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Standard Test Method for Laboratory Measurement of the Sound Transmission Loss of Door Panels and Door Systems[1]

This standard is issued under the fixed designation E 1408; 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.

1. Scope

1.1 This test method describes the laboratory measurement of the sound transmission loss for door panels and door systems. It also includes the measurement of the force required to close and latch, as well as to unlatch the door under test. An appendix presents methods to determine the respective contribution of the door components and seals to the sound transmission loss of a door system.

1.2 *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:*

C 634 Terminology Relating to Environmental Acoustics[2]

E 90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions[2]

E 336 Test Method for Measurement of Airborne Sound Insulation in Buildings[2]

E 413 Classification for Rating Sound Insulation[2]

2.2 *ANSI Standards:*

ANSI/BHMA A156.2 American National Standard for Bored and Preassembled Locks & Latches[3]

ANSI/BHMA A156.4 Standard 301 American National Standard for Door Controls—Closers[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method see Definitions C 634.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *door*—any sliding, folding, rolling, lifting, swinging or dropping partition that provides access and can be manually or automatically opened and closed.

3.2.2 *door panel*—the component of the door system that constitutes a movable barrier without accessories: that is, the portion of a door system which may be tested as a fixed panel (room divider). The term *door panel* may be used in the report as part of the description of the designated door system (for example, door panel construction).

3.2.3 *door system*—the combined assembly of the components designated by or provided by the test sponsor which enables a fully operable door panel to function in normal manner while fulfilling its intended purpose. The door system shall include a jamb, threshold/plate/finished floor, lockset/latch/deadbolt, knob/lever/handle, hinges/rollers/guides, stops, panel/barrier/partition, strike plate, hardware, and seals (fixed, automatic, pneumatic, magnetic, or manually adjustable). The system may include mail slots, vision lights, security devices, bells, buzzers, chimes, knockers, door closures, vents, and add-on panels.

3.2.4 *multiple doors*—two or more doors mounted side by side (in a single vertical plane), with a common astragal or mullion; or two or more doors mounted in tandem [a series of vertical planes with intermediate airspace(s)].

3.2.5 *operable and fixed seals*—the combined assembly of components intended to minimize the passage of air, light, or water through or around the door panel and frame assembly. The seals may also perform other functions such as controlling effects of chemical, thermal, blast, security, hydraulics, meterology, radio frequency interference (RFI) or electro magnetic interference (EMI); however, for this test method, only the reduction of airborne sound transmission shall be evaluated.

4. Summary of Test Method

4.1 After the complete door system is installed and all final adjustments are completed, the force or torque to open and to close the door shall be measured during the operable test (see Section 7). Subsequently the sound transmission loss of the door system shall be tested for two conditions in any order of preference: a fully operable door and a sealed panel (see Section 6).

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[1] This test method is under the jurisdiction of ASTM Committee E-33 on Environmental Acoustics and is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

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[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

5. Significance and Use

5.1 This test method is used for three purposes: the laboratory measurement of (*1*) the sound transmission loss of fully operable doors equipped with a particular combination of hardware and seals, (*2*) the sound transmission loss of a laboratory sealed door panel and (*3*) the force or torque required to operate the door system.

5.2 This test method relies upon Test Method E 90 for acoustical testing, and all requirements in that standard, including Annex A2 (Laboratory Accreditation). Also see 6.1 for additional references and requirements.

5.3 This test method is not intended for field tests. Field tests of sound transmission should be performed in accordance with Test Method E 336.

5.4 This test method evaluates the overall sound transmission loss of an operable door system which may include various seals and hardware components. An additional (nonmandatory) test procedure for assessing individual door components is given in Appendix X1.

6. Procedure

6.1 The following sections of Test Method E 90 are applicable to this test: Test Rooms; Flanking Transmission, Test Specimens; Size and Mounting, Measurements of Average Sound Pressure Levels; and the Determination of Receiving Room Absorption.

6.2 Both the fully operable door and the sealed panel tests shall be conducted in accordance with the procedures designated in the annex of Test Method E 90 (Operable Walls and Doors). If the door is manually operated (non-automatic), the force required to fully close and latch and to open (unlatch) the door shall be measured (see Section 7). If the door contains an automatic door closer, the forces required to open and to close the door shall be measured (see 7.1.5.).

NOTE 1—It is suggested that the operable door condition be tested first. If the sealed panel condition is tested first, carefully remove all sealant residue from the specimen before testing the operable door condition.

