Designation: E2964 – 21

Standard Test Method for Measurement of the Normalized Insertion Loss of Doors[1]

This standard is issued under the fixed designation E2964; 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.

INTRODUCTION

This test method is part of a set of standards for evaluating the sound-insulating properties of building elements and the sound isolation between spaces. It is designed to measure the field sound isolation performance of doors. Others in the set cover the airborne sound transmission loss of an isolated partition element in a controlled laboratory environment (Test Method E90), field measurements of the sound isolation between rooms in buildings (Test Method E336), 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), and the measurement of sound transmission through a common plenum between two rooms (Test Method E1414).

1. Scope

1.1 The sound insulation properties of a door are measured in a laboratory as the sound transmission loss in accordance with Test Method E90. Using those data, the single-number rating sound transmission class (STC) is assigned. In the field, the rooms on one or both sides of a partition containing a door are often either too small or too large and absorptive to allow the apparent transmission loss (ATL) of the partition-door assembly to be measured. Even if that is not the case, the result measured is the composite ATL of the partition including the door, and not that of the door itself. Test Method E336 states that it is impossible to measure the ATL of a portion of a partition such as a door according to the procedures of that standard. This test method provides a method of evaluating doors in the field using a normalized insertion loss with a resulting single-number rating door transmission class, DTC. This method is intended primarily for hinged personnel doors with latching mechanisms and is limited to door openings of area less than 6 m^2. The flanking effects of surrounding structure are reduced compared to Test Method E336 but not completely eliminated. In a laboratory environment, the DTC is close to or equal to the STC of the door, but in the field results less than the laboratory STC are to be expected due to flanking.

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

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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

E336 Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings

E413 Classification for Rating Sound Insulation

E492 Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies

[1] This test method is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

Current edition approved Aug. 1, 2021. Published September 2021. Originally approved in 2014. Last previous edition approved in 2019 as E2964 – 19. DOI: 10.1520/E2964-21.

[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.

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 Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum
E3091 Specification for Systems to Measure Sound Levels

2.2 *ANSI Standards:*[3]
S1.40-2006 Specifications and Verification Procedures for Sound Calibrators

2.3 *IEC Standards:*[4]
IEC 60942:2013 Electroacoustics–Sound calibrators

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

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; decibel; diffuse sound field; flanking transmission; pink noise; receiving room; sound absorption; sound attenuation; sound insulation; sound isolation; sound pressure level; sound transmission loss, TL; source room

NOTE 1—The unqualified term average sound pressure level in this document means that sound pressure levels were averaged for specified periods of time.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *apparent transmission loss, ATL, 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,
A_2 = the sound absorption in the receiving room,
$\bar{L}_1$ = the average sound pressure level in the source room, and
$\bar{L}_2$ = the average sound pressure level in the receiving room resulting from the combined effect of direct and flanking transmission.

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

3.2.3 *door transmission class, DTC, n*—a single-number rating obtained by applying the classification procedure of Classification E413 to normalized door insertion loss data.

3.2.4 *normalized door insertion loss, NDIL, n—of a door installed in a building in a specified frequency band* is operationally defined as

$$NDIL = \left(\bar{L}_{(rec\ open)} - \bar{L}_{(rec\ closed)}\right) + \left(\bar{L}_{(source\ closed)} - \bar{L}_{(source\ open)}\right) \quad (2)$$

when a sound source is operated on the source side of the door, where:

$\bar{L}_{(rec\ open)}$ = the average sound pressure level on the receiving side of the door with the door open,
$\bar{L}_{(rec\ closed)}$ = the average sound pressure level *due to the source* on the receiving side of the door with the door closed (the background-adjusted average level in the receiving room with the door closed),
$\bar{L}_{(source\ closed)}$ = the average sound pressure level on the source side of the door with the door closed, and
$\bar{L}_{(source\ open)}$ = the average sound pressure level on the source side of the door with the door open.

