



# SURFACE VEHICLE RECOMMENDED PRACTICE

**SAE**

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## Laboratory Measurement of the Acoustical Performance of Body Cavity Filler Materials

### RATIONALE

Increased use of cavity filler materials on rockers, pillars, posts and other cavities has resulted in the need to develop a standardized procedure for rank ordering the performance of these materials in a controlled environment in the laboratory using a channel that simulates the application.

#### 1. SCOPE

This SAE Recommended Practice describes a laboratory test procedure for measuring the acoustical performance of a system consisting of a body cavity filler material formed into a rectangular cross-section channel. Materials for this test may include both heat reactive and chemically reactive products, with or without a shelf to simulate a baffle in an application, or a combination of body cavity filler and aluminum foil to enhance the performance. These materials are commonly installed in transportation systems such as ground vehicles, and thus reduce the noise propagation through the rails, rockers, and pillar/posts.

This document is intended to rank order the acoustical performance of materials for application on channels using general automotive steel, such that the effects of sealing of pinch welds in addition to the material could be easily evaluated. However, the channel is not an actual part (i.e., real life section) of the vehicle, and therefore results obtained from this study will have to be carefully interpreted considering limitations of section size/shape and full sealing (or not) of the section.

The acoustical performance is expressed in terms of insertion loss (IL) which is described in Section 3 Test Method. The test procedure described here is based on the method described in SAE J1400. However, this document differs from the SAE J1400 method in that the J1400 measures sound transmission loss, and this document measures IL of body cavity materials in a cavity.

This document covers the useful frequency range of interest in 1/3 octave band center frequencies. The lower limit of the actual frequency range is limited by the size of the channel and/or the volume of the reverberation room. Two rectangular cross-section channels are cited in this standard. These are 75 mm x 75 mm and 150 mm x 150 mm in cross-section and provide valid data at and above 800 Hz and 400 Hz 1/3 octave band frequencies, respectively, provided the reverberation room can generate diffuse sound field at those frequencies.

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## 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 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE TSB 003 Rules for SAE Use of SI (Metric) Units

SAE J184 Qualifying a Sound Data Acquisition System

SAE J1400 Laboratory Measurement of the Airborne Sound Barrier Performance of Automotive Materials and Assemblies

#### 2.1.2 ANSI PUBLICATIONS

Available from American National Standards Institute, 25 West 43<sup>rd</sup> Street, New York, NY 10036-8002, Tel: 212-642-4900, [www.ansi.org](http://www.ansi.org).

ANSI S 1.1 Acoustical Terminology

ANSI S 1.4 Specifications for Sound Level Meters

ANSI S1.40 Specifications for Acoustical Calibrators

ANSI S 1.11 Specification for Octave Band and Fractional Octave Band Filter Sets

## 3. TEST METHOD

The method is based on evaluating the performance in terms of Insertion Loss (IL). The term, IL in this case is the difference in sound pressure levels at a receiving location resulting from insertion of the sound insulating structure in a hollow cavity (channel) (Figure 1). The sound insulating structure in this case is the body cavity filler material. The concept of IL measurement assumes that the sound pressure level produced by the source is the same for both the "Before" and "After" test conditions. Both unfilled (bare) and filled channels need to be tested. The IL performance is expressed as:

$$IL = SPL_1 - SPL_2 \quad (\text{Eq. 1})$$

where:

SPL = Sound pressure level, dB

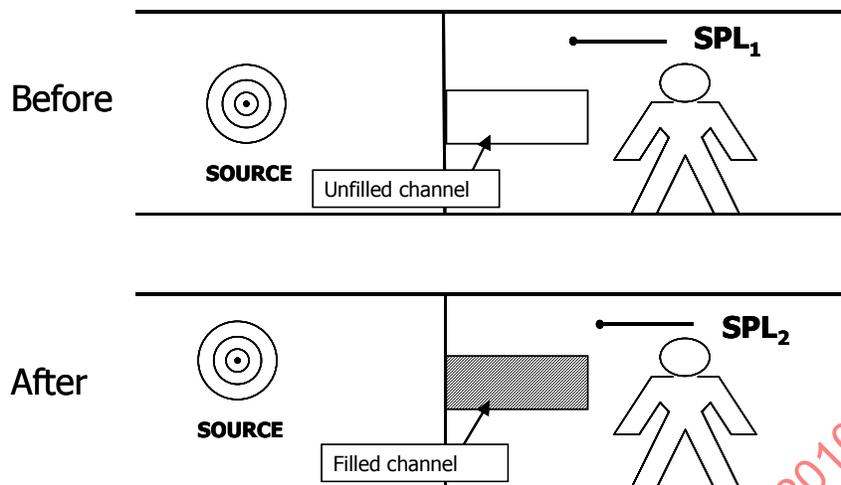
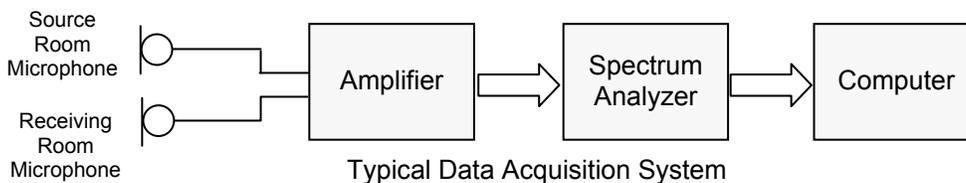
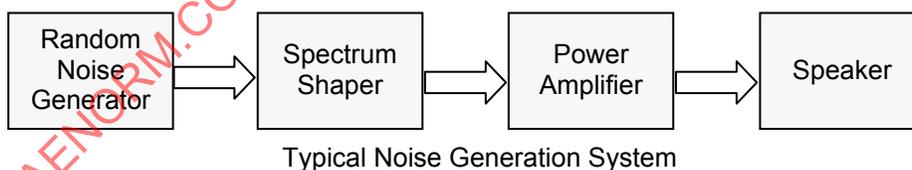


FIGURE 1 - INSERTION LOSS SCHEMATIC

#### 4. INSTRUMENTATION

The instrumentation to be used is as follows:

- 4.1 A microphone, measuring amplifier, and a sound data acquisition system which meets the requirements of SAE J184, or a sound level meter meeting Type I requirements of ANSI S 1.4 shall be used.
- 4.2 A one-third-octave band filter set covering the range of center frequencies from 100 to 10 000 Hz; the filters shall meet the Class III requirements of ANSI S 1.11.
- 4.3 A sound level calibrator that meets the Class 1 requirements of ANSI 1.40 and is accurate to  $\pm 0.5$  dB.
- 4.4 An acoustical sound generating system shall be selected to *generate random noise containing a continuous distribution of frequencies over the range of interest.*
- 4.5 A schematic diagram of the instrumentation is shown in Figure 2.



Stationary Single Microphones, Spatially-averaged Single  
Microphones or Averaged Multi-point Microphones

FIGURE 2 - TYPICAL MEASUREMENT SYSTEM

## 5. TEST FACILITY

The facility needed for this study is generally the same as that for the sound transmission loss test as discussed in the SAE J1400 test procedure. This includes a reverberation room that is used as the source room and an anechoic, a hemi-anechoic, or a quiet room that is used as the receiving room with a test window in between to mount the channel. The test window is typically vertical. It is recommended that the receiving room be anechoic in order to minimize the influence of flanking paths and modal coupling between the two rooms. Refer to the SAE J1400 standard for the details of the room including criteria to eliminate flanking paths. A schematic diagram of a typical measurement facility is shown in Figure 3.

