Designation: ~~E2964 – 19~~ 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 single number~~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 ~~actually~~ 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 ~~such cases~~the field using a normalized insertion loss with a resulting ~~single number~~ 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 ~~should be expected.~~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.*

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[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.

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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 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]

~~S1.4 Specification for Sound Level Meters~~

~~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~~S1.40-2006 ~~Specification~~Specifications and Verification Procedures for Sound Calibrators

2.3 *IEC Standards:*[4]

~~IEC 60804 Specification for Integrating-Averaging Sound Level Meters~~

IEC ~~60942~~60942:2013 Electroacoustics–Sound ~~Calibrators~~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; ~~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 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 source room average sound pressure level, and~~

$\bar{L}_1$ = the average sound pressure level in the source room, and

~~$\bar{L}_2$ = the receiving room average sound pressure level resulting from the combined effect of direct and flanking transmission.~~

$\bar{L}_2$ = the average sound pressure level in the receiving room resulting from the combined effect of direct and flanking transmission.

[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.

[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.

3.2.1.1 *Discussion—*
Throughout this test method, log is taken to mean log10,log_{10}, unless otherwise indicated.
3.2.1.2 *Discussion—*
This definition attributes all the power transmitted into the receiving room,room by direct and flanking paths,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 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

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

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

when a sound source is operated on the source side of the door.

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

$L_{(rec\ open)}$ = the average sound pressure level on the receiving side of the door with the door open,
$L_{(rec\ closed)}$ = the average sound pressure level *due to the source* on the receiving side of the door with the door closed,
$L_{(source\ closed)}$ = the average sound pressure level on the source side of the door with the door closed, and
$L_{(source\ open)}$ = the average sound pressure level on the source side of the door with the door open.

$\bar{L}_{(rec\ open)}$ = 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 the door 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 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.

5.2 The results of this measurement are the normalized door insertion loss, NDIL, at individual frequencies, and the single number 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.

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

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.~~ 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 ~~ANSI S1.4 for Type 1 sound level meters, except that B and C weighting networks are not required.~~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 *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 4—It is desirable that the frequency range be extended to include at least the 100 and 5000-Hz bands as this is required to calculate octave-band results. With modern-parallel measurement instruments, no extra work is required.~~

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~~S1.40-2006 or IEC ~~60942.~~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—~~ANSI S1.10~~Specification E3091 provides more information on calibration.

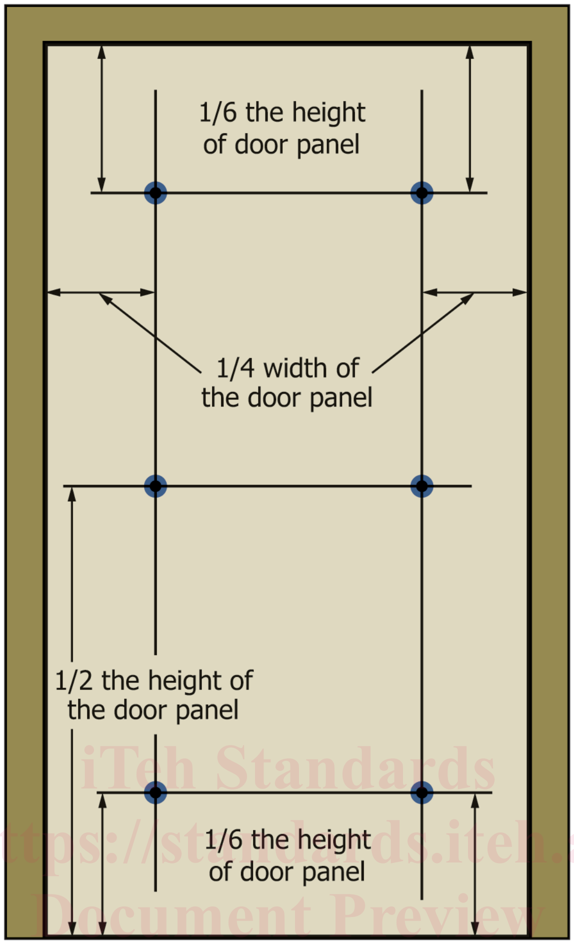

FIG. 1 ~~Microphone Locations for Opening~~ Elevation View of Microphone Positions for Openings of Width 1 m or Less ~~Wide~~

