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

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ε[1] NOTE—Editorially corrected 6.3 in February 2017.

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 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 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 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.

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 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
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

[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] 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.

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

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 Specification and Verification Procedures for Sound Calibrators

2.3 *IEC Standards:*[4]
IEC 60804 Specification for Integrating-Averaging Sound Level Meters
IEC 60942 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; 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
$\bar{L}_2$ = the receiving room average sound pressure level resulting from the combined effect of direct and flanking transmission.

3.2.1.1 *Discussion*—Throughout this test method, log is taken to mean log10, 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

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

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

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.

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 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.

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. 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, 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.

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.

6.4 *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 5—ANSI S1.10 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 will be a door in a partition that separates the source and receiving rooms.

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

8.3 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 ducts or through plenums over acoustical ceilings.

NOTE 6—If it is desired to investigate the effect of flanking, this might be done by constructing a cover over the source side of the door and repeating the measurements of the receive side level with the door closed. A suitable cover could be a layer of gypsum spaced approximately 100 mm from the door with sound absorptive material in that cavity and the edges sealed.

8.4 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 when measurements are made on the receiving side with the door closed.

8.5 When the door is opened it shall be opened as far as possible for each open door measurement to minimize the influence of reflections from its surface.

9. Door and Room Selection

9.1 When measurements are being made to evaluate the apparent sound insulation performance of a particular door, the door may be 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.

NOTE 7—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.

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 as the source space. An outdoor space may be used as the receiving side if background sound is not a problem, but an outdoor space may 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.

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. If the loudspeakers are directional, aim them into corners most distant from the door or into the wall of a corridor opposite 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 beyond the ends of the partition containing the door.

NOTE 8—Sound sources should be far enough away from the door that the direct field reaching the latter is as small as possible compared to 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 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.

11.2 The body of the operator may interfere with the sound field. To the extent possible, the operator should 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 the operator should avoid placing the microphone directly between the operator's body and the sound source on the source side. Similarly, the operator should avoid placing the microphone 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 door panel when in the closed position, and pointed toward that plane. Either fixed microphone positions or a scanning method as described below can be used. These positions shall also be used for background level 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 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 door surface. The lateral and vertical tolerances on the locations shown in Figs. 1 and 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 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 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.

11.3.1.4 *Averaging Time*—When measuring sound pressure levels in all frequency bands simultaneously at fixed locations, the minimum averaging time shall be 10 s for measurements down to 125 Hz. If frequency bands are measured sequentially, the averaging time may be 5 s at 250 Hz and above. The minimum averaging time, T_a, at frequency f that is less than 250 Hz must be computed from:

$$T_a = \frac{1240}{f} \text{s} \tag{3}$$

NOTE 10—This provides 95 % confidence limits of ± 0.5 dB. For more information, see Ref (3).

11.3.1.5 *Determination of Space-Average Levels*—Use the following equation to obtain the average sound pressure level which is a space and time average level:

$$\bar{L} = 10 \log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{L_i/10}\right] \tag{4}$$

where:

L_i = the level measured at the ith microphone position and there are n locations.

11.3.2 *Scanning Method*—A manual scanning method can be used. The microphone shall be held well away from the operator's body (a boom serves to increase the distance). The microphone speed shall remain as constant as practical. Take care when moving the microphone or its cable, especially when measuring sound in the receiving room. The data can be contaminated by footstep sounds or extraneous signals due to inadvertent contact between the microphone or cable and the operator's body.