NOTE 2—In some applications the hardware of the operable or fixed seals furnished by the client for the test may contribute to the acoustical performance of the door system (example: a mass loaded automatic door bottom inserted into the bottom of a hollow core door). To determine the contribution of that component or of the door panel, see Appendix X1.

6.3 In some applications the door system may not contain prefabricated seals. For example, the hinge side of the door may not have a fixed seal where the door panel butts against the bare frame. The situation where no seal exists on the top, bottom, or either side of the door/frame assembly shall be reported and taken into consideration when comparing both sets of data.

6.4 *Sealed Panel Condition*—Suitable acoustical sealant is applied to both sides of the specimen (if possible) at the peripheral junction between the edge of the door panel and the frame so the peripheral gap between the door and the frame is completely sealed. The sealant should not extend beyond 12.7 mm (0.5 in.) from the leading edge of any manufactured sealing component or any other element of the door system.

6.4.1 The laboratory should evaluate the sealed door panel for sound leaks using a stethoscope, sound level meter, sound intensity meter, etc. throughout the test frequency range prior to performing any sound measurements.

NOTE 3—Much of the transmission loss difference between the two test conditions may be attributed to the door accessories used, in combination with the door panel alone. There is a possibility that part of the difference may be due to changes in the panel boundary conditions caused by use of acoustical sealant in the sealed panel test.

6.5 For multiple doors, the transmission loss (TL) tests shall be conducted with all doors operable for the operable condition and all doors sealed for the sealed panel condition. For the sealed panel tests, applying sealant to both sides of all the doors in a tandem assembly becomes impractical, thus sealing both sides of one door and one side of the other door is acceptable but must be referenced in the report.

NOTE 4—Since multiple doors mounted side by side can present a greater sound transmission area (the area common to both sides) or expose additional seals and hardware to the sound source, lower transmission loss (TL) values may result even though the components utilized in all the assemblies consist of the same materials, fabricated by the same manufacturer for a single door assembly. For this reason, the TL test results obtained from a single door should not be applied to multiple doors or single doors with different overall dimensions.

6.6 *Measurements*— For both test conditions (operable door and sealed panel) the sound transmission loss (TL) and the sound transmission class (STC) shall be determined.

6.6.1 The area used in determining the sound transmission loss for both the operable door and sealed panel tests shall be the area of the door panel(s).

6.7 The test signal shall be in conformance with the specifications listed in Test Method E 90.

6.8 *Standard Test Frequencies*—The minimum frequency range of measurements shall be a series of contiguous one-third octave bands with geometric center frequencies from 125 to 4000 Hz. It is recommended that the range be extended to include at least the 100 and 5000 Hz bands. Larger room volumes are recommended when employing lower frequencies.

7. Determination of the Force or Torque to Close, Latch, and Unlatch the Door

7.1 It is recommended that a calibrated push and pull tension meter[4] be used, one having a maximum reading hold and zero adjustment. The procedure described in 9.1.5 of ANSI/BHMA A156.2 should be used for measuring the force to latch a door. The procedure described is as follows:

7.1.1 *Swinging Doors*— Apply a force measuring device perpendicular to the face of the door at a point 25.4 mm (1.0 in.) from the lock edge of the door and on the center line of the latch bolt. The door should be ajar with the latch bolt slightly separated from the lip of the strike plate. Close the door slowly with minimal force by pushing the force measuring instrument against the door until the latch bolt fully enters the strike plate opening. The maximum force that is required to close and fully latch the door shall be recorded. A minimum of five measurements is required, and the range as well as the average force or torque shall be recorded.

[4] One suitable device (or an equivalent) is a DPP-50 Chatillon 0–50 lbs tension meter.

NOTE 5—A swinging door is defined as closed when the latch is fully secured in the strike plate and the door remains in the closed position.

7.1.1.1 *Sliding Doors (with latches)*—The door shall be placed just short of the latching position. The force measuring instrument shall be positioned horizontally at the latch location and parallel to the plane of the door. While maintaining the measuring instrument in the designated position, determine the average force or torque required to close and latch the door. A minimum of five measurements is required, and the range as well as the average force or torque shall be recorded.