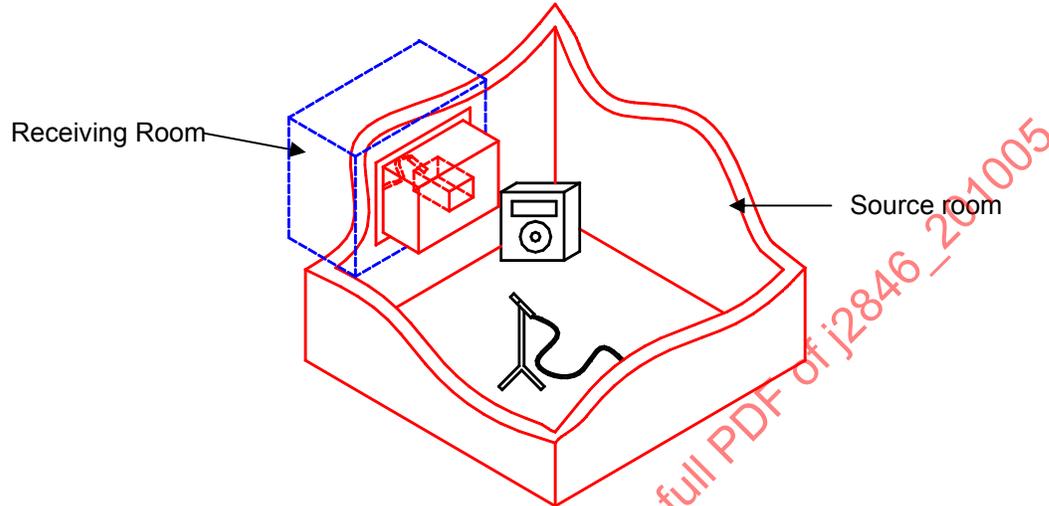


FIGURE 3 - A SCHEMATIC OF THE TYPICAL TEST FACILITY

## 6. TEST SET-UP/METHOD

The test set-up to be used is as follows:

- 6.1 The size of the channel and the environment of the test chamber is critical to the test results. The rockers, pillars, and posts in an application are all different. It is recommended to use rectangular cross-sectional channels with pinch welds for simplicity but still to provide some simulation of actual applications. The most common test channel to be used is of 75 mm x 75 mm in cross-section and 250 mm in length. However, in many applications, such as the sail panel, or D-Pillar, larger size channels may be required. Therefore, for such applications, a channel of 150 mm x 150 mm in cross-section and 250 mm in length should be used. The most common material for constructing the channels is 0.8 mm thick (20 gauge thick) cold rolled steel. Figure 4 shows an orthographic schematic of the channel, including mounting attachments (straps) to mount to a fixture.

