



Vacuum Brake Apply System Vehicle Noise Evaluation

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. Test method to subjectively and quantitatively evaluate the brake noise under normal driving conditions.

1.2 Applicability. This procedure is applicable to all passenger and light trucks.

1.3 Remarks. This evaluation should be used to rate the in-vehicle brake apply system noise. In particular, this evaluation is intended to rate booster whoosh sound level as experienced by the driver during static brake applies, such as when shifting an automatic transmission vehicle out of park or during low speed dynamic applies (parking lot maneuvers). This test is also intended to rate master cylinder squeak, and any other noise events generated by the apply system.

2 References

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

2.1 External Standards/Specifications.

DIN 45631/A1 IEC 651 ISO 532

2.2 GM Standards/Specifications.

None

2.3 Additional References.

LMS International, Laredo, TX, USA (<http://www.lmsinternational.com/>)

3 Resources

3.1 Facilities. All tests must be conducted in a location with an ambient noise background level at a minimum of 5 dB below the signal being measured (10 dB of separation is recommended for best signal to noise ratio).

Tests should be conducted on level ground such that the vehicle will not roll when the transmission is placed in neutral with the park brake unapplied.

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 Free-field microphone with appropriate signal conditioning and cables.

3.2.2 Sound level calibrator.

3.2.3 High gain accelerometer(s) with at least a 5k Hz cutoff frequency.

3.2.4 A brake pedal force transducer capable of measuring up to 500 N. Use a known mass for verification and/or calibration of the force transducer.

3.2.5 Vacuum transducer capable of measuring up to 100 kPa.

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3.2.6 Acoustical quality data acquisition system with a minimum sampling rate of 44.1 kHz (80 dB dynamic range) and at least 16 bit quantization. This hardware shall meet Class 1 accuracy corresponding to IEC 651 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.2.7 Data processing system capable of performing Zwicker Loudness, Sound Pressure level calculations, and sound data analysis.

3.3 Test Vehicle/Test Piece. The specific vehicle chosen for testing should be representative with respect to brake system and Noise, Vibration and Handling (NVH) performance.

3.4 Test Time.

Calendar time: < 1 day

Test time: 2 hours to 4 hours

Coordination time: 1 hour

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. This test requires an experienced, trained brake tester capable of performing repeatable brake applies and subjective noise ratings. Hearing evaluation of the brake tester is suggested.

4 Procedure

4.1 Preparation. Not applicable.

4.2 Conditions.

4.2.1 Environmental Conditions. Ambient conditions during the test shall be $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

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.

4.3.1 All accessories should be off during testing.

4.3.2 All windows should be closed.

4.3.3 Air conditioning fan setting restricted to off position during testing. Any device that generates any noise must be disabled.

4.3.4 Automatic transmission cars should be tested with the gear selector in the neutral position with the park brake unapplied to remove any noise related to the brake shift interlock switch.

4.3.5 In order to obtain good repeatability noise results, start vehicle and operate until normal operating conditions are achieved or as directed by testing engineer.

4.3.6 The coordinates of the measuring points and all possible microphone and seat positions are defined in Appendix C, Figures C1 and C2. Standard positions to be used for testing are left front seat, right ear (LFRE), seat is occupied by a driver and right rear (RR). The standard positions are mirrored symmetrically for Right Hand Drive (RHD) vehicles (i.e., right front seat, left ear (RFLE) and left rear (LR)). This vehicle diagonal configuration captures events on both sides of the vehicle and in both the front and rear seat positions.

4.3.7 Install load cell in brake pedal, and a vacuum transducer in line with the booster check valve.

4.3.8 For section 4.5, set an accelerometer in the back of the master cylinder as shown in Figure 1.

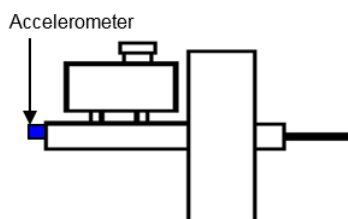


Figure 1: Accelerometer Setup

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4.3.9 Set additional accelerometers and microphones in all suspected locations where noise may originate (if applicable).

4.3.10 Prepare the data acquisition equipment (LMS International or equivalent) to collect data following the set up parameters in Appendix B, Table B1. All transducers must be calibrated and zeroed.

4.3.11 Ensure that the driver's foot is lightly resting on the pedal prior to the start of apply to keep from recording the impact sound of the driver's foot on the pedal.

4.4 Booster Whoosh Evaluation Test.

Note: This test is intended to assess the booster whoosh, with several force apply rates and force targets. See more details in Appendix A, Table A1 column 4.4.