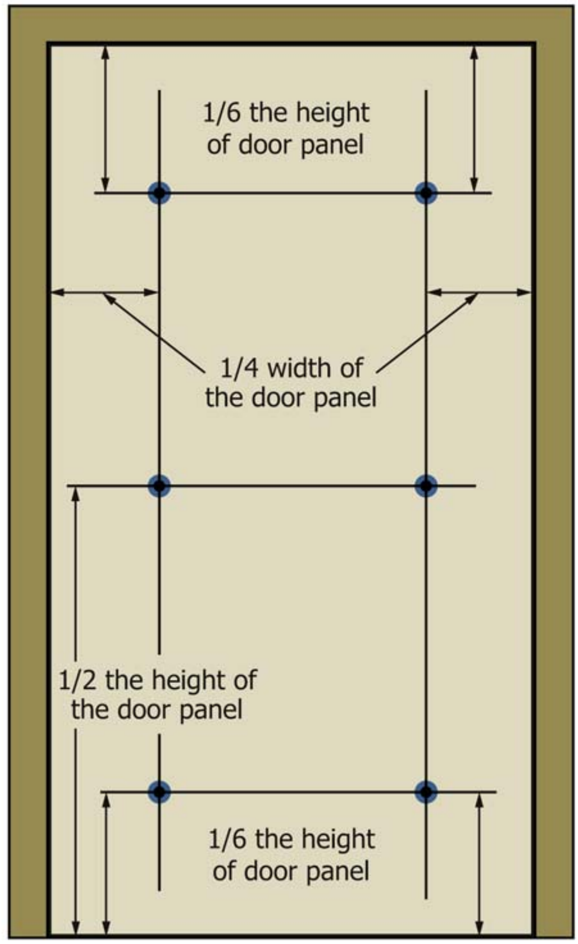

FIG. 1 Microphone Locations for Opening 1 m or Less Wide

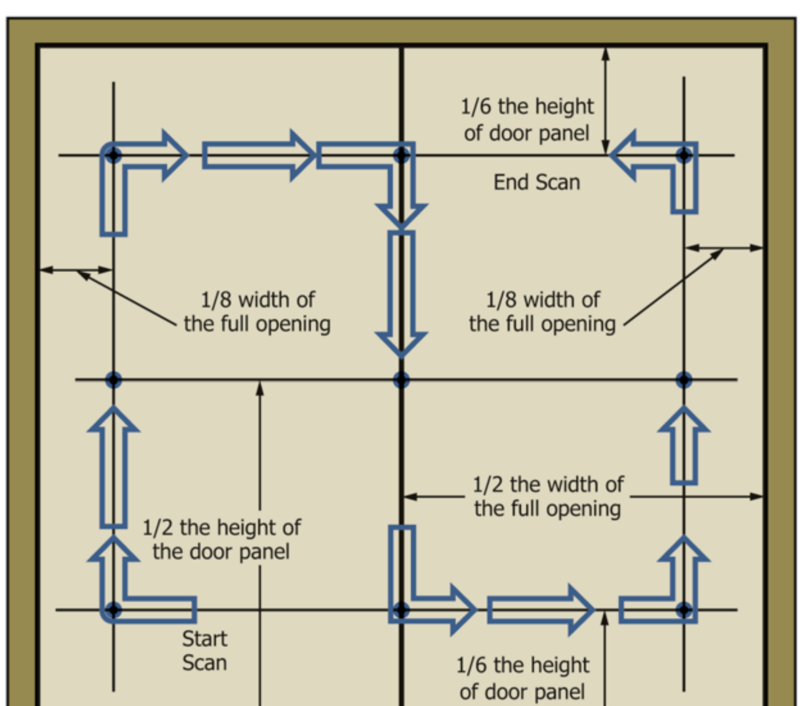

FIG. 2 Microphone Locations for Opening More than One Meter Wide with Scan Pattern

11.3.2.1 If the opening is 1 m or less wide, the scan shall follow a rectangular pattern passing through the six microphone positions shown in Fig. 1.

11.3.2.2 If the opening is more than 1 m wide, the scan shall follow the pattern shown on Fig. 2 passing through the nine identified microphone positions.

11.3.2.3 Scan time shall be at least 30 seconds.

NOTE 11—Before proceeding with a full set of measurements, consider making measurements at one location on the receiving side of the background sound and source level with the door closed, and of the source level with the door open to evaluate the adequacy of the source level and determine whether there are major problems with door seals that should be fixed before proceeding with the full measurement.

11.4 *Recording of Measured Levels*—Record all measured levels in dB accurate to one decimal place.

11.5 *Source Room Level*—With the sound source(s) operating at a constant level, measure the average sound pressure level at each frequency in the source room, with the door closed and then with the door open.

