



Suspension Damper System Structure Borne Noise 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 standard is to outline a method for determining the potential for a damper system (strut/shock and top mount) to transmit structure borne noise (commonly referred to as "loose lumber", "chuckle", "knock", "rattle", or "rumble") into the vehicle passenger cabin.

1.2 Applicability. This procedure applies to all passive suspension dampers. It may also be applied to electronically controlled suspension dampers provided that the appropriate control equipment, power source, logic, etc. is supplied. However, details specific to electronically controlled dampers are not within the scope of this procedure.

1.3 Remarks. Structure borne noises will result in customer complaints if not kept to a minimum level.

2 References

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

2.1 External Standards/Specifications.

IEC 61672

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Component Technical Specification (CTS) in the Statement of Requirements (SOR)
- Design center of damper stroke (L_m) (mm)
- Siemens LMS Test.Lab software, including the Time Signal Calculator module, connected to a Scadas III frontend. See Uniform Resource Locator (URL)
https://www.plm.automation.siemens.com/nl_nl/products/lms/testing/test-lab/index.shtml

3 Resources

3.1 Facilities. Temperature controlled work area that contains the test equipment with lighting, power and benches.

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.

3.2.1 Test Station. A servo-hydraulic or other electro-dynamic system into which a vehicle corner module (inclusive of damper, mount, spring and tower as needed) can be installed. The test station shall:

- Generate sine waves from 10 Hz to 13 Hz with 5 mm to 10 mm peak-to-peak displacement
- Have an upper fixture that simulates the vehicle strut/shock upper mounting interface. **Note:** The stiffness of upper fixture shall be > 10 kN/mm along the damper axis.

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- Have a lower fixture and that simulates the vehicle strut/shock lower mounting interface, i.e., rigid mounted clevis, lower eye ring with bushing, etc.

3.2.2 Data Acquisition Equipment. Hardware capable of calculating frequency domain results between 2 kHz and 10 kHz, with a minimum of 80 dB dynamic range. This hardware shall meet Class 1 accuracy corresponding to IEC 61672 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$). The preferred data acquisition system consists of a personal computer running Siemens LMS Test.Lab software, including the Time Signal Calculator module, connected to a Scadas III frontend. See Uniform Resource Locator (URL) https://www.plm.automation.siemens.com/nl_nl/products/lms/testing/test-lab/index.shtml.

3.2.3 Accelerometers. Three (3) low mass accelerometers (tri-axial preferred, uniaxial acceptable) with flat response from 2 Hz to 2000 Hz and an operating range of 10 °C to 50 °C.

3.3 Test Vehicle/Test Piece. A fully functioning damper with the top mount specific to the vehicle program.
Note: A suspension spring may also be required for retention of the top mount in the fixture or for preloading of the main rubber element in specific designs.

3.4 Test Time.

Calendar time: 1 days
 Test time: 2 hours
 Coordination time: 2 hours

3.5 Test Required Information. Design center of damper stroke (L_m) (mm). **Note:** this is the center of the test stroke.

3.6 Personnel/Skills. One qualified engineer or technician trained in the use of the test station and data acquisition with a basic knowledge of digital signal processing of acoustic or vibration signals. Knowledge of LMS Time Signal Calculator is also required.

4 Procedure

4.1 Preparation.

4.1.1 Set up the test station per the test conditions, this may include software configuration for amplitude and frequency settings.

4.1.2 Install upper and lower attachment fixtures to simulate damper and upper mount in-vehicle position.

4.1.3 Install damper at L_m . **Note:** Position may need to be adjusted to compensate for an internal rebound spring.

4.1.4 Calibrate accelerometers.

4.1.5 Identify mounting style based on Figure A1 in Appendix A.

4.1.6 Install accelerometers in specified locations per Figure A2 or Figure A3 in Appendix A.

4.1.7 Connect the accelerometers to the data acquisition equipment.

4.1.8 Calibrate/zero other instrumentation

4.2 Conditions. Unless otherwise supplied, the test station conditions shall be per Table 1.

Table 1: Test Station

Event	Waveform	Frequency (Hz)	Peak to Peak (pk-pk) Displacement (mm)
1 (Priming and Analysis)	Sine	10	5
2 (Analysis)	Sine	10	8
3 (Analysis)	Sine	10	10
4 (Analysis)	Sine	13	5
5 (Analysis)	Sine	13	8
6 (Analysis)	Sine	13	10

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Set the parameters of the data acquisition system to the following settings:

- Acquisition Type: Triggered on data channel
- Acquisition Length: > 30 s
- Pre-Trigger: 2.0 s
- Measurements Type: Time History (for all data channels)
- Sampling Rate: ≥ 5 kHz Bandwidth along with anti-aliasing filter
- Low Pass Filter: 1 kHz
- Window: Uniform

4.2.1 Environmental Conditions. Tests to be run at room temperature: $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

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. The test station shall be in displacement mode and will apply a displacement vs. time input to the test damper assembly.

4.3.1 Input. The input is constructed of seven (7) sine wave events with 3 s separations of zero (0) input between the events. There are also 3 s of zero (0) input at the beginning and end of the series of events.

4.3.1.1 Priming Input. The first event is to prime the damper. It consists of two (2) complete sine wave cycles with the amplitude and frequency specified in the first entry of Table 1. **Note:** These cycles will not be included in the analysis.

4.3.1.2 Analysis Input. The next six (6) events are each a sine wave of five (5) cycles duration. The frequency and amplitude for each of these events are specified in Table 1. An example of the complete input signal can be seen in Figure A4 in Appendix A.

5 Data

5.1 Calculations. For each of the measurement sets the following calculations need to be performed along the axis of damper (Z direction) using the LMS Time Signal Calculator or equivalent processing software.

5.1.1 Calculate Piston Z Acceleration. Calculate damper piston acceleration using the following equation:

$$\text{Damper Piston Z Acceleration} = \text{Damper Rod Z Acceleration} - \text{Damper Body Z Acceleration}$$

5.1.2 Filter High Frequency Noise from Damper Body Z Acceleration. A noise free measurement of the Damper Body Z Acceleration is needed to identify each of the areas in the time trace for further calculations. Low pass filter the Damper Body Z Acceleration with the following parameters. A sample measurement is shown in Figure A5 and Figure A6 in Appendix A.

- Low Pass Frequency: 30 Hz
- Filter Type: Infinite Impulse Response (IIR) Butterworth 10th order
- Phase Affect: 0 degrees phase change

5.1.3 Filter Noise and Non-Relevant Vibration to Reveal the Pertinent Z-axis Acceleration for Processing. Band pass filter the Damper Rod Z Acceleration, the Damper Body Z Acceleration, and the Damper Piston Z Acceleration with the following parameters. A sample measurement is shown in Figure A7 in Appendix A.

5.1.3.1 Hydraulic Structure Borne Noise.

- Low Pass Frequency 400 Hz
- Hi Pass Frequency 80 Hz
- Filter Type IIR Butterworth 40th order
- Phase Affect 0 degrees phase change

5.1.3.2 Mechanical Structure Borne Noise.

- Low Pass Frequency 1000 Hz

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