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Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings[1]

This standard is issued under the fixed designation E336; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

This test method is part of a set of standards for evaluating the sound-insulating properties of building elements. It is designed to measure the sound isolation between two rooms or to estimate lower limits for sound transmission through a partition element installed as an interior part of a building. Others in the set cover the airborne sound transmission loss of an isolated partition element in a controlled laboratory environment (Test Method E90), the laboratory measurement of impact sound transmission through floors (Test Method E492), the measurement of impact sound transmission in buildings (Test Method E1007), the measurement of sound transmission through building facades and facade elements (Guide E966), the measurement of sound transmission through a common plenum between two rooms (Test Method E1414/E1414M), and measurement of the normalized insertion loss of doors (Test Method E2964).

1. Scope

1.1 The sound isolation between two spaces in a building is determined by a combination of the direct transmission through the nominally separating building element (as normally measured in a laboratory) and any transmission along a number of indirect paths, usually referred to as flanking paths. Fig. 1 illustrates the direct paths and some possible structural flanking paths. Additional non-structural flanking paths may include transmission through common air ducts between rooms, or doors to the corridor from adjacent rooms.

1.2 The main part of this test method defines procedures and metrics to assess the sound isolation between two rooms or portions thereof in a building separated by a common partition including both direct and flanking transmission paths or the apparent sound insulation of the separating partition. Appropriate measures and their single number ratings are the noise reduction (NR) and noise isolation class (NIC), the normalized noise reduction (NNR) and normalized noise isolation class (NNIC), and the apparent transmission loss (ATL) and apparent sound transmission class (ASTC). With the exception of the ATL and ASTC under specified conditions, these procedures in the main part of the test method are only applicable when both room volumes are less than 150 m^3.

NOTE 1—The word "partition" in this test method includes all types of walls, floors, or any other boundaries separating two spaces. The boundaries may be permanent, operable, or movable.

1.3 The NR and NIC between two locations may always be measured and reported though conditions present will influence how measurements are made. Restrictions such as minimum room volume or dimensions or maximum room absorption are imposed for all other measures and ratings in this standard. Thus, conditions may exist that will not allow NNR (NNIC), ATL (ASTC) or FTL (FSTC) to be measured. Where a partition between rooms is composed of parts that are constructed differently, or contains an element such as a door, it is not possible to measure the ATL and ASTC of the individual elements or portions of the partition. To evaluate the field performance of a door less than 6 m^2 in area, use Test Method E2964.

1.4 Annex A1 provides methods to assess the sound transmission through a partition or partition element with the influence of flanking transmission reduced. These methods may be used when it must be demonstrated that a partition has achieved a specified minimum sound attenuation. The results are the field transmission loss (FTL) and field sound transmission class (FSTC).

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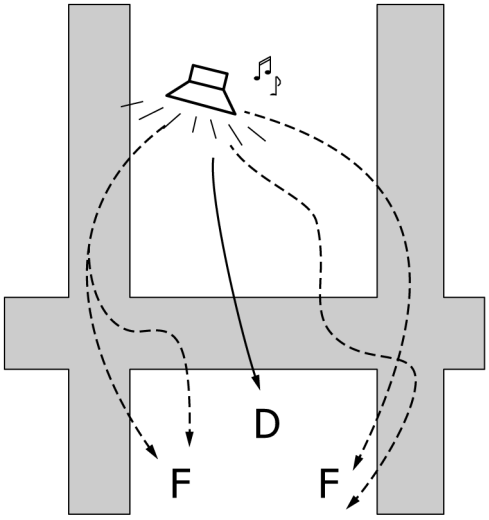

FIG. 1 Direct (D) and Some Indirect or Flanking Paths (F and Dotted) in a Building

1.5 Annex A2 provides methods to measure the sound isolation between portions of two rooms in a building separated by a common partition including both direct and flanking paths when at least one of the rooms has a volume of 150 m^3 or more. The results are the noise reduction (NR) and noise isolation class (NIC).

