Designation: E 1111 – 92 (Reapproved 1996)$^{\epsilon 1}$

Standard Test Method for Measuring the Interzone Attenuation of Ceiling Systems[1]

This standard is issued under the fixed designation E 1111; 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.

ϵ^1 NOTE—Keywords were added editorially in September 1996.

INTRODUCTION

This test method is one of a series for the measurement and evaluation of acoustical parameters affecting speech privacy in open-plan spaces. The maximum privacy theoretically available at normal working distances in open-plan spaces, with partial height space dividers (screens), is insufficient to cope with normal speech without the assistance of relatively elevated background masking sound levels. Thus, the provision of adequate speech privacy in open-plan offices and schools is one of the most difficult tasks in the architectural acoustics field. This test method provides a means of objectively measuring the relevant acoustical characteristics of one component in the open-plan space, the ceiling system.

1. Scope

1.1 This test method[2] is intended to provide measurements of the sound reflective characteristics of ceiling systems when used in conjunction with partial-height space dividers. This arrangement is commonly used in offices and schools to achieve speech privacy between work zones in the absence of full-height partitions. This test method is applicable to any ceiling configuration, including, for example, a pattern of sound-reflective panels in an otherwise sound-absorptive ceiling. This test method, as specified, is primarily restricted to measurements with a fixed space divider height of 1.50 m (60 in.), a ceiling height of nominally 2.70 m (108 in.), a source height of 1.20 m (48 in.), and microphone positions at 1.20 m (48 in.) height.

1.2 *Laboratory Accreditation*—A procedure for accrediting a laboratory for purposes of this test method is given in Annex A1.

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.*

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 423 Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method[3]

C 634 Terminology Relating to Environmental Acoustics[3]

E 1110 Classification for Determination of Articulation Class[3]

E 1179 Specification for Sound Sources Used for Testing Open Office Components and Systems[3]

2.2 *ANSI Standards:*

S1.6 Preferred Frequencies and Band Numbers for Acoustical Measurements[4]

S1.11 Specification for Octave Band and Fractional-Octave-Band Analog and Digital Filters[4]

S1.12 Specification for Laboratory Standard Microphones[4]

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *interzone attenuation*—at a specified position, for a one-third octave band, the difference between the sound pressure level at the nominal reference position 0.9 m (3 ft) from the sound source and the sound pressure level at the point in question.

3.1.2 *nominal interzone attenuation*—for a one-third

[1] This test method is under the jurisdiction of ASTM Committee E-33 on Environmental Acoustics and is the direct responsibility of Subcommittee E33.02 on Open Plan Spaces.

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[2] This test method is similar to a procedure developed by the U.S. Government General Services Administration, Public Buildings Service, designated 'PBS-C.2, Test Method for the Sufficient Verification of Speech-Privacy Potential Based on Objective Measurements including Methods for the Rating of Functional Interzone Attenuation and NC-Background.' August 1972.

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

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

octave-band, at a specified point, the arithmetic mean interzone attenuation calculated using the interzone attenuation for the point in question and for two adjacent positions 0.3 m (1 ft) to either side. For example, the nominal interzone attenuation at the 3.0-m (10-ft) position is the arithmetic mean of the interzone attenuations at the 2.7, 3.0 and 3.3-m (9, 10, and 11-ft) positions.

4. Summary of Test Method

4.1 The test facility (Fig. 1) is essentially an expanse of floor and ceiling in which all vertical surfaces have negligible sound reflections. The facility may be set up in a laboratory, in a mock-up of a proposed building, or in a completed building. The standard space divider is of such dimensions and construction that sound generated on one side can reach a measuring point on the other side only by way of diffraction over the top of the space divider and by reflection from the ceiling. With the diffracted component fixed by the dimensions of the space divider and by the height of the source and measurement position, the difference between the sound levels measured on each side of the space divider provides a comparative measure of the contribution of ceiling system reflection to the total sound transmission.

4.2 When the test is conducted in a mock-up of a proposed building or in a completed building, strict adherence to the test method may not be possible in that the conditions of ceiling height and plenum depth, etc., cannot be met because of the building design. Under these circumstances, the measurements apply only to that situation and other identical situations.

