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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Measuring the Interzone Attenuation of Sound Reflected by Wall Finishes and Furniture Panels[1]

This standard is issued under the fixed designation E 1376; 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 December 1994.
ε[2] NOTE—Fig. 1 was corrected in November 1996.

INTRODUCTION

This test method is one of a series for the measurement and evaluation of acoustical components affecting speech privacy in open-plan spaces. This test method provides a means of objectively measuring the degree to which sound reflected by furniture panels and wall finishes is attenuated.

1. Scope

1.1 This laboratory test method[2] measures the degree to which reflected sound is attenuated by the most commonly found vertical surfaces in open-plan spaces. Reflection of sound from vertical surfaces is a concern in open-plan spaces because it can reduce speech privacy. The vertical surfaces covered by this test method include wall finishes such as sound-absorbent panels, and furniture panels or screens. It does not cover such items as window finishes or furniture other than panels.

1.2 This test procedure was originally developed using the foot-pound system of units for prescribing measurement positions and distances. However, the use of SI units is preferred by ASTM. For this reason, dimensions are provided in SI units, with approximate foot-pound conversions indicated in parentheses.

1.2.1 Unless otherwise qualified, all dimensions specified in this test method shall be understood to have a tolerance of ±25 mm (±1 in.), even though the indicated approximate conversion of the numerical dimensions given will not always be accurate to this extent. All measurements shall be made in SI units or the corresponding exact foot-pound units.

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:*

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 795 Practices for Mounting Test Specimens During Sound Absorption Tests[3]

E 1110 Classification for Determination of Articulation Class[3]

E 1130 Test Method for Objective Measurement of Speech Privacy in Open Offices Using Articulation Index[3]

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

2.2 *ANSI Standards:*

S1.4 Specification for Sound Level Meters[4]

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*—For definitions of terms used in this test method, see Terminology C 634. The term *source point* is defined in Specification E 1179.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *furniture panel*—a furnishing that does not extend to the ceiling, and that is used to subdivide an open-plan space and provide some degree of visual and acoustical privacy. Furniture panels include interlocking systems furniture and freestanding screens.

3.2.2 *interzone attenuation*—at a specified position for a

[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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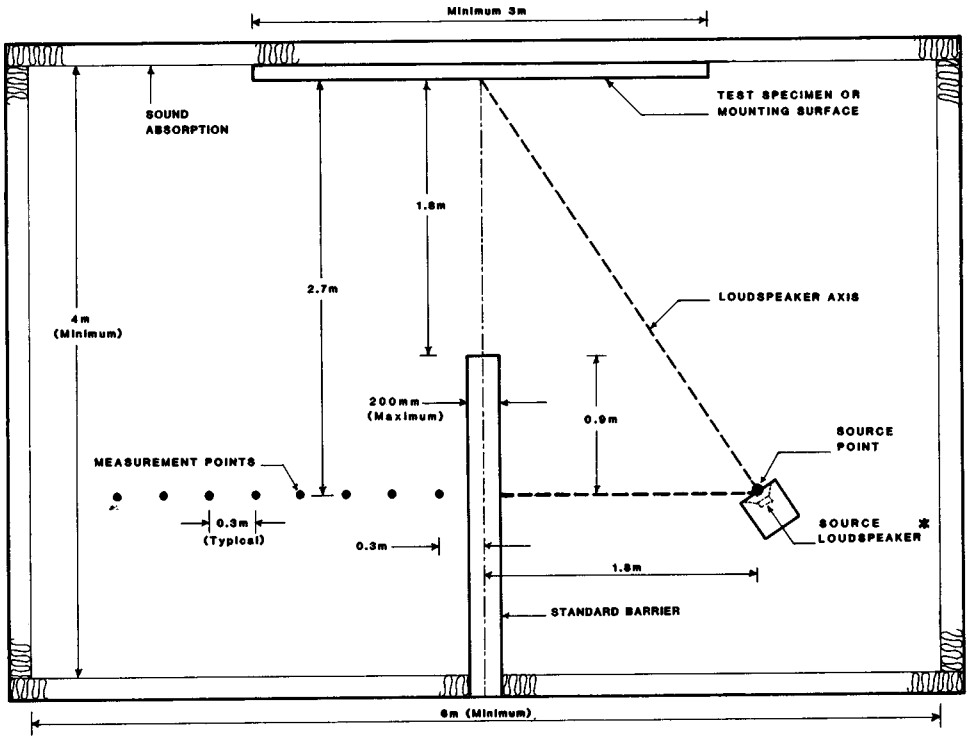
[2] This test method is similar to a procedure developed by the U.S. Government General Services Administration, Public Buildings Service, designated "PBS-C.2, Procedure X, Test Method for the Sufficient Verification of Speech-Privacy Potential Based on Objective Measurements Including Methods for the Rating of Functional Interzone Attenuation and NC-Background," April 1980.