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 The text of this test method references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

1.8 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns, if any, 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C634 Terminology Relating to Building and Environmental Acoustics

E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

E413 Classification for Rating Sound Insulation

E492 Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine

E966 Guide for Field Measurements of Airborne Sound Attenuation of Building Facades and Facade Elements

E1007 Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures

E1414/E1414M Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum

E2235 Test Method for Determination of Decay Rates for Use in Sound Insulation Test Methods

E2964 Test Method for Measurement of the Normalized Insertion Loss of Doors

2.2 *ANSI Standards:*[3]

S1.10 Pressure Calibration of Laboratory Standard Pressure Microphones

S1.11 Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters

S1.40 Specification and Verification Procedures for Sound Calibrators

S1.43 Specifications for Integrating-Averaging Sound Level Meters

2.3 *IEC Standard:*[4]

IEC 60942 Electroacoustics–Sound Calibrators

IEC 61672 Electroacoustics–Sound Level Meters

2.4 *ISO Standard:*[5]

ISO 16283-1:2014 Acoustics -- Field measurement of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, ~~http://www.ansi.org.~~ http://www.ansi.org.

[4] Available from International Electrotechnical Commission (IEC), 3 rue de Varembé, Case postale 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

[5] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

3. Terminology

3.1 The following terms used in this test method have specific meanings that are defined in Terminology C634:

3.1.1 airborne sound; background noise; decay rate; decibel; diffuse sound field; field sound transmission class, FSTC; field transmission loss, FTL; flanking transmission; pink noise; receiving room; self-noise; sound absorption; sound attenuation; sound insulation; sound isolation; sound pressure level; sound transmission loss, TL; source room

NOTE 2—The unqualified term *average sound pressure level* in this document means that sound pressure levels were averaged over the measurement region for specified periods of time.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *apparent transmission loss, ATL (dB), n—of a partition installed in a building, in a specified frequency band* is operationally defined as:

$$ATL = \bar{L}_1 - \bar{L}_2 + 10\log\left(\frac{S}{A_2}\right) \quad (1)$$

where:

S = the area of the partition common to both source and receiving rooms, m^2
A_2 = the sound absorption in the receiving room, m^2
$\bar{L}_1$ = the source room average sound pressure level, dB and
$\bar{L}_2$ = the receiving room average sound pressure level resulting from the combined effect of direct and flanking transmission, dB.

3.2.1.1 *Discussion—*

Throughout this test method, log is taken to mean $\log_{10}$, unless otherwise indicated.

3.2.1.2 *Discussion—*

This definition attributes all the power transmitted into the receiving room, by direct and flanking paths, to the area of the partition common to both rooms. If flanking transmission is significant, the ATL will be less than the TL for the partition. Apparent transmission loss (ATL) is equivalent in meaning to apparent sound reduction index (ASRI) used by ISO 16283-1:2014.

3.2.2 *apparent sound transmission class, ASTC, n*—a single number rating obtained by applying the classification procedure of Classification E413 to apparent transmission loss data.

3.2.3 *coupled space, n*—a secondary space that is adjacent to and partially open to the primary space on the same side of the separating partition and which meets spatial and sound level distribution requirements sufficient to allow the secondary space to be included as part of the measurement space with the primary space.

3.2.3.1 *Discussion—*

Fig. 2 and Fig. 3 illustrate conditions that may be coupled spaces.