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 ~~will~~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 Flanking transmission in the structure adjacent to the door will be present.~~

8.2 ~~While this method is designed to minimize the influence of flanking, major flanking due to weakness of the partition in which the door is installed (or other paths) may influence results. If such is suspected, temporary improvements to the partition or other paths may be made. Such improvements shall be reported.~~ Particular attention shall be given to identifying potential flanking paths ~~that may be present through~~ not only through the surrounding partition but also through ducts or through plenums over acoustical ~~ceilings.~~ceilings before conducting testing. Report any temporary improvements made to reduce flanking influence.

NOTE 5—~~If it is desired to~~ 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, this might be done by constructing~~ flanking is to construct a cover over the source side of the door and ~~repeating~~repeat the measurements of the receive side level with the door closed. A suitable cover ~~could be~~ 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.

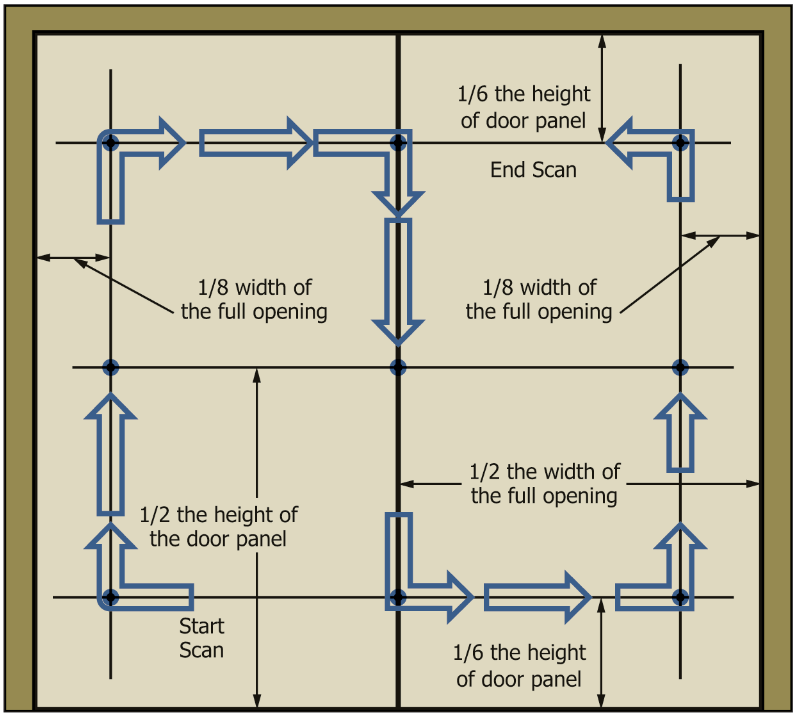

FIG. 2 ~~Microphone Locations for Opening More than One Meter Wide with Scan Pattern~~Elevation View of Microphone Positions and Scan Pattern for Openings More than 1 m Wide

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 ~~latched~~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~~ open-door measurement to ~~minimize~~reduce the influence of reflections from its surface.

9. Selection of Door ~~and Room Selection~~Location and Direction of Measurement

9.1 ~~When measurements are being made to evaluate the apparent sound insulation performance of a particular door, the door may be~~ If the door location or locations for testing within a building have not been specified by the party requesting the ~~test. In other cases it may be necessary to select a door or number of doors to be examined from among many. This method does not impose particular requirements on the test spaces except that it is desirable that the ATL of the partition into which the door is installed be significantly greater than that of the door. Thus, where partitions differ, it is desirable to select doors in partitions believed to have the highest transmission loss and least flanking transmission.~~test, select a representative door location or a number of door locations to be examined.

NOTE 6—~~Results from a single field test of a door should not be used to represent performance of similar or nominally identical doors.~~ 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 consideration should be given to testing all doors.~~site, consider testing multiple doors or all doors. See 13.3.5.

9.2 ~~In general for this method it is desirable to have the sound on the source side as diffuse as possible, and to have the space on the receiving side as large and absorptive as possible. Thus, the corridor or smaller room shall be used~~ Select the corridor or the smaller of the rooms as the source ~~space.~~ 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 ~~may be used~~ is acceptable as the receiving ~~side if background sound is not a problem,~~ side, but an outdoor space ~~may~~shall not be used as the source space.