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

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



NOTE 1—See Fig. 2 for measurement positions for reference levels.

FIG. 1 Plan of Test Arrangement

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

3.2.3 *nominal interzone attenuation*—for a one-third octave-band, at a specified position, the arithmetic mean interzone attenuation calculated using the interzone attenuation for the position 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. (See Fig. 1.)

4. Summary of Test Method

4.1 The test facility is a room constructed so that sound reflections from the walls and ceiling are negligible. Sound is generated on one side of a standard barrier that extends from floor to ceiling, with a gap at the end facing the test specimen, and is partially reflected by the test specimen to reach the other side. The difference in magnitude of the sound pressure levels measured on the source and receiving side of the barrier provides a measure of to what degree sound energy reflected from the specimen is attenuated (see Fig. 1). Sound-absorbent specimens will reflect less energy around the barrier than sound-reflective specimens. Two test conditions are established in this test method. Specimens that are wall finishes are applied over a sound-reflective side wall, whereas specimens that are furniture panels are placed against a sound-absorptive side wall.

5. Significance and Use

5.1 In open-plan spaces, furniture panels are often used in lieu of full height walls to visually and acoustically separate workstations. The use of these units, compared to full-height walls, can significantly lower the degree of speech privacy or noise isolation afforded between workstations. The degree of speech privacy or noise isolation between workstations depends on many factors. Sound may travel from one workstation to another by reflecting from the ceiling elements, or from columns, walls, windows, or furniture. It may also be diffracted over or around a furniture panel, or be transmitted through it. Thus, in designing or evaluating open-plan spaces, all possible propagation paths must be considered. The provision of adequate speech privacy in open-plan spaces requires the use of an acoustically absorbent ceiling and often a masking sound system, in addition to partial height acoustical barriers.

5.2 This test method assesses the sound reflected from vertical surfaces, such as furniture panels or wall finishes. This test method does not cover the testing of window finishes or other furniture. The measurement of the performance of other open-plan components, such as ceilings, is addressed by other test methods. Test Method E 1130 is available to evaluate the overall speech privacy between workstations that results from a specific configuration of components.

6. Apparatus

6.1 A sound source meeting Specification E 1179 is required.

6.2 Microphones shall meet the requirements in ANSI S1.12.

6.2.1 The microphones, as used, shall satisfy the requirements of 11.1.

6.3 Electronic instruments used to process the microphone

signals shall conform to the relevant sections of ANSI S1.4 and shall meet Type 1 requirements.

7. Test Facility

7.1 The preferred test facility is a hemi-anechoic room, a room with negligible reflections from the walls and ceiling, in the frequency range of the measurements. A room meeting the requirements of 7.2 is satisfactory. The floor shall be made from a hard, sound-reflective material, such as concrete or wood, covered with carpet as specified in 7.3.

7.2 The wall and ceiling coverings shall have random incidence sound absorption coefficients of at least 0.95 at all frequencies at which measurements are to be made.

NOTE 1—Since reflections from the walls and ceiling of the facility may reduce the measured sound attenuations with the specimen in place, it is important to eliminate these reflections as much as possible.

7.2.1 The random incidence sound absorption coefficients of the facility wall and ceiling coverings shall be measured in accordance with Test Method C 423 and Practices E 795. The mountings used for the test shall be those that will be used in the actual test facility.

7.2.2 Because specimens that are wall finishes are to be mounted on a hard, sound-reflecting wall surface, the sound absorbing material on this wall should either be demountable or be covered with a hard surface when the requirements of 8.1 are being satisfied.

