



Air Induction System and Exhaust System Silencer - Transmission Loss Evaluation 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 transmission loss of an induction or exhaust system or element using a Silencer Transmission Loss (TL) Test Rig, a standardized test fixture.

1.2 Applicability. The test procedure is appropriate for the evaluation of the transmission loss of any silencer-type test sample that can be incorporated into the Silencer TL Test Rig.

This is a generalized procedure for measuring the transmission loss silencer elements and systems that include, but are not limited to: mufflers, induction system elements, complete exhaust systems and complete induction systems.

1.3 Remarks. This test is to be used for the purpose of establishing new product goals through the benchmarking of competitive components and subsystems and the development of new product program designs to achieve the specified vehicle interior sound. It may also be used to support validation of analytical models of exhaust or induction transmission loss. This test procedure shall be followed in its entirety.

2 References

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

2.1 External Standards/Specifications.

IEC 651

2.2 GM Standards/Specifications.

GMW14172

2.3 Additional References. None.

3 Resources

3.1 Facilities. Not applicable.

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 TL Test Rig Hardware. Includes speaker enclosure, driver, transition cone, cables and power amplifier.

3.2.2 Duct adapters, couplings and support stands.

3.2.3 Anechoic Termination. Includes three (3) sections of Poly Vinyl Chloride (PVC) pipe filled with absorptive material that will absorb at least 98% of the acoustic energy from 50 Hz to 3200 Hz.

3.2.4 Four (4) 0.25 in microphones and pre-amplifiers with flat response between 3.15 Hz to 10 kHz and appropriate signal conditioning and cables, meeting Class 1 accuracy corresponding to IEC 651 or equivalent for the application (precision ± 0.7 dB or $\pm 8\%$ shall be used).

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3.2.5 Four (4) microphone taps.

3.2.6 High pass filter.

3.2.7 A four (4) channel Fourier Transform Analyzer.

3.2.8 A random noise generator.

3.2.9 Microphone calibrator with adapter for a 0.25 in microphone.

3.2.10 Miscellaneous petroleum jelly for fitting faces.

3.2.11 Duct tape, duct sealant or permagum.

3.3 Test Vehicle/Test Piece. The test specimen shall be qualified to ensure that it represent the level of hardware desired for testing and that it includes all pertinent hardware. All boundaries and interfaces must be represented correctly. If the test specimen is not design intent, the deviations shall either be corrected or otherwise noted on the test description sheet.

Note: Fabrication of adapters is necessary to install test specimens into the TL Test Rig.

3.4 Test Time.

Calendar time: 1 day

Test time: 2 hours

Coordination time: 1 hour

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. At least one (1) technician and/or one (1) engineer skilled in noise data acquisition, analysis, equipment use and test setup is required.

4 Procedure

4.1 Preparation. As needed, fabricate adapters per guidelines in Appendix A, Figure A1 and Figure A2. Set up TL Test Rig, seal all pipe interfaces and align system.

4.2 Conditions. The TL Test Rig may be set up in any environment that is relatively free from noise and vibration. A hemi-anechoic room is not required.

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 Configure the TL Test Rig as shown in Appendix B, Figure B1. Ensure that all microphones are flush mounted with the interior surface of the tube wall. Install the 20 in straight pipe in the test specimen position. Ensure the pipe ends are sealed and aligned.

4.3.2 Set up the data acquisition system (DAS) as follows:

- 1 Hz frequency resolution
- 4096 Hz maximum frequency
- 70 averages
- Four (4) channel data acquisition
- Hanning windows with 65% overlap
- Autopower spectra Channels 1, 2, 3 and 4
- Cross power spectra with references to Channels 1 and 3

4.3.3 Turn on high pass filter and power amplifier. The high pass filter cut off frequency should be set to 50 Hz. The power amplifier gain should be high enough to provide adequate dynamic range at the upstream and downstream microphones. Do not overdrive the system and avoid shock waves in the system (air pumping).

4.3.4 Verify the calibration of all four (4) microphones per GMW14172.

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4.3.5 Calculate the system correction factors by acquiring the necessary data described in 4.3.5.1 thru 4.3.5.4. See Appendix C for calculations for correction factors. Section 4.3.5.1 describes the microphone positions and data acquisition process to acquire the data to use with the calculations in Appendix C. Appendix B, Figure B1 shows the locations in which to insert the microphones. The autospectra and cross spectra are described for the location in which the microphones are located during the measurement. For example, in 4.3.5.1, G_{AA} refers to the autospectra for the microphone located in the A location in the test setup (see Appendix B) and G_{AB} refers to the cross spectra for the microphones located in the A and B locations in the test setup (see Appendix B).