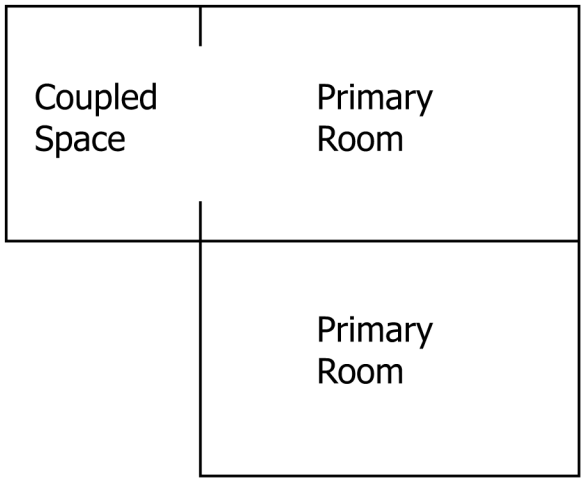

FIG. 2 Coupled Spaces Adjacent to a Primary Space

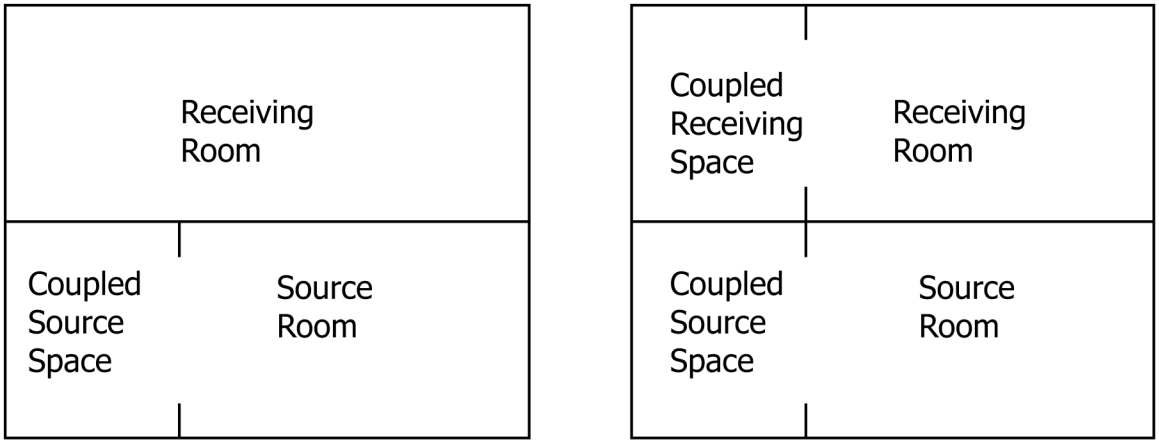

FIG. 3 Receiving Spaces Adjacent to a Coupled Source Space

3.2.3.2 *Discussion—*

To qualify as a coupled space in this standard the space must meet requirements specified in 9.4.1.

3.2.4 *direct transmission, n*—sound that travels between a source and a receiving room only through the common (separating) building element.

3.2.5 *noise reduction, NR, (dB), n—in a specified frequency band*, the difference between the sound pressure levels at two well-defined locations.

3.2.6 *noise isolation class, NIC, n*—a single-number rating calculated in accordance with Classification E413 using measured values of noise reduction.

3.2.7 *normalized noise reduction, NNR, (dB), n—between two rooms of less than 150 cubic meters, in a specified frequency band*, the value that the noise reduction, NR, in a given field test would have if the reverberation time in the receiving room were 0.5 s. NNR is calculated as follows:

$$NNR = NR + 10\log\left(\frac{T}{0.5}\right) \tag{2}$$

where:

NR = noise reduction, dB, and
T = reverberation time in receiving room, s.

3.2.7.1 *Discussion—*

The normalized noise reduction is intended to approximate the noise reduction that would exist between two ordinarily furnished rooms.

3.2.8 *normalized noise isolation class, NNIC (dB), n*—a single-number rating for noise isolation between two rooms both less than 150 cubic meters calculated in accordance with Classification E413 using measured values of normalized noise reduction. (See *normalized noise reduction*.)

4. Summary of Test Method

4.1 The source and receiving rooms are selected, the measurement spaces and volumes in each room are defined and the metrics to be measured are identified based on information given in Section 5 within the restrictions given in 11.3 and Annex A2.

4.2 The number and location of sound sources are chosen, sound is produced in the source room and sound pressure levels are sampled spatially in the measurement spaces in both the source and receiving rooms.

4.3 Sound decay rates are measured as necessary depending on the result to be reported.

4.4 If a value for noise reduction is to be measured between rooms immediately adjacent to a common partition where either is 150 m^3 in volume or greater, the requirements and procedures of Annex A2 must be satisfied.

4.5 If values of NNR are to be reported, the requirements of 9.3 must be satisfied. If values of ATL are to be reported, the requirements of 9.4.1 must be satisfied and if ATL is to be reported for a partition between spaces where either is 150 cubic meters in volume or greater, the requirement of 9.4.1.2 must be satisfied.

4.6 If a value for the field transmission loss (FTL) is to be measured, the requirements and procedures of Annex A1 must be satisfied.