7.3 The floor shall be of solid material such as concrete or plywood. It shall be covered with carpet, without underpad, typical of those used in open-plan spaces. The carpet shall have a noise reduction coefficient (NRC) in the range of 0.20 to 0.40 when measured in a Type A mounting (see Practices E 795) according to Test Method C 423. The carpet may be installed and tested using tape or adhesive.

7.4 The dimensions of the facility will limit the size of specimens that can be tested. The required minimum set of plan-view room dimensions is 4 by 6 m (13 by 20 ft) measured to the inner face of the absorptive coverings. The height of the facility, measured from the floor to the inner face of the sound-absorptive covering on the ceiling, shall be 2.7 m (9 ft).

NOTE 2—The facility may be intended for use with other test procedures whose requirements may be more or less stringent than these. These standards should be consulted so that for newly engineered facilities, an optimum design is achieved.

7.5 The standard barrier shall extend from the floor to the ceiling of the test facility and shall be no greater than 200 mm (8 in.) thick. It shall comprise a septum of rigid, impermeable material having a surface weight of approximately 10 kg/m^2 (2 lb/ft^2) such as 13 mm (0.5 in.) gypsum board or plywood, and sound-absorbing material on both sides of the septum. This sound absorbing material shall have a minimum noise reduction coefficient of 0.8 when measured in a Type A mounting (see Practices E 795) in accordance with Test Method C 423.

7.5.1 The bottom edge of the barrier shall fit snugly against the floor when installed in the test chamber. If the barrier is assembled in sections, care shall be taken to minimize sound leaks at the joints. At the end remote from the specimen, the barrier should be extended to meet the wall of the test chamber to prevent sound transmission.

7.5.2 The standard barrier shall be constructed to meet the requirements of 8.1.3 and 8.2.2. (See also Note 4 and Note 6.)

8. Test Specimens

8.1 *Wall Finishes*:

NOTE 3—It is anticipated that wall finishes tested using this test method will be chiefly sound absorbent and intended to attenuate reflected sound. However, hard, sound-reflective finishes such as gypsum board or wood paneling may also be test specimens. While it might appear unnecessary to install a sound-reflective specimen over a sound-reflective panel that is part of the test facility, it is not always possible to clearly distinguish in advance whether a specimen is reflective enough to require no backing. For this reason, *all* wall finishes are to be installed over a hard reflecting surface.

8.1.1 Mount specimens that are wall finishes on an impervious, hard-vertical reflecting surface such as gypsum board or plywood, with a surface mass of at least 10 kg/m^2 (2 lb/ft^2). The mounting surface shall be perpendicular to the plane of the standard barrier and shall extend at least 1.5-m (5-ft) on either side of it (see Fig. 1).

8.1.2 The specimen mounting surface shall extend from the floor to the ceiling of the test facility.

8.1.3 The perpendicular distance from the edge of the standard barrier to the nearest point of the specimen shall be 1.8 m (6 ft) (see Fig. 1).

NOTE 4—To satisfy the requirements of 8.1.3 and 8.2.2, it may be necessary to have an adjustable edge on the standard barrier or a removable hard mounting surface.

8.1.4 The specimen, whether applied as a continuous layer or an array of patches, should be mounted on the hard surface so that it is disposed symmetrically on either side of the centerline of the standard barrier. Small specimens may be butted together to form a larger specimen. If an interlocking method is normally used to join sections of the specimen, the specimen should be so mounted.

NOTE 5—Unless patches or spot treatments are being tested, the specimen should cover the full hard mounting surface. Otherwise, the sound-reflective properties of the exposed portion of the mounting surface may influence the test results.

8.1.5 If the specimen to be tested extends beyond the normal limits for the mounting surface, then the mounting surface must be extended so that it has at least the same lateral dimensions as the specimen.

8.2 *Furniture Panels*:

8.2.1 Furniture panels shall be tested with all walls of the test facility acoustically absorptive in accordance with 7.2. There shall be no hard mounting surface present.

8.2.2 The perpendicular distance from the edge of the barrier to the nearest point of the specimen shall be 1.8 m (6 ft).