11.6 *Receiving Room Level*—With the sound source(s) operating at a constant level, measure the average sound pressure level at each frequency in the receiving room with the door open and then with the door closed.

11.6.1 When measurements are made in areas with fluctuating background noise, the operator shall listen to the noise in the receiving room during measurements of the receiving room level with the door closed. If any intermittent interfering sounds are heard during the measurements, the measurements must be repeated until no such sounds are heard during the collection period.

11.7 *Background Noise Level*—With the sound source(s) shut off, and door closed, measure the average sound pressure level at each frequency in the receiving room using the same measurement method (fixed or scanning) with the same microphone positions or scanning pattern and same instrument range setting used to measure receiving room levels. If fixed microphone positions are used then use a minimum averaging time of 20 s at each microphone position.

NOTE 12—A longer integration time is needed for the measurement of background noise since its level may vary significantly with time.

11.7.1 Compare the receiving room levels with the door closed and background noise levels. If at any frequency the background noise level is within 10 dB of the receiving room level, increase the source level if possible to achieve at least a 10 dB difference at each frequency and repeat all level measurements.

11.7.2 It may be necessary to filter the spectrum of the noise source to concentrate the available sound power in a few bands to increase the source room sound pressure level. In such cases, the bandwidth of the filter applied to the source signal shall extend at least one-third-octave band above and below the frequency band(s) measured in the receiving room.

11.8 *Corrected Receiving Room Door-Closed Levels*—If the difference between the background and the combined level in the receiving room with door closed due to source and background is more than 10 dB at all frequency bands then no corrections to the receiving room levels are necessary.

11.8.1 If, after increasing the source level, the difference between the background and the receiving room level with door closed is between 5 and 10 dB, the adjusted value of the receiving room level shall be calculated as follows:

$$L_s = 10\log\left(10^{L_{sb}/10} - 10^{L_b/10}\right) \quad (5)$$

where:

L_b = the background noise level in each band, dB,
L_{sb} = the combined level of signal and background (the receiving room level), dB, and
L_s = the adjusted signal level, dB.

11.8.2 If the background level is within 5 dB of the receiving room level, then subtract 2 dB from the receiving room level and use the result as the corrected receiving room level. In this case, the measurements shall only be used to provide an estimate of the lower limit of the noise reduction or other derivative result. Identify such measurements in the test report.

12. Calculation of Normalized Door Insertion Loss and Door Transmission Class

12.1 Calculate the normalized door insertion loss at each frequency from 125 to 4000 Hz in accordance with Eq 2 as shown below:

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

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.

NOTE 13—The average sound pressure levels in this equation are the space and time averaged results, adjusted for background if appropriate.

12.2 Using the measured values of normalized door insertion loss and the method of Classification E413, determine the Door Transmission Class.

12.3 This test method specifies the use of one-third-octave bands for measurement and calculation of normalized door insertion loss. It does not allow measurement of octave band results because these are very sensitive to the shape of the source and receiving room spectra. In applications where octave band values are required, they shall be calculated from the one-third-octave band results using the expression:

$$NDIL_{oct,fc} = -10\log\left[1/3\sum_{B=B_c-1}^{B_c+1} 10_B^{-NDIL/10}\right] \quad (6)$$

where:

f_c = a preferred octave band mid-band frequency as specified in ANSI S1.6.

12.3.1 The summation is made over three one-third-octave band *NDIL* values: one at the frequency f_c with band number B_c and the adjacent one-third-octave bands, with band numbers B_c+1 and B_c–1.

NOTE 14—The octave band values calculated from this expression approximate what would be measured if the spectrum in the source room had the same sound pressure level in each one-third-octave band. (Random noise with this spectrum is known as "Pink noise.")

13. Report

13.1 The report shall include the following information:

13.1.1 *Statement of Conformance to Standard*—State that the tests were conducted in accordance with this test method. State whether the fixed microphone or scanning method was used. Note any deviations clearly and if any exist, place a statement on any page containing test results stating: "This test does not conform fully to the requirements of ASTM E2964."

13.1.2 *Description of Test Environment:*

13.1.2.1 A general description of the source and receiving spaces and their environs, including furnishings, and clearly indicating which is the source room and which is the receiving room.

