



SURFACE VEHICLE STANDARD

J1400™

OCT2023

Issued 1982-05
Reaffirmed 1989-05
Revised 2023-10

Superseding J1400 JUL2017

Laboratory Measurement of the Airborne Sound Barrier Performance of Flat Materials and Assemblies

RATIONALE

The SAE J1400 technical report has transitioned from being an SAE Recommended Practice and is now classified as an SAE Standard. This updated version expands the measurement frequency range from 8000 to 10000 Hz and extends the control sample sound transmission loss values in Table 3 to 10000 Hz. Furthermore, the tolerance levels for pressure transducers measuring ambient conditions, as outlined in 3.6, have been tightened. Additionally, the legend in Figure C1 has been modified, and 4.3 has been paraphrased to enhance readability.

FOREWORD

This SAE Standard has been modified in response to user comments and to clarify some of the theoretical basis for the testing. The fundamental methodology of this procedure has not been changed from previous revisions.

INTRODUCTION

This document is intended to provide a means of measuring the sound transmission loss (STL) of materials. At each test frequency, the STL is determined based on the measured noise reduction (MNR) of the test specimen using a correlation factor (CF). The respective CF for the test condition is determined as the difference between the MNR of a homogeneous limp panel, such as mass loaded vinyl, and its theoretically calculated field-incidence STL. Note that the calculated STL is for a theoretical panel of infinite dimensions, and the intent is to remove the effect of different size test windows found in different labs, with consideration of low frequency limitations imposed by smaller openings. This SAE Standard then recognizes that many laboratories have measurement variances that can be corrected to a certain extent using this methodology.

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Documents

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1. SCOPE

This SAE Standard presents a test procedure for determining the airborne sound insulation performance of materials and composite layers of materials commonly found in mobility, industrial, and commercial products under conditions of representative size and sound incidence so as to allow better correlation with in-use sound insulator performance. The frequency range of interest is typically 100 to 10000 Hz 1/3-octave band center frequencies.

This test method is designed for testing flat samples with uniform cross section, although in some applications the methodology can be extended to evaluate formed parts, pass-throughs, or other assemblies to determine their acoustical properties. For non-flat parts or assemblies where transmitted sound varies strongly across the test sample surface, a more appropriate methodology would be ASTM E90 (with a reverberant receiving chamber) or ASTM E2249 (intensity method with an anechoic or hemi-anechoic receiving chamber).

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J184 Qualifying a Sound Data Acquisition System

Ebbitt, G. and Hansen, M. (2007). *Mass law—Calculations and measurements* (Paper no. 2007-01-2201. SAE International. <https://doi.org/10.4271/2007-01-2201>.

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ANSI S1.1 Acoustical Terminology

ANSI S1.4a Specification for Sound Level Meters

ANSI S1.40 Specification for Acoustical Calibrators

ANSI S1.11 Specification for Octave Band and Fractional Octave Band Filter Sets

ANSI S1.26 Method for Calculation of the Absorption of Sound by the Atmosphere

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM C423 Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

ASTM E90 Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions

ASTM E2249 Standard Test Method for Laboratory Measurement of Airborne Transmission Loss of Building Partitions and Elements Using Sound Intensity

2.1.4 Other Publications

Beranek, L.L. (1988). *Noise and vibration control* (Revised edition). Institute of Noise Control Engineering.

Beranek, L.L. and Vér, I.L. (2005). *Noise and vibration control engineering: Principles and applications* (Second edition). John Wiley & Sons.

Bohn, D.A. (1988). Environmental effects on the speed of sound. *Journal of the Audio Engineering Society*, 36(4), 223-231.

Moritz, C., Shaw, J., and Carrera, A. (2015). The influence of test fixture damping on the measurement of sound transmission loss. *The Journal of the Acoustical Society of America*, 137, 2215. <https://doi.org/10.1121/1.4920070>.

