Designation: E3133 – 18

Standard Test Method for Laboratory Measurement of Floor Impact Sound Radiation Using the Tapping Machine[1]

This standard is issued under the fixed designation E3133; 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 used to evaluate the impact sound radiation in the source room of various floor structures in a controlled laboratory environment. The method is similar to that used in Test Method E492, and provided that the Test Method E492 laboratory facility's source room meets the room requirements of this test method, this test can be performed simultaneously with the Test Method E492 test. This test method does not require a separate receive room as the measurements are made in the room that also contains the impact noise source. It is anticipated that a different standard will be developed in the future to enable field measurement of floor impact sound radiation. Other related standards include field measurement of impact sound transmission through floor-ceiling assemblies (Test Method E1007) and laboratory measurement of the effectiveness of floor coverings in reducing impact sound transmission through concrete floors (Test Method E2179).

1. Scope

1.1 This test method covers the laboratory measurement of impact sound radiation from floor structures using a standardized tapping machine. While the finished floor surface is usually the primary factor, it must be noted that the floor structure below the finished floor also plays a major role in the level of noise generated in the source room by impacts to the floor surface. As a result, the report must include a full description of the complete floor structure and its support (for example, perimeter support only, multiple point supports, or full continuous support like a slab on grade). It is assumed that the impact sound generated by the tapping machine in the test room is a good approximation to a diffuse sound field.

1.2 Measurements may be conducted on floor structures of all kinds, including those with floating-floor or suspended ceiling elements, or both, and floor-ceiling assemblies surfaced with any type of floor-surfacing or floor-covering materials.

1.3 This test method prescribes a uniform procedure for reporting laboratory test data in both one-third-octave-band and overall A-weighted sound power levels generated by the tapping machine impacts on the floor structure (test specimen).

1.4 *Laboratory Accreditation*—The requirements for accrediting a laboratory for performing this test method are given in Annex A2.

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

1.6 *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.*

1.7 *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]

C423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method

C634 Terminology Relating to Building and Environmental Acoustics

[1] This test method is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.10 on Structural Acoustics and Vibration.

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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.

E90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements
E492 Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine
E1007 Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures
E2179 Test Method for Laboratory Measurement of the Effectiveness of Floor Coverings in Reducing Impact Sound Transmission Through Concrete Floors
E2235 Test Method for Determination of Decay Rates for Use in Sound Insulation Test Methods
E3091 Specification for Systems to Measure Sound Levels

2.2 *ANSI Standards:*[3]

ANSI S1.10 Pressure Calibration of Laboratory Standard Pressure Microphones
ANSI S1.11 Electroacoustics – Octave-band and Fractional-octave-band filters
ANSI S1.40 Specifications and Verification Procedures for Sound Calibrators
ANSI S12.51 Acoustics—Determination of sound power levels of noise sources using sound pressure—Precision methods for reverberation test rooms

2.3 *IEC Standards:*[4]

IEC 60942 Electroacoustics—Sound Calibrators

2.4 *ISO Standards:*[5]

ISO 140/6 Acoustics—Measurement of sound insulation in buildings and of building elements Part 6: Laboratory measurements of impact sound insulation of floors
ISO 3741 Determination of sound power levels of noise sources using sound pressure—Precision methods for reverberation test rooms
ISO 6926 Acoustics—Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels

3. Terminology

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

airborne sound
average sound pressure level
background noise
decay rate
Decibel
diffuse sound field
impact insulation class
one-third-octave-band
receiving room
reverberant sound field
reverberation room
sound absorption
sound pressure level

4. Summary of Test Method

4.1 A standard tapping machine is placed in operation on a floor structure, which can represent a horizontal separation between two rooms, a floor structure elevated above grade, or a floor structure on grade. The average spectrum of the sound pressure levels generated by the tapping machine impacting on the floor structure is measured in the reverberant field of the test room (that contains the tapping machine) in one-third-octave-bands.

