Data sampling rate should be set at 44.1 kHz.
- A minimum of 10 s of sound data shall be recorded for analysis.
- A 20 Hz high pass filter should be used (often built into microphone power supply and/or analyzer).

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4.3.2 Swept Sine Test (Optional). A swept sine test should only be used for diagnosing product noise sources. The swept sine can be especially useful for root sourcing a squeak or rattle. It is required that noises be noted using shaped random input. Once noted, the swept sine can be used for analysis. Any swept sine test level, which excites the noise of concern, is adequate. There is no squeak and rattle product requirement for sinusoidal inputs.

5 Data

5.1 Calculations. Loudness calculations must be made using HEAD Artemis Analyzer or a system that has been correlated to Artemis. The noise recordings shall be analyzed using the following parameters:

Filter Pool

- Serial Filter.
- Filter Kind: High Pass.
- Filter Type: Butterworth.
- Filter Order: 4th order.
- Frequency: 300 Hz.

Analysis: Loudness versus Time

- Calculation Method: Filter/ISO 532.
- Sound Field: Free.
- Scale: Sone.
- Filter Order: 6th order.

Statistics (Optional)

- Percentile (requirement is based on 90th percentile value or N10).

Note: Instead of calculating the N10 level in Artemis, an Excel macro (a spreadsheet program) can be used if data is written to Excel (a spreadsheet program).

Destination Pool

- Excel (a spreadsheet program) Export.
- Mark Analyzer (Optional).

5.2 Interpretation of Results. The measured N10 Loudness at any measured location must not exceed the N10 Loudness requirement specified in the CTS/SSTS.

5.3 Test Documentation. Test equipment serial numbers, calibration information, test documentation, description of test material (including design revision, lot or batch, options, specifics about any design proposals, etc.) test specification date and reference, pertinent setup information and a summary of results, should be documented on data sheets provided.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Instationary Zwicker Loudness: Loudness (sones) involves linearization of subjective perception of the loudness of acoustic signals. The unit of loudness, the sone, corresponds to a sine tone of frequency 1 kHz and a level of 40 dB.

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Tones twice as loud (perceived as such) have the loudness value 2 sones; tones three times as loud have the value 3 sones, and so on.

Instationary Loudness is sometimes called real time loudness. Instationary Loudness is calculated from sound pressure measurements acquired approximately every 3 ms.

Stationary Loudness is calculated from an averaged $\frac{1}{3}$ octave sound pressure measurement. The sampling time for the $\frac{1}{3}$ octave sound pressure measurement is typically 250 ms.

N10 Zwicker Loudness: N10 Loudness is a statistically calculated loudness value based on the 90th percentile value of the time varying loudness values. The 90th percentile means that 10% of the population has a value greater than the N10 value and 90% of the population has a value that is less.

N-Sigma Clipping: N-Sigma clipping occurs when the peak amplitude is cut off based on a normal statistical distribution limit. Often 3-sigma clipping is selected.

Power Spectral Density (PSD): A plot of acceleration versus frequency. The acceleration values have the units of $(\text{m/s}^2) \sqrt{\text{Hz}}$.

7.2 Acronyms, Abbreviations, and Symbols.

- μV_{rms} Micro Volts Root Mean Square
- **ABTS** All Belts to Seat
- **CD** Compact Disk
- **DIC** Driver Information Center
- **DVD** Digital Video Disk
- **FRT** Front
- **HUD** Heads Up Display
- **ICP** Integrated Circuit Piezoelectric
- **IP** Instrument Panel
- **N&V** Noise and Vibration
- **PQMS** Performance and Quality Management System
- **PSD** Power Spectral Density
- **RESS** Rechargeable Energy Storage System
- **RMS** Root Mean Square
- **S&R** Squeak and Rattle
- **SPL** Sound Pressure Level
- **VPO** Vehicle Performance Owner

8 Coding System

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

Test to GMW14011

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9 Release and Revisions

This standard was originated in May 2004. It was first approved in May 2004. It was first published in June 2004.

Issue	Publication Date	Description (Organization)
1	JUN 2004	Initial publication.
2	OCT 2006	Added figure for steering rack measurements. (Global N&V S&R Harmonization Team)
3	NOV 2008	Added figures for bench and bucket seats in folded down and stowed positions, overhead console, and package shelf measurements. Updated figure for bench and bucket seats in upright position and renumbered all figures. (Global N&V S&R Harmonization Team)
4	NOV 2010	Revised text for "Fixture" in 3.2.2 and modified several pictures and notes in Appendix C. (Global N&V S&R VPO Team)
5	MAR 2015	Revised to current template. Figure C33 added. (Global N&V VPO Team – Squeak and Rattle)
6	APR 2016	Revised Appendix C for Seats to specify directions of excitation. (Interior - Seats)

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Appendix A: Instrument Calibration Data Sheet

SUBMIT THIS SHEET WITH THE OTHER DATA SHEETS WHEN THE INFORMATION IS NOT OTHERWISE PRESERVED IN THE TESTING LABORATORY RECORDS.