5. Significance and Use

5.1 The substitution of moveable part-height space dividers for fixed full-height partitions between work zones in open-plan offices and schools may introduce problems of inadequate speech privacy or distraction between zones. A space divider placed between zones serves as a partial sound barrier, but its effectiveness can be compromised by deflection of sound over the space divider by the ceiling. An evaluation of the sound reflective characteristics of a ceiling system may therefore serve as a useful design tool in providing the speech privacy required in a given open-plan layout. Although the potential speech privacy may be limited by other components of the

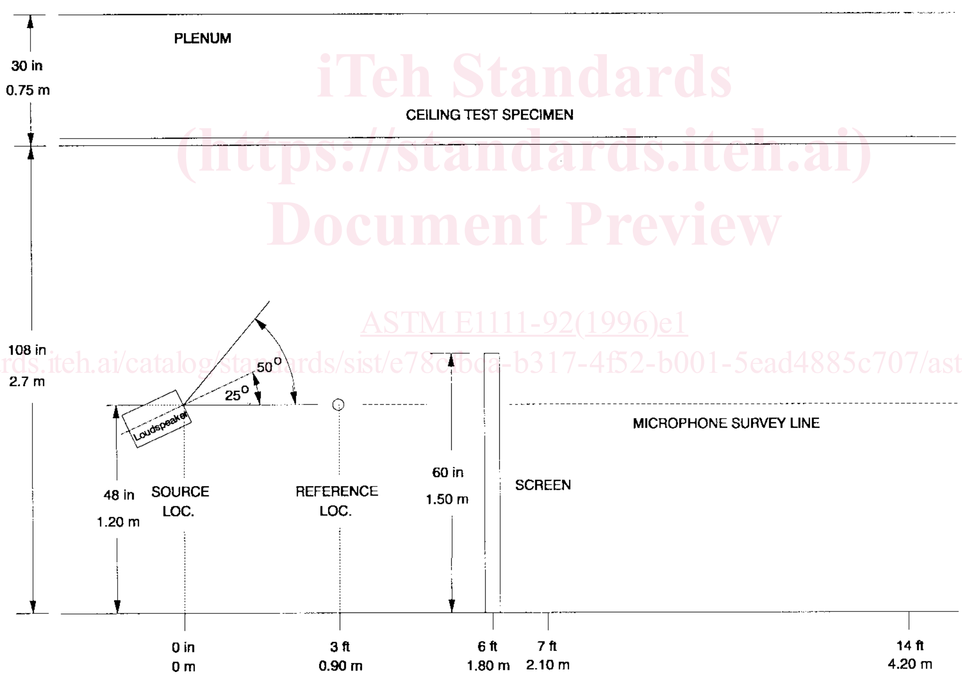

FIG. 1 Ceiling Test Facility

open-plan space, this document is concerned only with ceiling system performance in association with a specified space divider construction.

5.2 The provision of speech privacy in open-plan spaces is dependent upon many factors, the most significant of which are the following: *(1)* the *shadow* zone of part-height space dividers and the diffraction of sound from the edges of space dividers; *(2)* the primary sound reflective properties of the ceiling system; *(3)* the level of masking sound present in the space; and *(4)* the distance between speaker and listener.

NOTE 1—The first factor is standardized in this test method and the third is eliminated. Experience has indicated that results obtained by this test method may not fairly represent the speech privacy that may be achievable with nonflat ceiling systems.

5.3 The significance of test results obtained by this test method must also be considered with regard to the attainable measurement accuracy. The attainment of speech privacy in the presence of masking noise is critically dependent upon sound level of the speech relative to the masking sound; a change as small as 2 dB in either the speech or masking sound may change the privacy from significant to insignificant perceived speech intelligibility. The normally accepted test accuracies for sound attenuation measurements may be inadequate to evaluate ceiling systems having marginal interzone attenuation performance for open-plan space needs.