4.2 The measured space and time average sound pressure levels are then used to calculate the radiated sound power levels using either the direct or comparison method as specified in ANSI S12.51.

5. Significance and Use

5.1 This standard provides a method to measure the level of sound power generated in a room by impacts on a given floor surface within the same room. The test results could be used to compare the relative sound power of tapping machine impact noise on various finished floor surfaces. The resulting data could be used for comparing relative levels of unwanted noise from footfalls and objects accidentally dropped on the floor.

5.2 The spectrum and level of the sound power produced by floor impacts is determined by:

5.2.1 The mechanical properties of the floor structure, such as its size, construction, surface, mounting or edge restraints, stiffness, or internal damping,

5.2.2 The measured acoustical characteristics of the test room,

5.2.3 The location of the object or device producing the impacts, and

5.2.4 The nature of the impact.

5.3 This test method is based on the use of a standard tapping machine of the type specified in 8.1 placed in specific positions on the floor. This machine produces a continuous series of uniform impacts at a uniform rate on a test floor and generates broadband sound pressure levels that are sufficiently high to make measurements possible with most floor types even in the presence of background noise. The tapping machine itself, however, is not designed to simulate any one type of impact, such as produced by male or female footsteps.

5.4 Because of its portable design, the tapping machine does not simulate the weight of a human walker. The degree of correlation between the results of tapping machine tests in the laboratory and the subjective acceptance of floors under typical conditions of domestic impact excitation is uncertain. The correlation will depend on both the type of floor construction and the nature of the impact excitation in the building.

5.5 This test method is not intended for field tests.

6. Test Room

6.1 The test facility shall be a reverberant room meeting the requirements of ANSI S12.51 (Annex C).

[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, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.
[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

6.2 *Volume of Test Room*—The recommended minimum volume of the test room is 200 m^3. Smaller test rooms may be used, provided that all measurement microphone locations are far enough from the source to be in the reverberant field of the room while still meeting the room boundary clearances (see ANSI S12.51, Section 8.3).

NOTE 1—See ANSI S12.51 (Annex E) for if room volume is less than 200 m^3.

6.3 *Room Absorption*—The sound absorption in the test room should be low to achieve the best possible simulation of the ideal diffuse field condition, and to minimize the region dominated by the direct field of the test specimen. In the frequency range that extends from $f = 2000/V^{1/3}$ to 2000 Hz, the absorption in the receiving room (as furnished with diffusers) shall be no greater than:

$$A = V^{2/3}/3 \quad (1)$$

where:

V = the room volume, m^3, and
A = the sound absorption of the room, m^2.

6.3.1 For frequencies below $f = 2000/V^{1/3}$, somewhat higher absorption may be desirable to accommodate requirements of other test methods (for example, ISO 3741); in any case, the absorption should be no greater than three times the value given by Eq 1.

NOTE 2—For frequencies above 2000 Hz, atmospheric absorption may make it impossible to avoid a slightly higher value than that given in Eq 1.

6.4 During the sound pressure level and sound absorption measurements in the test room, the average temperature shall be in the range 22 ± 5°C and the average relative humidity shall be at least 30 %.

6.5 During the sound pressure level and the corresponding sound absorption measurements, variations in temperature and humidity in the test room shall not exceed 3°C and 3 % relative humidity, respectively. Temperature and humidity shall be measured and recorded as often as necessary to ensure compliance.

6.5.1 If a relative humidity of at least 30 % cannot be maintained in the test room, users of the test method shall verify by calculation that changes in sound power levels due to changes in temperature and humidity do not exceed 0.5 dB.

NOTE 3—Procedures for calculating air absorption are described in Test Method C423.

7. Test Specimens

7.1 The test specimen shall be prepared and described in the test report in accordance with Annex A1 of Test Method E90.

7.2 *Size and Mounting*—The test specimen shall have a minimum lateral dimension of 2.4 m. An area of at least 10 m^2 is recommended. The test specimen shall include all of the essential constructional elements and surfacing materials normally found in an actual installation. Some elements may have to be reduced in size to fit each laboratory's test opening.