13.1.2.2 The approximate dimensions and volumes of the test rooms.

13.1.2.3 The dimensions and construction of the partition into which the door is mounted including all of the essential constructional elements, their size and thickness.

13.1.2.4 If the door cannot be opened at least 170 degrees, or if there is a partition perpendicular to the partition containing the door within 1 m of the door on either side, report these conditions, how far in degrees approximately the door does open, and whether a perpendicular partition within 1 m is on the source or receive side of the door.

13.1.2.5 Describe any obvious potential source of flanking that appears to be a significant influence on results and any steps taken to evaluate or limit flanking.

13.1.3 *Description of Test Specimen:*

13.1.3.1 Provide the manufacturer and model number of the door if available, the size and general construction (steel, wood, solid core, hollow core) and a description of the seals.

13.1.3.2 Observe the condition and adjustment of the seals and report whether they appear to be properly adjusted or appear to have deficiencies in adjustment or required further adjustment before the test for which results are reported.

13.1.3.3 Any description of the test specimen should as far as practicable be based upon measurement and examination of the specimen itself, rather than upon the building plans or information received from the builder or others. The source of any description not based on direct observation shall be stated.

13.1.3.4 If the construction or installation of the test specimen is, for some reason, such that the results do not represent normal performance of the specimen, state this fact explicitly and put a statement of this on each page containing test results.

13.2 *Description of Test Equipment*—List all sound source and measurement equipment including microphones and field calibrators by make, model, and serial number where applicable, and for the measurement equipment including microphones and field calibrators also list the date of the last complete laboratory calibration.

13.3 *Statement of Test Results:*

13.3.1 Provide in tabular form in dB to one decimal place for each third-octave-band the following quantities: $L_{(source\ closed)}$, $L_{(source\ open)}$, $L_{(rec\ open)}$, $L_{(rec\ closed)}$ as measured, the background level, and the background adjusted values of $L_{(rec\ closed)}$ when required.

13.3.2 Provide in the table the values of NDIL for each third-octave band rounded to the nearest decibel. The NDIL results may also be presented graphically.

13.3.3 Clearly indicate in the stated results the third-octave bands for which receiving room sound pressure levels were within 5 dB of the background noise levels (see 11.8.2).

13.3.4 On each page of the report containing test results, place the statement "This page alone is not a complete report."

13.3.5 Include in the report the following statement, "The results stated in this report represent only the specific door and acoustical conditions present at the time of the test. While the test method attempts to minimize the influence of flanking and non-ideal test conditions, such can still influence results such that results in the field will likely be less than they would be under laboratory conditions. Details of seal adjustments and installation quality can vary from door to door, and even for the same door, pressure on seals may vary from test to test. Thus, the expected performance for an untested door cannot be derived from the test result of a single door (or a sample thereof) of the same door design."

13.4 *Single Number Ratings*—Report the door transmission class, DTC.

13.5 Number all pages of the report, and indicate the total number of pages on each page of the report.

14. Precision and Bias

14.1 *Precision*—Repeatability for this test method may be thought of as the variation that might be seen if the same measurement team repeated the measurements of the same door using the same equipment with perhaps some minor variations in microphone and loudspeaker positions. The reproducibility would be the variation if different teams performed the measurements of the same door. Repeatability and reproducibility are complicated in this test by the fact that the specimen may not remain unchanged. The specimen performance is dependent of the door seals, and the performance of the seals in some cases can vary from one closing to another.