3. INSTRUMENTATION

Instrumentation to be used is as follows:

3.1 Sound Level Meter

A sound level meter that meets the Type 1 requirements of ANSI S1.4a is required. As an alternative to making direct measurements using a qualified sound level meter, a microphone, measuring amplifier, and a sound data acquisition system may be used, provided the system meets the requirements of SAE J184.

3.2 Filter Requirements

A third-octave filter set covering the range of center frequencies of interest. The filters shall meet the Class III requirements of ANSI S1.11.

3.3 Microphone Calibrator

A sound level calibrator that meets the Class 1 requirements of ANSI S1.40.

3.4 Source Room Speakers

An acoustical sound generating system shall be selected to generate random noise containing a continuous distribution of frequencies over each test band.

3.5 Instrumentation

A schematic diagram of the instrumentation is shown in Figure 1.

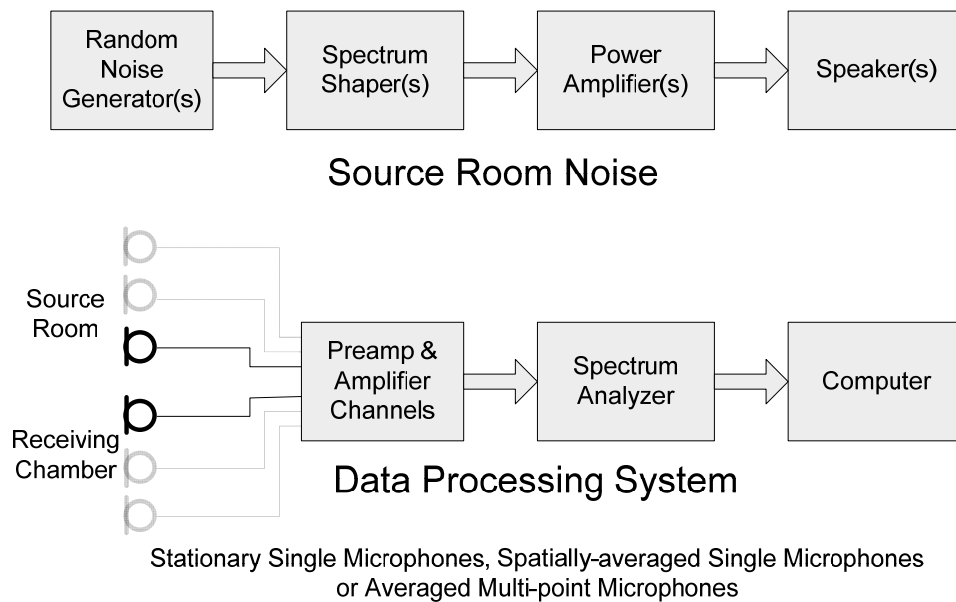


Figure 1 - Typical measurement system

3.6 Ambient Sensors

Temperature and humidity sensors should be used to monitor and record ambient test conditions in the source and receiving chambers, preferably in the vicinity of the sample mounting location.

Recommended accuracy of the sensors:

- ± 1 °C for temperature
- $\pm 3\%$ for relative humidity
- ± 5 kPa for barometric pressure

4. FACILITIES

A schematic diagram of a typical measurement facility is shown in Figure 2.