6. Laboratory Test Facility

6.1 The area of the facility shall be preferably at least 4.5 by 9 m (15 by 30 ft).

6.2 The floor shall be of a solid material such as concrete or plywood weighing at least 20 kg/m^2 (4 lb/ft^2). It shall be covered with carpet without underpad typical of those used in open plan spaces. The absorption coefficients of the carpet shall be measured in accordance with Test Method C 423, and the noise reduction coefficient (NRC) shall lie in the range from 0.2 to 0.4.

6.3 The walls shall have random incidence sound absorption coefficients of at least 0.9 for all test frequencies.

6.3.1 The wall covering sound absorption shall be measured in accordance with Test Method C 423 with a mounting equivalent to that used in the test facility.

6.4 The space divider shall be 1.50 m (60 in.) high and shall extend the full width of the facility between the side walls and shall be placed at least 2.70 m (108 in.) from both end walls. It shall have a core of rigid, impermeable material weighing not less than 7.0 kg/m^2(1.4 lb/ft^2), and shall be faced on both sides with a 50 mm (2.0 in.) thickness of sound absorbing material. The core shall extend fully to the top of the space divider, as shall the sound absorption facing material. The space divider shall have a minimum NRC of 0.80 when measured in general accordance with the provisions for testing office space dividers in Test Method C 423. There shall be no gap between the bottom of the space divider and the floor. If the space divider is assembled in sections, care shall be taken to minimize sound transmission at the joints.

7. Field Test Facility

7.1 For tests in a field prototype or completed building, the same degree of suppression of horizontal reflections shall be achieved as for the laboratory facility. This may be effected either by enclosing the test area temporarily with highly absorptive panels, by covering nearby reflective vertical surfaces with such materials, or by choosing a test site that is far removed from any reflective vertical surfaces.

7.2 The space divider shall be at least 4.5 m (15 ft) wide and of substantially the same construction as for the laboratory facility.

8. Apparatus

8.1 *Loudspeaker*, enclosed in a small box, driven by broadband or random noise. The loudspeaker shall meet the specifications and requirements of Specification E 1179.

8.1.1 The generated sound power shall be adequate to maintain one-third octave band sound pressure levels of at least 10 dB above the ambient noise levels of the test facility and the internal noise levels of the measuring instrumentation at each of the desired measurement locations.

8.2 *Microphone*—The microphone shall meet the requirements of ANSI S1.12 and shall have a free field correction of not more than 2 dB for sound waves at all measurement frequencies incident on the microphone diaphragm from 30 to 90°. The microphone shall be mounted vertically with the diaphragm pointing upwards.

8.3 *Filters*—Filters used with the microphone or source amplifiers shall conform to ANSI Specification S 1.11 for Order 3, Type 1, ⅓ octave-band filters.

9. Sampling

9.1 A ceiling system constructed as a specimen for this test method will be a complex assembly of many component parts. Therefore, a requirement for minimum sampling is impractical and not required. However, the individual components shall be randomly selected from normal stock.

10. Test Specimen

10.1 The ceiling to be tested shall cover the entire area of the laboratory facility, or at least a 4.5 by 9 m (15 by 30 ft) area in a field test facility. Its nominal level shall be 2.75 m ± 50 mm (9 ft ± 2 in.) above the floor, and it shall be suspended from a flat structural slab or deck with a plenum depth of not less than 0.60 m (24 in.) with a preferred depth of 0.75 m (30 in.). The upper and perimeter surfaces of the plenum shall be sound reflective. The plenum shall contain no ducts, beams, or similar obstructions that will affect the test results. The nominal ceiling level shall be defined as that of the exposed surface of a continuous flat ceiling, or of the lowest exposed surface of a nonflat ceiling. If, in a field test situation, the ceiling height and plenum conditions cannot be met, this test method may be used to evaluate the test setup and may not be used to obtain general interzone attenuation data for the ceiling system.

10.2 When the ceiling assembly includes differing elements in the horizontal plane, such as light fixtures or varying ceiling levels, the orientation with respect to the space divider and the sound measurement survey line shall be described and reported.

NOTE 2—In a ceiling containing both sound absorptive and reflective areas such as light fixtures, interzone attenuation values may vary widely depending on the location of the survey line with respect to the ceiling