



Sound Power to Pressure Transfer Function Master Test 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. To measure the sound power to pressure transfer function in a full vehicle. This document provides a master procedure to acquire the airborne noise path characteristics of a vehicle.

1.2 Applicability. This test procedure applies to all passenger vehicles.

Sound Power to Pressure Transfer Function tests allow the source points and response points to be placed in the vehicle or components. There are a variety of applications: for example, from exterior (source points) to interior (response points) called a Power Based Noise Reduction (PBNR) test; or from interior to interior, determining absorption and propagation effects; or from exterior to exterior, measuring exterior sound field distribution.

1.3 Remarks. This procedure shall be applied to validate Subsystem Technical Specification (SSTS) targets for vehicle development, benchmarking, or validation purposes. This procedure shall also be referred to facilitate Statistical Energy Analysis (SEA) validation tests and other noise path analyses.

2 References

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

2.1 External Standards/Specifications.

ISO 3745

2.2 GM Standards/Specifications.

GMW14172

2.3 Additional References.

- Subsystem Technical Specification

3 Resources

3.1 Facilities. Vehicle tests will be performed in a hemi-anechoic room.

Source calibration verification tests will be performed either in an anechoic room or in the same hemi-anechoic room where the vehicle test is conducted (see Appendix D).

Test Rooms:

- Hemi-anechoic Room: The ambient background noise levels measured at all the frequencies must meet the criterion, 10 dB lower than the noise levels generated at responses when the source is either placed inside or outside the vehicle.
- Anechoic Room: The test room must be in accordance to the requirements as set for ISO 3745.

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.

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3.2 Equipment.

3.2.1 Test Equipment. Appendix C (Tables C1 and C2) contains some detailed information regarding minimum acquisition system requirements and transducer examples.

3.2.1.1 Data acquisition system with at least two channels must be used.

3.2.1.2 A Point Source. See Appendix B for specifications of a typical point source.

3.2.1.3 Microphones. See Appendix C.

3.2.1.4 Miscellaneous cabling and signal conditioning as needed.

3.2.2 Test Fixtures.

3.2.2.1 Fixtures for positioning the point source (see Appendix B).

3.3 Test Vehicle/Test Piece. This test procedure is applicable for any trimmed body or full vehicle level test.

3.4 Test Time.

Calendar time: 1 d to 2 d

Test hours: 6 h to 12 h

Coordination hours: 1 h to 4 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. To complete this test, at least one technician and/or one engineer skilled in acoustic data acquisition, analysis, equipment use, and test setup are required.

4 Procedure

4.1 Preparation.

4.1.1 Trimmed Body/Vehicle Preparation. The trimmed body or vehicle shall be placed in the hemi-anechoic room. The vehicle shall be located in the room center at least 1.8 m away from wall or other anechoic ally treated surface.

4.1.2 Verify Instrument Calibration.

4.1.2.1 Verify Source Calibration. See Appendix D.

4.1.2.2 Verify Transducer System Calibration. See GMW14172.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient temperature shall be between 18 °C and 29 °C and temperatures shall not vary more than 6 °C during a given test unless otherwise specified.

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 narrow band transfer function will be measured. See Appendices A and E for detailed information.

Default Acquisition Parameters.

- Free run trigger
- 1 Hz resolution
- The values for maximum frequency depend on the limitations of the point source used.
- Hanning windows for all the channels
- AC Coupled (100 Hz high pass filter), see Appendix E, (E1.5).
- 30 averages (minimum)
- Enable overload detection
- Dynamic range: 72 dB (minimum)

4.3.1 Measurement Location. Place the source and responses at positions of interest.

For standard measurements, the source locations for an exterior to interior transfer function measurement (PBNR) are: Right Front Seat (RFS), Left Front Seat (LFS), Right Rear Seat (RRS), Left Rear Seat (LRS), Right

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Rear Seat 3rd Row (RRS3), and Left Rear Seat 3rd Row (LRS3). See Appendix E, (E1.1) for the use of **Principle of Reciprocity**.