4.3.5.1 Place microphones in the “swapped pairs” positions. Turn on noise generator, adjust level and autorange the microphone channels.

Swapped Pairs Positions.

Microphone 2 in location A/Microphone 1 in location B

Microphone 4 in location C/Microphone 3 in location C

Acquire autopower and cross power spectra and label as:

$$G_{22 \text{ swap}} = G_{AA}$$

$$G_{44 \text{ swap}} = G_{CC}$$

$$G_{21 \text{ swap}} = G_{AB}$$

$$G_{43 \text{ swap}} = G_{CD}$$

4.3.5.2 Place microphones in the “swapped up/down” positions. Turn on noise generator, adjust level and autorange the microphone channels.

Swapped Up/Down Positions.

Microphone 3 in location A/Microphone 2 in location B

Microphone 1 in location C/Microphone 4 in location D

Acquire autopower spectra and label as:

$$G_{11 \text{ updown}} = G_{CC}$$

$$G_{33 \text{ updown}} = G_{AA}$$

4.3.5.3 Place microphones in the standard positions. Turn on noise generator, adjust level and autorange the microphone channels.

Standard Positions.

Microphone 1 in location A/Microphone 2 in location B

Microphone 3 in location C/Microphone 4 in location D

Acquire autopower and cross power spectra and label as:

$$G_{11 \text{ standard}} = G_{AA}$$

$$G_{33 \text{ standard}} = G_{CC}$$

$$G_{21 \text{ standard}} = G_{BA}$$

$$G_{43 \text{ standard}} = G_{DC}$$

4.3.5.4 Compute the correction factors, C_{AB} , C_{CD} , C_T using the equations as described in Appendix C.

C_{AB} upstream correction factor

C_{CD} downstream correction factor

C_T element correction factor

Compare correction factors to the standard curves shown in Appendix D, Figure D1. If the computed correction factors do not match the reference curves in Appendix D, check for leaks, alignment, reflections, source levels that are too high, microphones not mounted flush with interior wall of duct, etc.

4.3.6 Measure the TL of the 20 in straight pipe and compare it to the TL in Appendix D, Figure D2. Place microphones in the standard test positions as described in 4.3.5.3 and autorange the microphone channels.

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4.3.6.1 Acquire autopower and cross power spectra.

$$G_{11} \text{ measured} = G_{AA}$$

$$G_{33} \text{ measured} = G_{CC}$$

$$G_{21} \text{ measured} = G_{BA}$$

$$G_{43} \text{ measured} = G_{DC}$$

4.3.6.2 Compute the TL as described in Appendix C. Compare the measured TL to the curve shown in Appendix D, Figure D2. The theoretical TL of a straight duct is 0 dB.

4.3.7 Measure the TL of an expansion chamber of known dimensions. Perform a system check by comparing results with the calculated TL. An example of the measured and predicted TL of an expansion chamber is shown in Appendix D, Figure D3. The equations used to calculate transmission loss using the geometry of the expansion can are given in Appendix D, Figure D4.

4.3.7.1 Install standard expansion chamber in the test stand. Ensure all connections are sealed.

Place microphones in the standard test positions and autorange the microphone channels.

4.3.7.2 Acquire autopower and cross power spectra.

$$G_{11} \text{ measured} = G_{AA}$$

$$G_{33} \text{ measured} = G_{CC}$$

$$G_{21} \text{ measured} = G_{BA}$$

$$G_{43} \text{ measured} = G_{DC}$$

4.3.7.3 Compute the TL as described in Appendix C. Compare the TL to the curve shown in Appendix D.

4.3.8 Measure the TL of a test specimen. Install test specimen in the test stand. Ensure all connections are sealed. Refer to Appendix A for information on fixtures and guidelines on how to set up fixture to measure specific test elements. Place microphones in the standard test positions.

Autorange the microphone channels.

4.3.8.1 Acquire autopower and cross power spectra.

$$G_{11} \text{ measured} = G_{AA}$$

$$G_{33} \text{ measured} = G_{CC}$$

$$G_{21} \text{ measured} = G_{BA}$$

$$G_{43} \text{ measured} = G_{DC}$$

4.3.8.2 Compute the TL as described in Appendix C. Refer to Appendix E for information on the valid/useful frequency range.

5 Data

5.1 Calculations. Refer to Appendix C for a list of calculations used in this procedure.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. Refer to Appendix F, Figure F1.

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.

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