9.3 Select door openings of area less than 6 m^2.

9.4 When possible, select doors that will open at least ~~90 degrees.~~90°.

9.5 When possible, locations shall be selected where the surfaces opposite the door surface are at least 3 m from the door surface. All partition surfaces opposite the closed door shall be at least 1.5 m from the door surface. This means for instance that corridors used as the source space must be at least 1.5 m wide. When surfaces opposite the door are curved or irregular, all points on such surface directly opposite the door must be at least 1.5 m from the door surface.

10. Sound Source Placement

10.1 *Location*—Where possible, place the loudspeakers at least 3 m and preferably 5 m from the door, but do not choose the larger room as the source room ~~for this reason.~~ just to get the loudspeakers more than 3 m from the door. If the loudspeakers are directional, aim them into corners most distant from the ~~door or~~ door, or for a corridor source room into the wall ~~of a corridor opposite~~on the opposite side of the corridor from the door, unless the room is so large that it is necessary to place the loudspeakers closer to the door or aimed at the door for adequate sound. Directional loudspeakers aimed at the door shall be at least 5 m from the door. Where possible in a corridor, place ~~speakers~~loudspeakers beyond the ends of the partition containing the door.

NOTE 7—Sound sources should be far enough away from the door that the direct field reaching the latter is ~~as small as possible compared to~~ significantly less than the reverberant field.

10.2 Multiple sources or repeated and averaged tests with sources at multiple locations are preferred but not required. If more than one source position is used, the distance between positions shall be at least 2 m. If more than one source is used simultaneously, they shall be driven by separate noise generators and amplifier channels so the outputs are uncorrelated.

11. Measurement of Average Sound Pressure Levels

11.1 The test method requires four measurements of average sound pressure levels over the ~~frequency range specified with~~ series of contiguous one-third-octave bands with mid-band frequencies from 125 to 4000 Hz with the source(s) operating in the source room. Two are in the source room and two in the receiving room, one of each with the door open and closed. An additional measurement is made in the receiving room with the door closed and the source off.

NOTE 8—It is desirable that the frequency range be extended to include at least the 100 and 5000-Hz bands as this is required to calculate octave-band results.

11.2 The ~~body of the operator may interfere with the sound field. To the extent possible, the operator should~~ operator shall avoid standing between the sound source(s) and measurement positions on the source side or between the door and measurement positions on the receive side. ~~Also where possible~~ Also, the operator ~~should avoid placing~~ shall avoid standing in a location that would place the microphone directly between the operator's body and the sound source on the source ~~side. Similarly, the operator should avoid placing the microphone~~ side, or directly between the operator's body and the door on the receive side.

11.3 *Microphone Positions*—The measurement positions shall be 1 m from the plane of the door on each side. The microphone diaphragm shall on each side of the door opening be parallel with the plane of the closed door panel ~~when in the closed position,~~ and pointed toward that plane. Either fixed microphone positions or a scanning method as described below ~~can~~shall be used. ~~These positions~~ The same positions or scan path shall also be used for background ~~level~~noise measurements.

11.3.1 *Fixed Positions*—Measurement with fixed positions is the preferred method.

11.3.1.1 If the opening is 1 m or less wide, six measurement positions shall be used on each side of the door as shown on the elevation view of a door in Fig. 1.

11.3.1.2 If the opening is more than 1 m wide, nine measurement positions shall be used on each side of the door as shown in Fig. 2, with three additional measurement points at the midpoint of the total door opening width.

11.3.1.3 Microphone position tolerance shall be ±12 mm ~~from the~~ in the direction perpendicular to the door surface. The lateral and vertical tolerances on the ~~locations~~positions shown in ~~Figs. 1 and 2~~Fig. 1 and Fig. 2 are ±50 mm.

NOTE 9—If using a single microphone to make ~~measurements the fastest way to do the measurements may be to make~~ measurements, consider making all measurements at a given height before proceeding to measurements at another height. Alternatively, a fixture with an easy method to move the microphone to the required heights ~~could be~~ is useful. If a door panel is more than 1 m wide, it will be necessary to move the microphones to open and close the door.