7.1.1.2 *Sliding or Swinging Doors (without latches)*—In the case where no latching mechanism is used and the door relies upon magnetic seals or other means to keep the door closed, then a predetermined closed partition should be identified and accounted for during measurements. The procedure in 7.1.1.1 shall be used except the words *and latch* should be replaced by *to the predetermined closed position*. The door will be tested for transmission loss with the door at the designated predetermined closed position.

7.1.2 *Cylindrical Locksets*—Attach the grasping fixture (see Note 6) to the door knob and record the average torque necessary to unlatch the door. A minimum of five measurements is required, and the range as well as the average torque shall be recorded.

NOTE 6—*Torque Measuring Device for a Cylindrical Lockset*—It is recommended that a calibrated torque wrench[5] with a range from 0 to 300 in.-lbs be modified for use in this procedure. The modification includes a metal cap that fits over the door knob and is affixed to the door knob by four adjustable screws set 90° apart.

7.1.3 *Thumb Latches and Push Bars*—Push on the middle portion of the latch or bar with the compression end of the tension meter and record the average force required to unlatch or bar the door. A minimum of five measurements is required, and the range as well as the average force shall be recorded.

7.1.4 *Lever Latches*— Attach the tension end of the measuring instrument at 50.8 mm (2 in.) from the outer end of the lever and hold the device parallel to the door and perpendicular to the lever. Record the average force required to unlatch the door. A minimum of five measurements is required, and the range as well as the average force shall be recorded.

7.1.5 *Door Closers*— If the system contains a door closer the closing force shall be measured in accordance with Section 6.4 of ANSI/BHMA A156.4-1980 Standard 301, with the exception that the prerequisite 4000 closing cycles is waived.

7.1.6 The five force measurements involving the opening and closing of the door are independent of the open/close cycles required to determine that the door is fully operable (see Test Method E 90, Annex A1). Either order of force and sound measurements is acceptable as long as they are made during the operable test without any intervening adjustments to the door system. If any adjustments are made, the entire process of recording the force or torque to open and close the door must be repeated.

[5] A suitable instrument is a modified Sturtevant Model F300-1-S with a range from 0 to 300 in.-lbs (n-m) or a McMaster Carr Number 535 8A69 available from McMaster Carr, P. O. Box 4355, Chicago, IL 60680.

7.1.7 The units reported for the force or torque measurements shall be pounds or foot-pounds and newtons or Newton-meters, respectively.

8. Report

8.1 The report shall include the following.

8.1.1 A statement, if true in every respect, that the test was conducted in accordance with the provisions of this test method. Conformance to the relevant sections of Annex A1 of Test Method E 90 shall also be reported when applicable.

8.1.2 A description of the test specimen. The description must include information on the door panel, frame, and hardware. The information on the door panel shall include the model number, materials, dimensions, weight, and other relevant physical properties. The average surface mass (of the door panel) may be reported if applicable to the design. The information on the frame shall include the material and the installation procedures including whether the frame was hollow or packed. The information on the hardware shall include a full description of all latching and unlatching hardware components. Whenever possible, the testing laboratory should observe and report the materials, dimensions, mass, and other relevant physical properties of the major components and the manner in which they are combined, including a description of fastening elements. Detailed drawings should be provided by the manufacturer. A designation/description furnished by the sponsor may be included in the report provided the information is directly attributed to the sponsor. The curing period, if any, and the final condition of the specimen (shrinkage, cracks, etc.) shall be reported.

8.1.3 Describe the method of installation of the specimen in the test opening, including the location of framing members relative to the edges. If a filler wall is used, the type of filler wall and the sealing methods used at the perimeter shall be reported.

8.1.4 Clearances around movable elements including the gap between the door panel and the frame shall be reported as four average values (top, bottom, and two sides).

8.1.5 The sound transmission loss (TL) at all frequency test bands as well as the sound transmission class (STC) for both the operable door and sealed panel conditions.

8.1.6 The force or torque to fully close (latch) the door and the force or torque to unlatch the door (see Section 7).

9. Precision and Bias

9.1 The precision requirements for each of the two sound test conditions stated in this test method shall be in full conformance to the precision section of Test Method E 90. A combined precision statement of both the operable door and sealed panel conditions is optional; however, the individual confidence limits pertaining to each condition is required and shall be included in the report.