4. Summary of Test Method

4.1 The door and corresponding source and receiving rooms are selected.

4.2 The number and location of sound sources are chosen, sound is produced in the source room, and sound pressure levels are measured on each side of the door with both open and closed door conditions using either a fixed microphone or scanning method.

4.3 The background sound is measured in the receiving room with the source(s) off and the door closed.

4.4 Results and single-number ratings are calculated and reported.

5. Significance and Use

5.1 This standard provides a method for testing the apparent sound insulating properties of doors in the field originally proposed by Morin (**1**).[6] This allows doors to be evaluated with a result that has been found to be similar to the transmission loss.

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

[4] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, P.O. Box 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.

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

5.2 The results of this measurement are the normalized door insertion loss, NDIL, at individual frequencies, and the single-number rating door transmission class, DTC. The insertion loss is normalized by the small change in sound level which occurs on the source side when the door is opened and closed. The results are in theory the same when measured in each direction through the door, but differences have been observed in practice.

5.3 Comparative measurements using this method and the method of Test Method E90 on the same door installations in a laboratory indicate good agreement between the transmission loss and normalized door insertion loss when the door is in a wall between two rooms and flanking is not significant. No similar verification has been done for corridors. See Appendix X1 and Ref (**2**).

5.4 The fixed-microphone and scanning methods have been compared in the field. See Appendix X2.

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.

NOTE 2—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 with the door closed far enough above background noise to meet the requirements of 11.8.

6.2 *Measuring Equipment*—Microphones, amplifiers, filters, and electronic circuitry to process microphone signals and perform measurements shall satisfy the requirements of Section 5 and either Section 6 or Sections 7.1 to 7.4 of Specification E3091.

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 3—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 *Calibrators*—The field calibrator used for sensitivity checks shall be an acoustic or electroacoustic calibrator meeting class 1 requirements of ANSI S1.40-2006 or IEC 60942:2013.

6.4 Devices used to establish the microphone positions shown in Fig. 1 and Fig. 2 shall be capable of being read to the nearest millimeter.

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 4—Specification E3091 provides more information on calibration.

7.2 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 and Door Conditions

8.1 The test specimen shall be a door including seals and frame that must for this test be installed in a partition that separates the source and receiving rooms.

8.2 Particular attention shall be given to identifying potential flanking paths not only through the surrounding partition but also through ducts or through plenums over acoustical ceilings before conducting testing. Report any temporary improvements made to reduce flanking influence.

NOTE 5—While this method is designed to reduce the influence of flanking, significant flanking in the partition around the door or by other paths could influence results. A surrounding partition with a high apparent transmission class will reduce influence of the partition on results. A way to investigate the effect of flanking is to construct a cover over the source side of the door and repeat the measurements of the receive side level with the door closed. A suitable cover is a layer of gypsum spaced approximately 100 mm from the door with sound absorptive material in that cavity and the edges sealed. If the measured sound level on the receive side with the source operating after doing this is not significantly reduced, then that sound level is being controlled by either the background sound or flanking.

8.3 Results will be influenced by the performance of the door seals. Care shall be taken to assure the door is properly closed with any latch present properly engaged when measurements are made on the receiving side with the door closed.

8.4 When the door is opened, it shall be opened as far as possible for each open-door measurement to reduce the influence of reflections from its surface.

9. Selection of Door Location and Direction of Measurement

9.1 If the door location or locations for testing within a building have not been specified by the party requesting the test, select a representative door location or a number of door locations to be examined.

NOTE 6—If the door has acoustical seals, the DTC rating can vary widely depending upon the individual adjustment of these seals. Thus, if multiple doors of a given design exist on a site, consider testing multiple doors or all doors. See 13.3.5.

9.2 Select the corridor or the smaller of the rooms as the source space unless there is a compelling reason to do otherwise (such as high background sound in what would be the receiving room). An outdoor space is acceptable as the receiving side, but an outdoor space shall not be used as the source space.