A source shall be randomly located at a minimum of six points inside each acoustic volume. The response microphone shall be randomly located, unless otherwise stated, at a minimum of six points inside each acoustic volume (e.g., top side of engine, front floor, tailpipe).

The average value of a set of 1/3 octave transfer functions shall be calculated from one acoustic source volume to one acoustic response volume. The set shall include at least 36 transfer functions from six source points to six response points. See Appendix E, (E1.2) for the calculation of the average value.

4.3.2 Data Acquisition.

4.3.2.1 Observe the narrow band transfer function. The coherence functions are recommended to be equal to or larger than 0.9. See Appendix E, (E1.4).

4.3.2.2 After confirming the measurement quality, save the narrow band transfer functions, record subsystem locations, source/microphone locations, identification information (e.g., channel, test, user, and project), filename, and record appropriate test documentation.

5 Data

5.1 Calculations.

Power Based Noise Reduction (PBNR) Concept: The PBNR values are defined as the ratio of the sound power to the mean squared pressure as a function of 1/3 Octave frequency bands. It can be written as in terms of dB levels,

$$\text{PBNR} = 10 \cdot \log_{10} [\Pi / (p \cdot p^*) / \alpha]$$

with $\alpha = \Pi_{\text{ref}} / p_{\text{ref}}^2 = 1/400$ with a unit of $\text{s} \cdot \text{m}^4 / \text{kg}$. p^* is the conjugate of the pressure p . $(p \cdot p^*)$ is the mean squared pressure or the measured pressure auto-power spectrum. Note that the sound power, Π , of a point source is defined as the sound power of the source in the free field rather than that in the in-situ measuring positions.

Note: Appendix A shows two measurement methods to calculate the PBNR values.

PBNR Data Process: Take a Root Mean Square (RMS) average of the narrow band transfer functions from the source volume to the response volume. See Appendix E, (E1.2).

Convert the RMS averaged narrow band transfer functions into 1/3 octave bands. See Appendix E, (E1.3).

Convert to sound power from volume acceleration (see Appendix A) and correct for the band by band 1/3 octave source calibration curve (see Appendix D).

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. The data shall be presented in 1/3 octave bands.

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.

7 Notes

7.1 Glossary.

Interior Source Locations:

LFS: The volume directly over the left front seat and above the belt line.

LRS: The volume directly over the left rear seat and above the belt line.

LRS3: The volume directly over the third row left rear seat and above the belt line.

RFS: The volume directly over the right front seat and above the belt line.

RRS: The volume directly over the right rear seat and above the belt line.

RRS3: The volume directly over the third row right rear seat and above the belt line.

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7.2 Acronyms, Abbreviations, and Symbols.

ATF	Acoustic Transfer Function
Eq.	Equation
FFT	Fast Fourier Transform
LFS	Left Front Seat
LMS	Leuven Measurement Systems, a division of Siemens
LRS	Left Rear Seat
LRS3	Left Rear Seat 3 rd Row
PBNR	Power Based Noise Reduction
Ref	Reference
RFS	Right Front Seat
RMS	Root Mean Square
RRS	Right Rear Seat
RRS3	Right Rear Seat 3 rd Row
S/N	Signal to Noise
SEA	Statistical Energy Analysis
SPL	Sound Pressure Level
SSTS	Subsystem Technical Specification

8 Coding System

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

Test to GMW14174

9 Release and Revisions

This standard was originated in June 2005. It was first approved by the Global N&V Acoustic & ABN IDSR Harmonization Team in October 2005. It was first published in October 2005.

Issue	Publication Date	Description (Organization)
1	OCT 2005	Initial publication.
2	OCT 2010	Five year refresh. (Global N&V Airborne Noise VPO Team)
3	SEP 2015	Five year refresh. (Global N&V Airborne Noise VPO Team)

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