4.7 Results and single number ratings are calculated and reported.

5. Significance and Use

5.1 The main part of this standard uses procedures originally developed for laboratory measurements of the transmission loss of partitions. These procedures assume that the rooms in which the measurements are made have a sound field that reasonably approximates a diffuse field. Sound pressure levels in such rooms are reasonably uniform throughout the room and average levels vary inversely with the logarithm of the room sound absorption. Not all rooms will satisfy these conditions. Practical experience and controlled studies (**1**)[6] have shown that the test method is applicable to smaller spaces normally used for work or living, such as rooms in multi-family dwellings, hotel guest rooms, meeting rooms, and offices with volumes less than 150 cubic meters. The measures appropriate for such spaces are NR, NNR, and ATL. The corresponding single number ratings are NIC, NNIC and ASTC. The ATL and ASTC may be measured between larger spaces that meet a limitation on absorption in the spaces to provide uniform sound distribution.

5.2 Annex A2 was developed for use in spaces that are very large (volume of 150 m^3 or greater). Sound pressure levels during testing can vary markedly across large rooms so that the degree of isolation can vary strongly with distance from the common (separating) partition. This procedure evaluates the isolation observed near the partition. The appropriate measure is NR, and the appropriate single number rating is NIC.

5.3 It is sometimes necessary to demonstrate that the sound insulation of a partition meets or exceeds a specific criterion. Annex A1 provides additional requirements, and describes how shielding procedures can be used to reduce flanking transmission in stages to show that a partition has achieved a minimum value of the FTL or minimum value of the FSTC which may meet or exceed the criterion. If it is demonstrated that no significant flanking exists through shielding of all potential flanking paths, then, and only then, FTL and FSTC may be reported without qualification.

NOTE 3—Measuring the sound transmission loss properties of a partition itself to demonstrate that it meets or exceeds a specific criterion is very difficult in the field due to the presence of flanking (**2, 3**). Room volume and absorption requirements must also be met.

5.4 Several metrics are available for specific uses. Some evaluate the overall sound isolation between spaces including the effect of absorption in the receiving space and some evaluate the performance or apparent performance of the partition being evaluated. The results obtained are applicable only to the specific location tested.

5.4.1 *Noise Reduction (NR) and Noise Isolation Class (NIC)*—Describe the sound isolation found between the two spaces under consideration. Noise reduction data are based on the space- and time averaged sound pressure levels meeting the requirements of 11.3 or A2.3 as required depending on the sound absorption, volume, and shape requirements of 9.2. Noise reduction values are influenced by the absorption in the receiving space as well as the apparent performance of the partition. The noise reduction values in unfurnished spaces will usually be less than in furnished spaces, and noise reduction values between the spaces may differ depending on the test direction used and the sound absorption in the spaces. However, these effects are lessened when the method of Annex A2 is used.

5.4.2 *Normalized Noise Reduction (NNR) and Normalized Noise Isolation Class (NNIC)*—Describe the sound isolation between two residential or office spaces meeting the requirements of 9.3.1 adjusted to standardized room conditions typical of such spaces when normally furnished.

5.4.3 *Apparent Transmission Loss (ATL) and Apparent Sound Transmission Class (ASTC)*—Describe the apparent sound insulation of a partition separating two spaces. All sound transmission, including any flanking transmission, is ascribed to the partition. The actual transmission loss of the partition will usually be higher than the apparent transmission loss. These results are in theory the same in each direction but may differ with direction in practice.

5.4.4 *Field Transmission Loss (FTL) and Field Sound Transmission Class (FSTC)*—These results should theoretically approach the actual sound insulation of a partition or partition element as would be measured in a laboratory, but in practice they often do not. These values may be reported only if the stringent requirements of Annex A1 to reduce flanking transmission are met. Since all flanking is removed to obtain these metrics, they do not reflect the sound attenuation experienced by the occupants when flanking transmission is significant. These results are in theory the same in each direction but may differ with direction in practice.

NOTE 4—Since the metric ASTC includes the effect of direct and flanking transmission, the ASTC will be less than or equal to the FSTC. The difference depends on the magnitude of the flanking transmission. Thus, the ASTC can be used to demonstrate that a partition at least meets an FSTC requirement and may exceed it. If ASTC is measured under conditions that do not satisfy the more stringent requirements in Annex A1, this may introduce other variations.

6. Test Equipment

6.1 *Sound Sources and Signals*—Sound sources shall be loudspeaker systems driven by power amplifiers. The input signal to the amplifiers shall be random noise containing an approximately continuous distribution of frequencies over each test band. White or pink electronic noise sources satisfy this condition.

[6] The boldface numbers in parentheses refer to the list of references at the end of this standard.