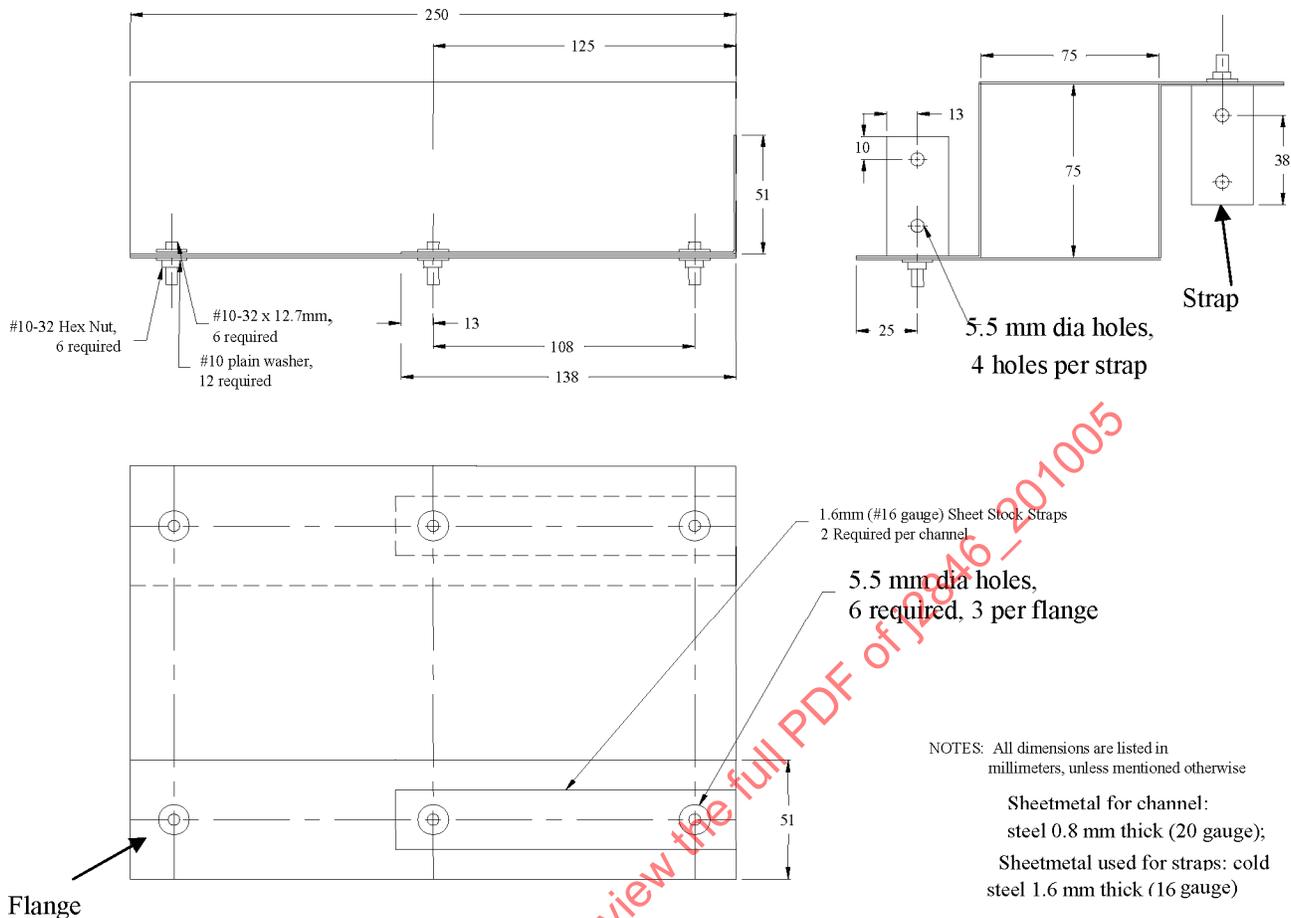


FIGURE 4 - ORTHOGRAPHIC SCHEMATIC OF THE CHANNEL

- 6.2 The largest size of the opening of the channel (i.e., the diagonal) based on one-quarter of the wavelength of sound, establishes the low frequency limit below which measurements cannot be made reliably (Table 1 in SAE J1400 standard). Above this frequency sound will propagate freely through the opening. The 75 mm x 75 mm cross-section channel has a useful frequency range starting from 800 Hz 1/3 octave band frequency and up based on the diagonal of the opening of the channel. At frequencies lower than 800 Hz, the results are affected by the fundamental resonance of the channel and although the results may still be useful, the reliability may be questionable, and therefore, it is recommended to use results above the useful frequency. The useful low frequency of the 150 mm x 150 mm channel, based on the diagonal of the opening of the channel, is 400 Hz 1/3 octave band frequency.
- 6.3 The channel is generally mounted on a plate that is placed in the opening between the source room and the receiving room. The channel can be extended toward the source room or the receiving room. Figures 5 and 6 show schematics of the channel extended toward the source room and toward the receiving room, respectively.

Extreme care needs to be taken when the channel extends in to the source room so that sound incident only on the opening of the channel is considered for the measurement. Likewise, care needs to be taken so that sound does not flank through the plate for a channel extended toward the receiving room. In order to ensure this, for a channel extended toward the source room, a special test fixture may have to be constructed (the plate to which the channel is mounted, could be used as part of the fixture) such that the anticipated insertion loss of the highest performing test channel is at least 10 dB greater than that of the same channel without any special test fixture. The fixture could be a massive box with a removable plate toward the source room and a fixed plate toward the receiving room as shown in Figure 5. The fixture walls need to have a minimum acoustical performance of equivalent to a homogeneous barrier of 40 kg/m<sup>2</sup>. Any open space inside the fixture should be filled with absorption materials to improve the effective acoustical performance of the fixture. For a channel extended toward the receiving room, the plate to which the channel is mounted also needs to have a performance comparable to that of a 40 kg/m<sup>2</sup> single layer barrier (Figure 6). In both cases the plates need to have openings at the center, of the cross-sectional area large enough such that the channel will be flush with the plate facing the source room. The channel should be sealed within the plate with ancillary shielding or seals to help ensure a minimum of sound flanking the test sample (Figure 7).