10. Keywords

10.1 door panels; door systems; sound transmission loss

APPENDIX

(Nonmandatory Information)

X1. EVALUATION OF THE SOUND TRANSMISSION LEAKS

Step by Step Proceses

X1.1 The following step by step process allows the evaluation of the sound transmission (*leaks*) of components that can be acoustically blocked individually or in groups, whether they be airborne or structure-borne. Each test evaluates the equivalent open area of sound leak attributed to a component at each test frequency. The transmissivity of the equivalent leak area is considered unity.

NOTE X1.1—Experience indicates that the acoustical effectiveness of a door system component will vary with frequency and can vary among door systems.

X1.2 *Component Test Method (Optional)* —This procedure measures the effect of one or more sound leakage paths where it is suspected that they influence the acoustical performance of a normally installed door. An example of a *lockset* is given in X1.3. Other components may be tested by a similar procedure. In each case, the acoustical effect of the individual component under investigation may be determined by measuring the transmission loss with the door system entirely sealed and disconnected (*inoperable*) and then by measuring the transmission loss obtained when the individual component under test is unsealed (for example, lockset) or connected (for example, a hinge).

X1.3 *Specimen Preparation*—Remove the lockset and seal the lockset orifice (both sides). Use a minimum of sealing material and do not fill the lockset internal cavity. Remove the door hinges and seal their respective mounting holes. The door panel should be reinstalled with the same peripheral gap between it and the test frame structure as was used for the operable tests. Rigid spacers of the appropriate thickness should be placed under the two bottom door corners. To minimize the added mass, these spacers should be not more than 6.35 mm (0.25-in.) wide. See 8.1.4. The door panel is then acoustically sealed around its entire periphery and on both sides.

NOTE X1.2—In this *lockset* example, door panel edge restraint exists and the transmission loss values measured under X1.2 are the combined transmission of (*1*) the door panel itself, (*2*) airborne sound leakage created by the lockset and its internal cavities, and (*3*) the missing structure-borne sound transmission of the hinges.

X1.4 *Test Procedure*—Test Method E 90 is applied, providing a new transmission loss value at each test frequency for an inoperable, disconnected and sealed door panel, then repeated with only the test component connected or unsealed.

X1.4.1 *Theory*—Test Method E 90 effectively measures the transmission loss, TL, which is related to the transmissivity (τ) as:

$$TL = 10 \log (1/(\tau) \quad \text{(X1.1)}$$

The sound power, *W*, transmitted by the test specimen depends on its transmissivity, τ, its area, *S*, and the incident sound intensity, *I*. For the door panel alone, inoperable, disconnected and sealed, this transmitted power is:

$$W_i = kI\, S_d (\tau)_i \quad \text{(X1.2)}$$

where:

W_i = sound power transmitted through the door panel alone,
k = constant, dependent on the sound velocity and the air density and the sound field diffusion,
S_d = area of the door system, and
$(\tau)_i$ = transmissivity of the door panel alone.

The sound power transmitted by a test door specimen including an air leak of area S_a *is:*

$$W_t = W_i + W_a = kI\, S_d (\tau)_i + kI\, S_a (\tau)_a \quad \text{(X1.3)}$$

where:

W_t = sound power transmitted through a test door system,
W_a = sound power transmitted through the leak, and
S_a = equivalent area of the leak.

For purposes of this test method, air leak transmissivity is assumed to be unity:

$$(\tau)_a = 1 \quad \text{(X1.4)}$$

For purposes of this appendix, the test procedures as described in Test Method E 90 are used to measure both the test door transmission loss, termed TTL and the inoperative door transmission loss, termed IDTL. The TTL value relates to Eq X1.3 as:

$$10^{-\mathrm{TTL}/10} = W_t/(kIS) = (\tau)_i + S_a/S_d \quad \text{(X1.5)}$$

Results Analysis

X1.5 *Method 1: Performance Derived from Direct Measurements*—Eq X1.5 can be rewritten in three useful forms using the transmission loss of a test door (TTL), an inoperative door totally sealed and disconnected, IDTL, the door area, S_d and the leakage area, S_a. Knowledge of any two can be used to deduce the third:

$$\mathrm{TTL} = -10 \log (10^{-\mathrm{IDTL}/10} + S_a/S_d) \quad \text{(X1.6)}$$

$$\mathrm{IDTL} = -10 \log (10^{-\mathrm{TTL}/10} - S_a/S_d) \quad \text{(X1.7)}$$

$$S_a = S_d\, (10^{-\mathrm{TTL}/10} - 10^{-\mathrm{IDTL}}) \quad \text{(X1.8)}$$