NOTE 5—Ideally, loudspeaker systems should be omnidirectional. In practice, using multiple driver elements to cover different frequency ranges and placing and aiming sources into trihedral corners of the room will normally be adequate.

6.1.1 The sound power of the source(s) must be sufficient to raise the signal level in the receiving room far enough above background noise to meet the requirements of 11.8.

6.2 *Measuring Equipment*—Microphones, amplifiers, and electronic circuitry to process microphone signals and perform measurements shall satisfy the requirements of ANSI S1.43 or IEC 61672 for Type 1 integrating-averaging sound level meters, except that B and C weighting networks are not required.

6.2.1 Measurement quality microphones 13 mm or smaller in diameter and that are close to omnidirectional below 5000 Hz shall be used.

NOTE 6—If measurements are to be made above 5000 Hz, a diffuse-field (random-incidence) microphone or corrector is preferred.

6.2.1.1 If multiple microphones are used, they shall all be of the same make and model.

6.3 *Bandwidth and Filtering*—The measurement system filters or each test band, shall meet or exceed the specifications of ANSI S1.11 for one-third-octave band filter set, class 1 or better.

6.3.1 The minimum range of measurements shall be a series of contiguous one-third-octave bands with mid-band frequencies from 125 to 4000 Hz.

NOTE 7—It is desirable that the frequency range be extended to include at least the 100 and 5000-Hz bands.

6.4 *Calibrators*—The field calibrator used for sensitivity checks shall be an acoustic or electroacoustic calibrator meeting class 1 requirements of ANSI S1.40 or IEC 60942.

7. Calibration and Sensitivity Checks

7.1 A thorough calibration of acoustical instrumentation by a calibration laboratory at regular intervals is necessary to help assure that the equipment is operating within instrument standards and manufacturer's specifications. The appropriate calibration interval depends on several factors including the complexity of the instrument, frequency of use, frequency of field use and transportation, manufacturer recommendations, and history of reliability or problems as observed in prior calibrations.

NOTE 8—ANSI S1.10 provides more information on calibration.

7.2 If equipment is sensitive to line voltage variations, use a line-voltage regulator.

7.3 Perform sensitivity checks of the entire measuring setup (including the microphone, all cables, and instruments) with the same calibration equipment before and after the measurements. If the calibration values differ by more than 0.5 dB, the results are invalid and measurements shall be repeated.

8. Test Site Conditions

8.1 No building elements that separate and define the source and receiving rooms shall be modified by any temporary means to improve performance except when attempting to measure the field transmission loss in accordance with Annex A1. Any permanent modifications made after the beginning of testing shall be reported.

8.2 Flanking transmission in the structure will be present. No efforts to suppress such structural flanking transmission shall be made.

8.3 Major flanking due to doors or other openings into common areas adjacent to the source and receiving rooms may exist. Efforts to suppress such major flanking may be made only if the intent of the test is to evaluate the partition between rooms and structural flanking without the effects of such major flanking. Such efforts must be reported.

8.4 Coupled spaces may exist as part of a basic design where there are adjacent spaces that are partially divided but not separated by doors, or may be created by fully opening doors between adjacent spaces. Multiple coupled spaces may exist adjacent to a given primary space as shown in Fig. 4. Any coupled space included in measurements must be verified. For a space to be considered a coupled space for purposes of this standard, the following conditions must be met:

8.4.1 The opening between the primary and secondary spaces must be at least 33% of the total area of the partition separating the primary and secondary spaces.

8.4.2 Unless one or more of the dimensions of a secondary space is less than 1 m (such as spaces A1, A2, and B in Fig. 4), it must be demonstrated by measurement with the sound source operating that the difference between the space-averaged A-weighted overall sound level in the primary and secondary spaces (such as D and F in Fig. 4) is not more than 6 dB.

8.4.3 If either dimension of the secondary space in the plane of the opening between spaces is less than 1 m (such as space B in Fig. 4), the dimension perpendicular to that plane shall not be more than 1 m.

NOTE 9—A bay window, niche, or open shallow closet-like space of less than one meter depth (such ~~a~~as A1 and A2 in Fig. 4) are examples of spaces that could be coupled and considered part of the overall volume without measurements within them but with measurements approaching them.

NOTE 10—A corridor less than 1 m wide and extending away from the primary space for more than 1 m (such as space B in Fig. 4) would not be considered coupled and its volume would not be included as it would be impossible to measure within it.