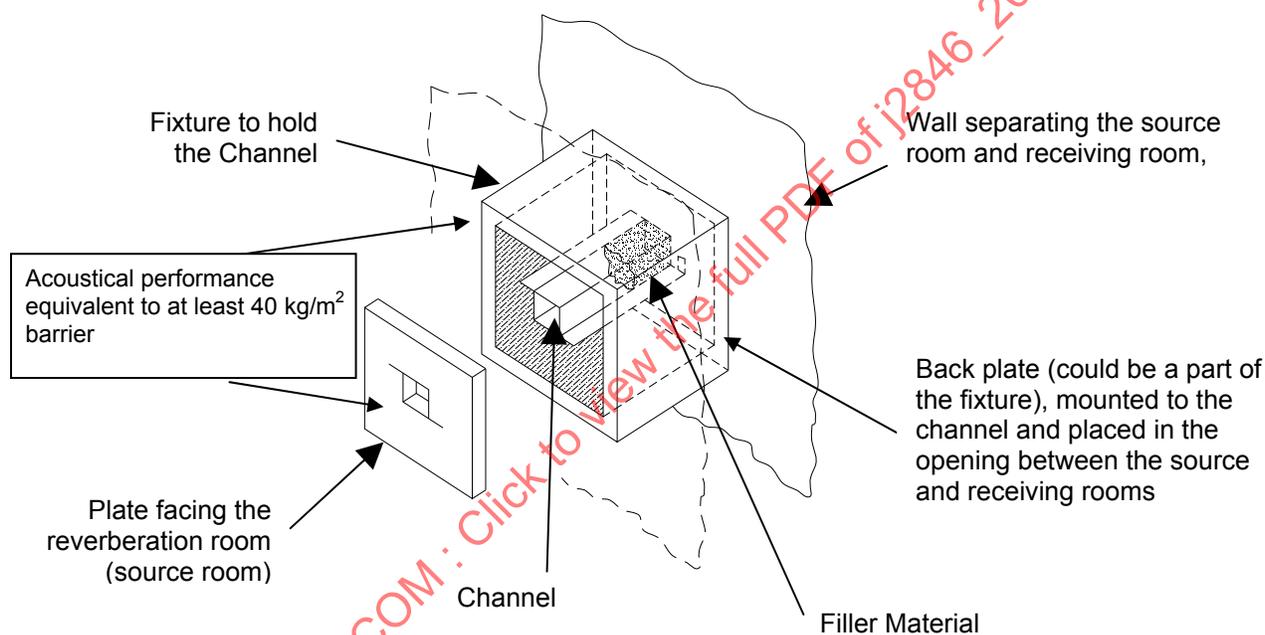


FIGURE 5 - SCHEMATIC OF THE TEST SET-UP WHERE THE CHANNEL IS EXTENDED TOWARD THE SOURCE ROOM

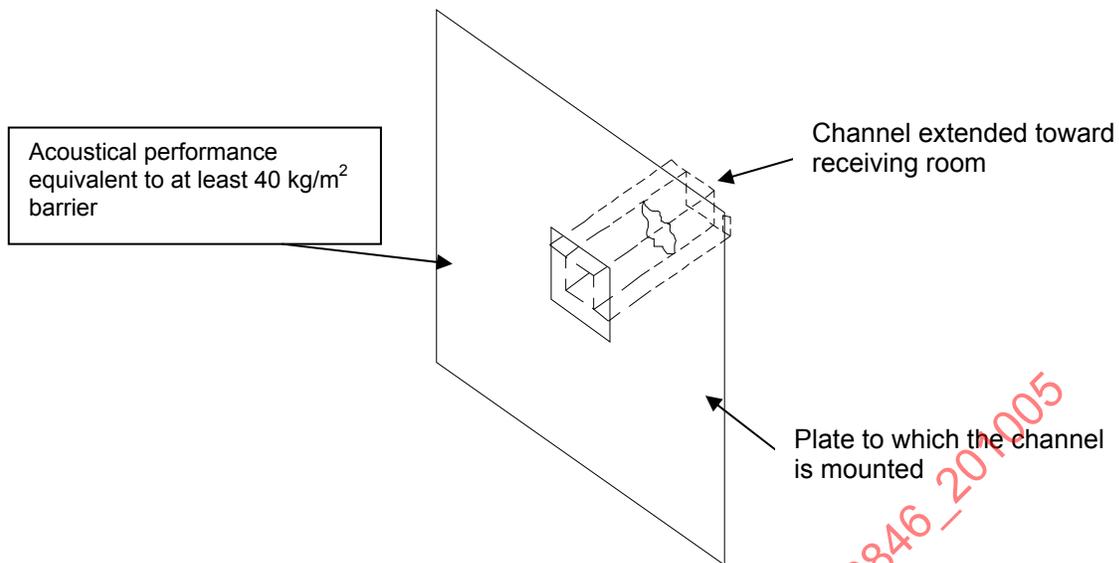


FIGURE 6 - SCHEMATIC OF THE TEST SET-UP WHERE THE CHANNEL IS EXTENDED TOWARD THE RECEIVING ROOM



FIGURE 7 - ILLUSTRATION OF SEALING ON THE FRONT PLATE TO MINIMIZE SOUND FLANKING

- 6.4 The test samples should be prepared in such a way that the filler material is flush as much as possible at one end of the channel and this end of the channel should face the receiving room. It should be noted that although the material is made to be flush to one end of the channel (this can be attained by using a plate or some other constraining surface that can be either left there should the application require, e.g., a carrier, or removed after the sample is prepared), it is made to expand toward the other end freely.
- 6.5 The receiving room microphone should be 100 mm away from the end of the channel at the centerline of the channel longitudinal axis, facing the test sample (this is also the vertical plane where the filler material is flush to the end of the channel) (Figure 8).

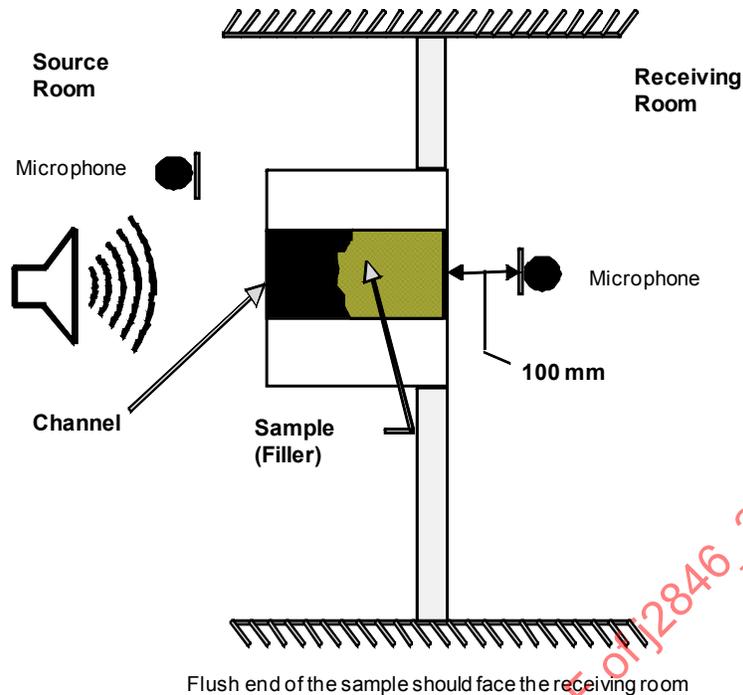


FIGURE 8 - SCHEMATIC OF THE TEST SET-UP (THIS FIGURE SHOWS THAT THE CHANNEL IS EXTENDED TOWARD THE SOURCE ROOM)

## 7. PROCEDURE

### 7.1 Sample Conditioning

Although it is not required, it is encouraged to condition the test samples for at least 12 hours at the same temperature and humidity as the test rooms. The source and receiving room temperatures should be controlled to  $22\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ . Relative humidity should be controlled for both chambers at 40 to 70%.

### 7.2 Measurements

Background noise levels within both the source and receiving rooms shall be measured and noted in all measurement bands. It is recommended that the source signal be filtered or shaped so that with the test sample sealed in place, the source room and receiving room signal levels are each at least 15 dB higher than the background noise levels in the respective rooms for the same gain settings and within the dynamic range capability of the measurement system at all 1/3 octave band frequencies of interest.

7.2.1 Install the unfilled (bare) channel in the test fixture.

7.2.2 The time and space averaged one-third octave band sound pressure level in the source room and the corresponding sound pressure level at a single microphone location in the receiving room shall be measured and recorded over the desired measurement frequency range with the bare channel sealed into the fixture in the test opening. The total averaging time of the sound level data acquired shall be at least 30 seconds.

7.2.3 After removing the bare channel, the test channel with the body cavity filler material in place (i.e., the filled channel) is installed and sealed into the same opening and the measurements of 7.2.2 are repeated.