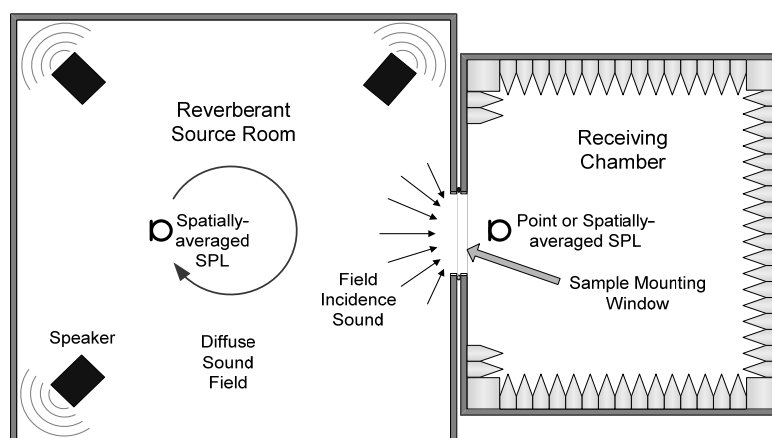


Figure 2 - Typical measurement facility

4.1 Layout of Chambers

Two adjacent chambers are located such that they share a common test window, into which test samples are mounted. The two chambers must be isolated from each other so that the only significant transmission path is through the sample window. Test windows are normally oriented in the vertical plane, but may also be oriented horizontally or even non-orthogonally to the vertical or horizontal planes.

4.2 Receiving Chamber

It is recommended that the receiving chamber be fully anechoic in order to minimize the influence of flanking paths and modal coupling between the chambers. However, good results can also be achieved with semi-anechoic or even reverberant receiving chamber designs if proper care is taken for isolation between the chambers, modal decoupling through the test window and spatial averaging of receiving chamber microphone(s).

4.3 Chamber Sizes

Source room volume is required to be at least 50 m³ (1765 ft³), with approximately 200 m³ (7100 ft³) being the recommended volume. Table 1 shows low frequency cutoff for various room sizes. However, rooms smaller than those specified in Table 1 may be usable if measured diffusion criteria are met. In order to meet the criteria, ideally, room/chamber sizes should be established based on the presence of at least 20 natural frequency modes within the lowest 1/3-octave frequency band of interest for good diffusion of sound. For rectilinear design, room proportions of 1:2^{1/3}:4^{1/3}, or 1:1.26:1.59, are also recommended for good diffusion and modal separation.. Appendix X1 of ASTM E90 suggests some alternate volume criteria based on a smaller number of resonant modes in each 1/3-octave band. Reverberant receiving chamber proportions should be the same; but sized at least 10% smaller or larger in interior volume to avoid natural frequencies which coincide with the source room. It is also advisable to keep reverberant receiving chamber boundaries and sound absorber elements at least 1/4-wavelength from the sample test window. It is possible to do a test using the methodology of SAE J1400 using a small reverberation chamber as a source room, but this will increase the low frequency cutoff for valid test results.

4.4 Source Room Lower Cutoff Frequency and Diffusion

To qualify a test chamber once it has been built or whenever changes are made to the chamber which may affect diffusion, it is recommended that the population standard deviation of twenty randomly located sound pressure measurements in the source room be no more than 2 dB at the 1/3-octave center frequency which is one octave higher than the low frequency cutoff and above (for example, 200 Hz and above for a room with 100 Hz low frequency cutoff), with a representative test sample mounted in the test window. Microphones should be spaced at least 1/4-wavelength from each other, from diffusers and from any room boundaries at the lowest measurement frequency. Diffusion in the reverberation source room can be enhanced by the use of rotating or stationary diffusers. Note that excessively large reverberant source rooms may not exhibit diffuse field characteristics at high frequencies due to air absorption. Refer to Section 7 of ASTM C423 for guidance on reverberation room design. Refer to Annex A3 and Appendix X1 of ASTM C423 regarding room qualification and the use of diffusers to reduce the variability of sound pressure levels within the source room. See 4.9 regarding proper location and orientation of source room speaker(s).

NOTE: ASTM C423 and ASTM E90 procedures specify 5000 Hz as the highest 1/3-octave band. In order to measure accurately at higher frequencies, diffusion at these higher frequencies must be adequate. It is reasonable to extend the 5000 Hz values in Table A3.1 of ASTM C423 to higher frequencies for the purposes of room qualification. Ambient conditions (temperature and relative humidity) in the source room must be controlled to minimize air absorption—refer to Section 6 of ASTM C423 and ANSI S1.26.