Another useful value is the transmission loss due to leaks alone, ATL;

$$ATL = -10 \log (10^{-\mathrm{TTL}/10} - 10^{-\mathrm{IDTL}/10}) \quad \text{(X1.9)}$$

X1.6 *Results Analysis Method 2: Performance Curve Method* (Fig. X1.1)—A *total leak percentage*, $100(\tau)_a$ can be defined as the percentage of door area which represents sound leakage:

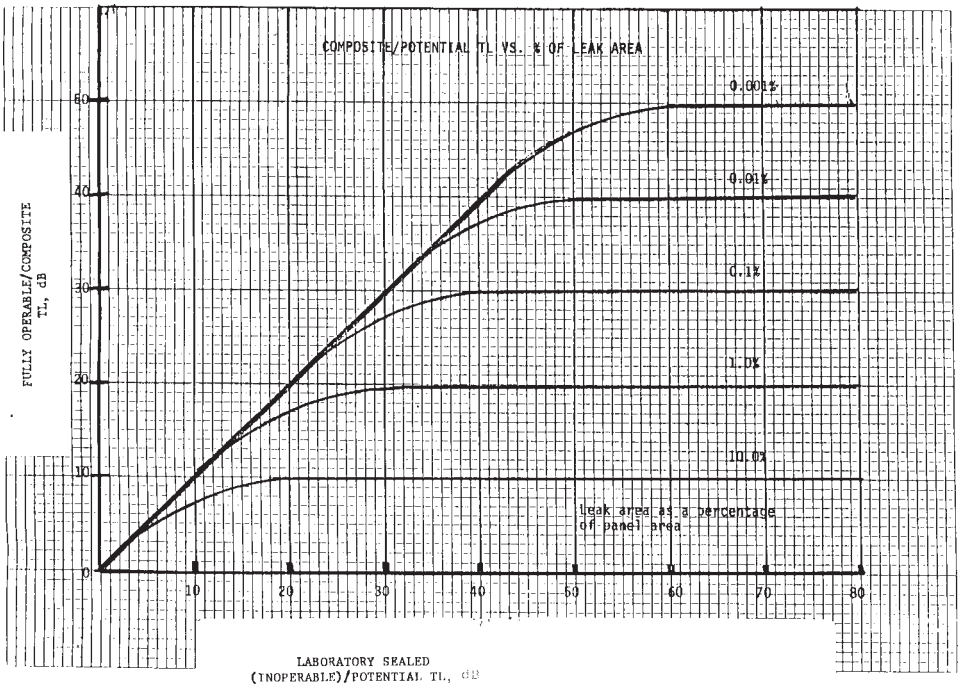

FIG. X1.1 Leak Percentage Curve

$$\text{Total Leak Percent} = 100(\tau)_a = ((\tau)_t - (\tau)_i) \quad \text{(X1.10)}$$

Combining with Eq X1.1, Eq X1.10 becomes:

$$100(\tau)_a = (10^{-\text{TTL}/10} - 10^{-\text{IDTL}/10}) \times 100\ \% \quad \text{(X1.11)}$$

NOTE X1.3—This *total leak percentage* value is not an absolute measure of the leak area, but rather only a representation of the cumulative leakage paths when the door and door hardware are installed and operated according to the description provided in the report.

Fig. X1.1 demonstrates the significance of Eq X1.11. For instance, if

$$\text{IDTL} - 50\ \text{dB} \quad \text{(X1.12)}$$

$$S_d = 21.5\ \text{square feet, and} \quad \text{(X1.13)}$$

$$S_a = 0.0215\ \text{square feet, then} \quad \text{(X1.14)}$$

$$T_a = 100\ (S_a/S_d)\% = 0.1\ \% \quad \text{(X1.15)}$$

From Fig. X1.1, the test door will have an TTL value of only 30 dB. This can be verified by solving Eq X1.11 for TTL:

$$\begin{aligned}\text{TTL} &= -10\ \log\ (T_a/100 + 10^{-\text{IDTL}/10}) \\ &= -10\ \log\ (10^{-3} + 10^{-5}) \\ &= 30\ \text{dB}\end{aligned} \quad \text{(X1.16)}$$

X1.7 *Other Component Tests*—This optional method can be used to measure the acoustical effectiveness of any door system component.

X1.8 The sum total leakage area of all the door system components can be found by using the normally operating door TL values obtained under the mandatory sections of this method as the TTL values.