4.4.1 Applies should be made per Appendix A, Table.

4.4.2 Ensure that the brake pedal is fully and completely released immediately after reaching the target brake force.

4.4.3 Allow enough time between the end of each brake apply cycle and the beginning of the next to allow the brake booster vacuum level to recover completely.

4.4.4 If the pedal apply rate and target is within the acceptable limits (per Appendix A, Table A2), save the data recording.

4.4.5 Record six (6) runs for each apply rate and target and provide a subjective rating for each run. (See Appendix A, Table A3.) Discount any applies with external noises or noises that are not representative of a typical apply in the vehicle.

4.5 Master Cylinder Noise Evaluation Test.

Note: This test is intended to assess the master cylinder noise conditions. See more details in Appendix A, Table A1. An in-line pressure sensor between the master cylinder port and the hydraulic brake line should be included to monitor the hydraulic pressure on "water hammer" conditions.

4.5.1 Applies should be made such that the master cylinder noise condition is generated. Determine the appropriate duration of the run based on the nature of the noise event.

4.5.2 Ensure that the brake pedal is fully and completely released immediately after reaching the target brake force.

4.5.3 Once the noise event is generated, save the data recorded and provide a subjective rating for each run. (See Appendix A, Table A3.) It is recommended to record six (6) different instances of the noise event for statistical analysis.

4.5.4 Discount any applies with external noises or noises that are not representative of the master cylinder noise event.

4.6 Apply System Sound Evaluation Test (Optional).

Note: This test is intended to assess any noise event emitted from the Apply System (not evaluated in 4.4 and 4.5). See more details in Appendix A, Table A1.

4.6.1 Applies should be made such that the noise event in question is generated. Determine the appropriate duration of the run based on the nature of the noise event.

4.6.2 Ensure that the brake pedal is fully and completely released immediately after reaching the target brake force.

4.6.3 Once the noise event is generated, save the data recorded and provide a subjective rating for each run. (See Appendix A, Table A3.) It is recommended to record 6 different instances of the noise event for statistical analysis.

4.6.4 Discount any applies with external noises or noises that are not representative of the noise event in question.

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5 Data

5.1 Calculations. The software used must be capable of performing listening-based audio file trimming, audio band pass filtering, time averaging of multiple sound files, calculating loudness (sones) versus time using Filter-Based ISO 532 method, and calculating 1/24th-Octave smoothed, Fast Fourier Transform (FFT) based frequency plots and in-band dB values from the FFT plots.

5.2 Interpretation of Results.

5.2.1 Booster Whoosh Data Analysis.

5.2.1.1 Post-process data per processing parameters in Appendix B, Table B1.

5.2.1.2 Plot the Zwicker Loudness (DIN 45631/A1) and Sound Pressure Level for the average of all configurations. Identify the peak and loudness for each run See Appendix A, Figure A1 for example.

5.2.1.3 Test results should be summarized in tabular format as shown in Appendix A, Table A4.

5.2.1.4 Plot a graph of apply rate (N/sec) vs. loudness (Sones) for each configuration, as shown in Appendix A, Figure A2.

5.2.2 Master Cylinder Noise Data Analysis.

5.2.2.1 Post-process data per processing parameters in Appendix B, Table B1.

5.2.2.2 Plot the graph of acceleration (G) vs. time (s) for the worst case run. Identify the peak G value and the name of each run.

5.2.2.3 Plot a graph of acceleration (G) vs. frequency (Hz) for the worst case run. Identify the peak G value and the name for each run. See Appendix A, Figure A3 for example.

5.2.3 Booster and Master Cylinder Sound Data Analysis.

5.2.3.1 Plot the graph of acceleration (G) vs. time (s) for the worst case run for all accelerometers installed. Identify the peak g value and the name of each run, to identify any irregular noise condition.

5.2.3.2 Based on the noise condition, apply the most appropriate data analysis from 5.2 and/or 5.3.

5.3 Test Documentation. Publish and distribute an engineering report.

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. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

ADC Analog to Digital Conversion

DC Direct Current

FFT Fast Fourier Transform

G gravity

GSSLT Global Subsystem Leadership Team

ICP Integrated Circuit Piezoelectric (Transducer)

LFRE left front seat, right ear

LR left rear

NVH Noise, Vibration and Harmonics

RFLE right front seat, left ear

RHD Right Hand Drive

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RR Right Rear

SPL Sound Pressure Level

8 Coding System

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

Test to GMW16743

9 Release and Revisions

This standard was originated in December 2011. It was first approved by the Global Chassis Brake Team in April 2012. It was first published in April 2012.

Issue	Publication Date	Description (Organization)
1	APR 2012	Initial publication.
2	SEP 2017	Revised to current template. (Chassis Brake Global Subsystem Leadership Team (GSSLT))

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