14.1.1 *Repeatability*—Repeated tests were conducted by the same person with the same equipment on the same door with a single sound source. Five tests were conducted using both scanning and fixed microphone methods on a door without seals using different source locations for each measurement. Five tests were conducted on a second door with seals using the fixed microphone method and the same source location for each measurement. Table 1 shows the standard deviations and 95% repeatability limits. Results are shown first for the DTC. Then the average, minimum and maximum values of standard

TABLE 1 Repeatability Data

	Door Not Sealed, Different Source Locations				Door Sealed, One Source Location	
	Fixed Microphone		Scanned Microphone		Fixed Microphone	
	Std Dev	95% Limit	Std Dev	95% Limit	Std Dev	95% Limit
DTC	0.4	1.1	0.4	1.1	0.4	1.1
NDIL AVG	1.2	3.4	1.2	3.4	0.4	1.1
NDIL MIN	0.4	1.1	0.4	1.1	0	0
NDIL MAX	2.6	7.3	2.4	6.7	0.9	2.5

deviation and 95% repeatability limits are shown for the NDIL in the range 125 to 4000 Hz.[7]

14.1.2 *Reproducibility*—The reproducibility of this method has not been established but will be established within five years of the initial adoption of this standard.

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E33-1014. Contact ASTM Customer Service at service@astm.org.

14.2 *Bias*—The bias in this method is unknown since there is no known true value for the results measured.

15. Keywords

15.1 door; door transmission class; field test; normalized door insertion loss

APPENDIXES

(Nonmandatory Information)

X1. COMPARISON OF NORMALIZED DOOR INSERTION LOSS AND TRANSMISSION LOSS

X1.1 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. Results have been measured in a laboratory and compared to measurements of the transmission loss and STC of the same two doors measured in accordance with E90. The transmission loss was measured twice for each door and the results arithmetically averaged. The NDIL was measured nine times for each door by both the fixed microphone and scanning methods. However, many of the scanned results were found to be strongly influenced by failure to close the door with seals properly sealed. Only the results with properly sealed doors were used. The arithmetic average normalized door insertion loss for each door and measurement method was subtracted from the arithmetic average transmission loss. Results are shown in Table X1.1. The significant variation at 80 Hz may have been room influence on the transmission loss results. The DTC is most commonly equal to or one point less than the STC of the door when there is no significant flanking, but DTC results in the field could be lower due to flanking or less than ideal test conditions. These laboratory tests were conducted with different absorptive conditions in the source and receive rooms demonstrating that such conditions have little effect on the DTC. See Ref (**2**).

TABLE X1.1 Transmission Loss (TL) minus Normalized Door Insertion Loss (NDIL)

	Frequency, Hz																	
	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000
Door 1																		
Nine tests fixed microphone	4.2	1.0	1.5	0.9	-1.0	-0.6	0.2	0.9	-0.1	0.4	-0.1	-0.1	-0.1	0.7	0.7	0.4	1.0	0.8
Seven tests scanned microphone	3.8	0.3	0.9	1.6	-0.7	-1.1	-0.7	-0.4	-1.2	-0.2	-0.6	-0.7	-0.8	-0.3	-0.8	-0.4	0.3	-0.2
Door 2																		
Nine tests fixed microphone	7.4	2.0	0.3	1.9	-1.5	-2.1	0.0	0.8	0.0	0.2	0.5	-0.1	1.0	0.7	1.1	0.6	1.4	3.9
Three tests scanned microphone	7.3	2.3	0.1	3.4	0.1	-1.5	-0.2	-0.5	0.1	-0.2	-0.8	-0.7	1.0	0.5	0.2	-0.3	0.3	1.2

X2. FIELD COMPARISONS OF FIXED AND SCANNING METHODS

X2.1 The fixed-microphone and scanning methods have been compared in the field. In one comparison, five measurements were made with each method on a door without seals using different source locations. The two methods yielded the same DTC results, with four results at one level and one result one point higher. In the other comparison, one scanned result was compared to five results with fixed microphones on a door with seals and a single source location. The scanned DTC matched the highest of the results with the fixed microphones, with the other four results with the fixed microphones one point lower. The measurements with the single source location showed less variation in the individual NDIL results, especially at low frequencies. This indicates the source location could influence results especially at low frequencies such that the use of multiple sources or multiple measurements with different source locations could yield more consistent results.

REFERENCES

(1) Morin, Michel, "Research project on the noise isolation provided by access doors in multi-dwelling buildings," prepared by MJM Acoustical Consultants, Inc., Montreal, for Canada Mortgage and Housing Corporation, 1993.

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(3) *Noise and Vibration Control*, L. L. Beranek, Ed., McGraw-Hill, 1971, p. 115.