7.3 Floor-surfacing materials, such as vinyl, carpets and pads, especially when installed with adhesive, significantly affect the response of the test specimen to impacts, both during test and in normal use. Consequently, such materials shall be deemed parts of the test specimen. The materials and the manner of installing them shall be fully described in the test report. The floor-surfacing material shall cover the whole test specimen, not merely the portion under the tapping machine.

8. Tapping Machine

8.1 This test method is based on the use of a standard tapping machine that conforms to the following specifications:

8.1.1 The tapping machine shall be motor-driven.

8.1.2 The tapping machine shall have five hammers equally spaced in a line. The distance between centerlines of neighboring hammers shall be 100 ± 3 mm.

8.1.3 Each hammer shall have an effective mass of 500 ± 6 g and shall fall freely from a height of 40 ± 3 mm.

8.1.4 The falling direction of the hammers shall be perpendicular to the test surface to within ±0.5°.

8.1.5 The part of the hammer carrying the impact surface shall be cylindrical with a diameter of 30 ± 0.2 mm.

8.1.6 The impact surface shall be of hardened steel and shall be approximately spherical with a curvature radius of 500 ± 100 mm.

NOTE 4—The mean curvature radius for each hammer face may be determined using a spherometer or other means.

8.1.7 The time between successive impacts shall be 100 ± 20 ms.

8.1.8 Since friction in the hammer guidance system can reduce the velocity of the hammer at impact, the tapping machine shall be checked for friction between the hammers and the guidance system. Any friction found should be eliminated or reduced as much as possible.

8.1.9 Following adjustment of the hammer drop in accordance with the specifications, the tapping machine is ready for use on any floor structure, including those surfaced with soft or resilient materials.

NOTE 5—The above requirements are a subset of the ISO 140/6 requirements.

8.2 *Tapping Machine Positions*—The tapping machine positions and orientations described in the following must be used. Fig. 1 illustrates one case.

8.2.1 *Position 1*—The middle hammer of the tapping machine shall be coincident with the midpoint of the floor area, that is, the point of intersection of floor diagonals. In framed construction, adjust this point to the centerline of the closest structural member or other support member, and arrange the tapping machine so that all hammers fall on the joist.

8.2.2 *Position 2*—Same as position 1, except rotate the tapping machine 90° about the axis of the middle hammer.

8.2.3 *Position 3*—Displace the tapping machine laterally from position 1, such that the long dimension of the machine is centered midway between and parallel to the central structural member. In the case of homogeneous concrete slab floors or solid deck construction without joists, the lateral displacement of the tapping machine shall be 0.6 m from that of position 1.

8.2.4 *Position 4*—Position the tapping machine so that all hammers fall on a 45° radial line extending from the middle