Data Sheet A1: Instrument Calibration Data Sheet**Test Date:** _____**Test Cell
Number:** _____

	Instrument/Transducer Description	Instrument Number	Calibration Date	Next Calibration Date
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

**Recorded by:
(Signature)** _____**Date:** _____**GM Confidential**

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Appendix B: Subsystem/Component Evaluation Data Sheet

Data Sheet B1: Subsystem/Component Evaluation Worksheet Data Sheet

Date	Supplier	Quantity	Part Description	Year/Make/Model	Build Level
Project Number	PQMS Number	Temperature	Humidity	Test Cell	
Equipment		Input Direction	Directory	File Name	

Requestor and Phone Number		Technician and Phone Number	
Microphone Signal Conditioner Gain (dB)		Calibration Factor (dB)	

Description of Filter Applied			
Ambient N10 Loudness (sones)		Background N10 Loudness (sones)	

Index Number	Component Description/Type/Position	Microphone Location	Subjective Rating	N10 Loudness (sones)	Comments

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Index Number	Component Description/Type/Position	Microphone Location	Subjective Rating	N10 Loudness (sones)	Comments

Note: PQMS = Performance and Quality Management System.

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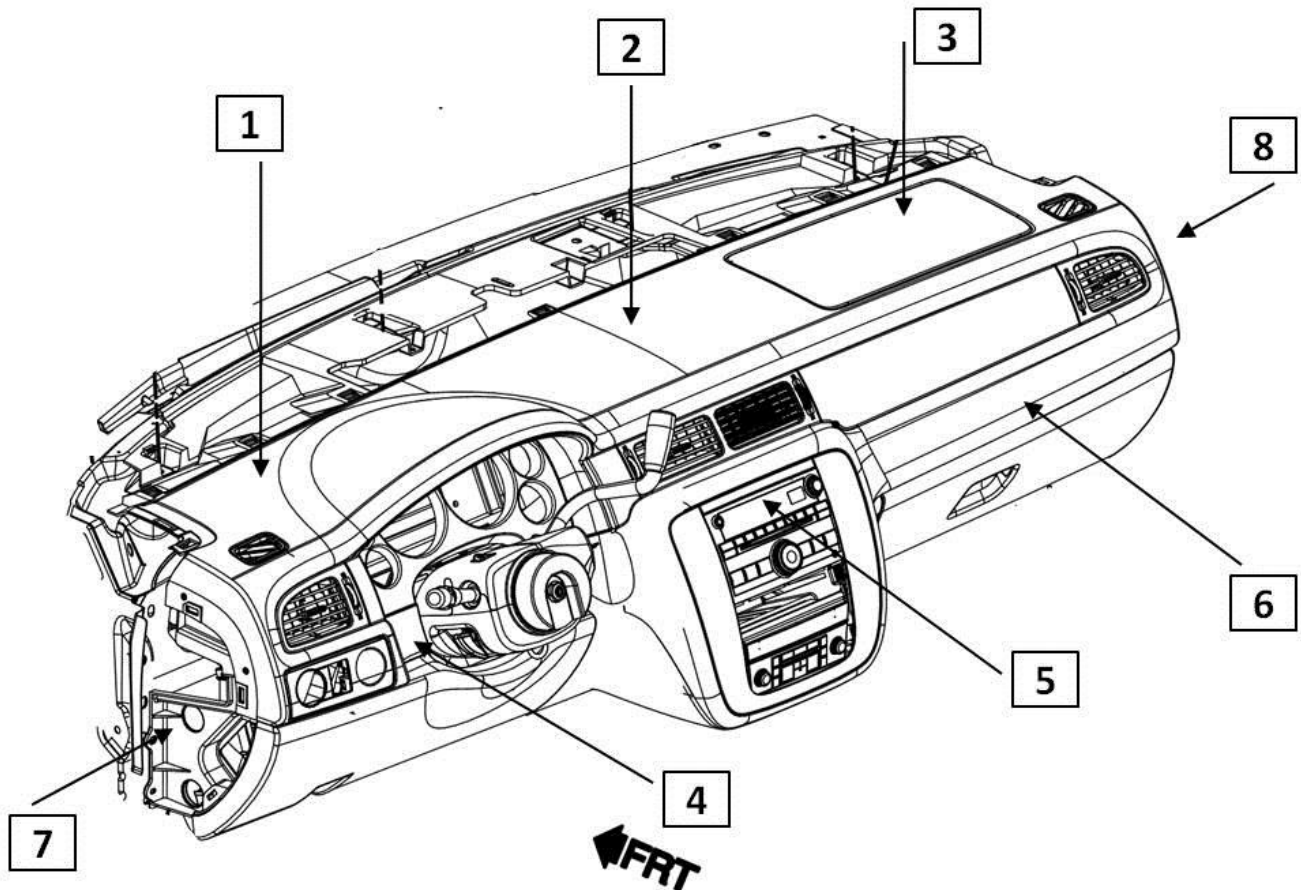


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Appendix C: Measurement Locations for Subsystems/Components

All drawings are typical examples. Detailed parts may vary.



Instrument Panel Structure and Trim.

- One (1) component position.
- See SSTs for test excitation direction and requirements.
- Eight (8) measurement locations.

Note: FRT = Front

Figure C1: Standard Noise Measurement Locations for an Instrument Panel

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