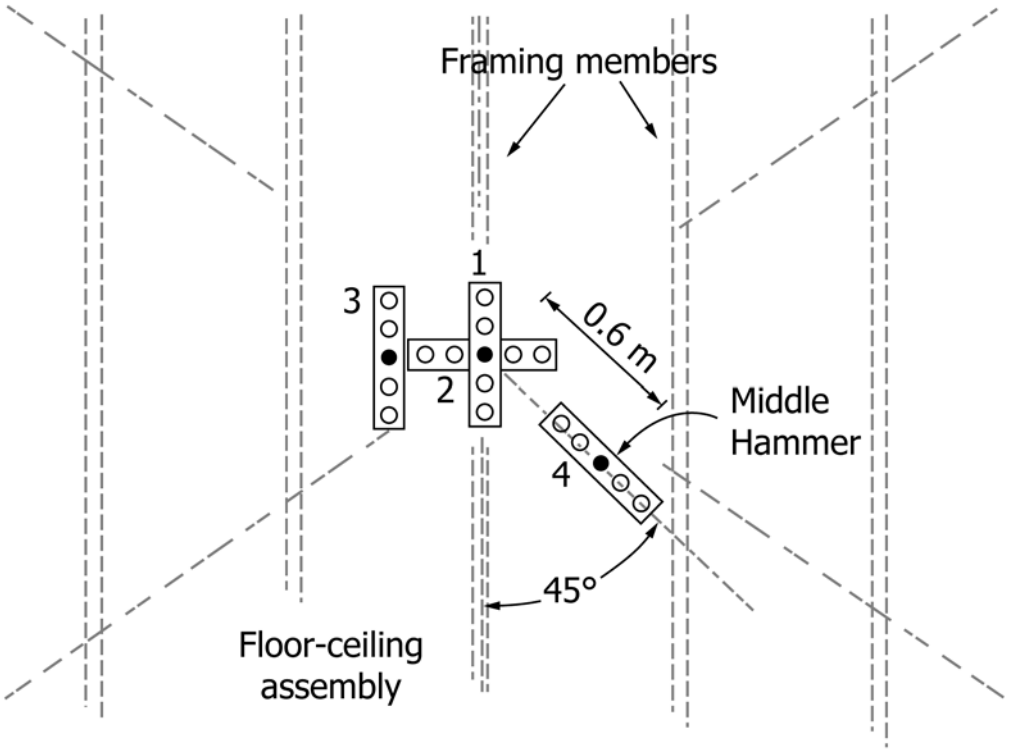

FIG. 1 Tapping Machine Positions on Floor with Structural Members 610 mm o.c.

hammer point of position 1. Locate the middle hammer 0.6 m from the midpoint of position 1.

9. Instrumentation Requirements

9.1 The measurement process must account for sound level fluctuations caused by spatial and temporal variations. Various systems of data collection and processing are possible, ranging from a single microphone moving continuously, a single microphone placed in sequence at several measurement positions, to several microphones making simultaneous measurements.

9.2 The measurement system shall conform to either Section 6 or Subsection 7.7 of Specification E3091.

9.3 *Calibration*—Calibrate each microphone over the whole range of test frequencies as often as necessary to ensure the required accuracy (see ANSI S1.10). A record shall be kept of the calibration data and the dates of calibration (see A2.4.1).

9.4 The calibration of the entire measurement system shall be checked before each set of measurements using an acoustical calibrator that generates a known sound pressure level at the microphone diaphragm and at a known frequency. The Class of Calibrator shall be class 1 or better per ANSI S1.40 or IEC 60942, or both.

9.5 *Standard Test Frequencies*—Measurements shall be made in all one-third-octave-bands with mid-band frequencies specified in ANSI S1.11 from 100 to 10 000 Hz. Additional one-third-octave-band measurements should be made at 50, 63, and 80 Hz to gain an understanding of low-frequency impact radiation properties.

9.6 *Bandwidth*—The overall frequency response of the filters used to analyze the microphone signals shall, for each test band, conform to the specifications in ANSI S1.11 for a one-third-octave-band filter set, class 1 or better.

10. Measurement of Sound Pressure Levels

10.1 Measurements of the average sound pressure levels shall be made in the reverberant field of the test room using a procedure that satisfies the requirements in Annex A1. The measurements shall be in a series of frequency bands specified in 9.5 for each of the tapping machine positions designated in 8.2.

10.2 *Background Noise Level*—Measurements of the background noise levels shall be made during each test to ensure that measurements of sound pressure level are not affected by extraneous airborne noise, operational noise of the tapping machine unrelated to impacts of the test specimen, or electrical noise in the receiving system. These measurements shall be made at the same microphone positions using the same analyzer gain settings used to measure sound pressure levels generated by the tapping machine.

10.2.1 Background noise shall be measured with the tapping machine operating, and placed on a minimum 1 in. thick pad of open cell foam rubber to eliminate the hammer impacts on the test specimen. The foam rubber pad shall be removed from the test room during all tests with the tapping machine impacting the test specimen.

10.2.2 If the background noise level is more than 10 dB below the combined level of signal plus background, then no correction is to be made.