NOTE 6—To satisfy the requirements of 8.1.3 and 8.2.2, it may be necessary to have an adjustable edge on the standard barrier or a removable hard mounting surface.

8.2.3 The vertical midline of the specimen shall coincide with the centerline of the standard barrier. The specimen shall be at least 2.0 m (6.5 ft) wide. If the specimen comprises sections joined together, a joint should not coincide with the vertical midline.

8.2.4 The lower edge of the specimen shall be no more than

0.5 m (1.5 ft) above the floor of the test chamber. The upper edge of the test specimen shall be at least 1.5 m (5 ft) above the floor of the test chamber.

8.3 Specimens may be tested with accessories such as shelves, cabinets, or work surfaces attached to them. Such attachments will alter the sound reflecting properties of the specimen, and the accessories as well as the position and method of attachment shall be described fully in the test report.

8.4 Specimens that are significantly asymmetrical, such as curved or irregularly shaped screens, or specimens with different accessories on each face, shall be tested twice, once with each side exposed to the sound source. The attenuations for each side shall be reported separately.

9. Test Signal

9.1 *Signal Spectrum*—The electrical signals used to generate the sound signals shall form a series of bands of random noise containing an essentially continuous distribution of frequencies over each test band.

9.1.1 The generated sound shall maintain, at each of the desired measurement locations, one-third octave-band sound pressure levels at least 10 dB above the background noise levels of the test facility and the measuring instrumentation.

9.2 *Bandwidth*—The measurement bandwidth shall be one-third octave. Specifically, the overall frequency response of the electrical system, including any filters in the source or sound measurement sections, shall for each test band meet the requirements of ANSI S1.11 for one third octave band filters of Order 3 or higher, Type 1 or better.

9.2.1 Filters in the sound measurement system serve to filter out extraneous noise lying outside the test bands, including possible distortion produced in the source system.

9.3 *Standard Test Frequencies*—The minimum range of measurements shall be a series of contiguous one-third octave bands with center frequencies from 200 to 5000 Hz conforming to ANSI S1.6. If desired, the range may be extended provided that the requirements of 9.1 and 7.2 are met.

10. Procedure

10.1 *Measurement of Sound Pressure Levels*:

10.1.1 Orient microphones so that for each frequency band they have a uniform directional response within ±1 dB in the plane that is parallel to the floor and that passes through the source point and the microphone. A vertical orientation of the microphone axis is preferred. Measure the directional responses of the microphones under laboratory-empty conditions, not with the specimen or barrier in place, or take from the manufacturer's literature.

10.1.2 Where multiple microphones are used, calibrate individually and make corrections for differences in sensitivity during the calculations.

10.1.3 *Loudspeaker Position*:

10.1.3.1 Position the sound source so that the loudspeaker axis is parallel to the floor and the source point is 1.2 m (4 ft) above the floor.

10.1.3.2 The source point is 1.8 m (6 ft) from the centerline of the barrier (see Fig. 1).

10.1.3.3 The source point and the measurement positions are on a horizontal line passing perpendicularly through the standard barrier, 0.9 m (3 ft) from its edge (see Fig. 1).

10.1.3.4 In plan view, the loudspeaker axis passes through the point where the centerline of the barrier intersects the face of the specimen (see Fig. 1).

10.1.4 *Measurement Positions*:

10.1.4.1 Position the microphone or microphones 1.2 m (4 ft) above the floor.

10.1.4.2 Measurements on the side of the barrier remote from the sound source are at distances of 2.1, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, and 4.2 m (7, 8, 9, 10, 11, 12, 13, and 14 ft) from the source point along a line perpendicular to the standard barrier and passing through the source point (see Fig. 1).

10.1.5 The reference sound pressure level in each one-third octave-band is the arithmetic average of the levels measured on the reference axis at 0.6, 0.9, and 1.2 m (2, 3, and 4 ft) from the source point (see Fig. 2). Obtain these values with no specimen or hard backing surface in place and with the carpet exposed. Alternatively, the reference values may be obtained with the source moved away from the specimen and walls, provided that any reflecting surfaces are covered with sound absorptive material.

10.1.5.1 Measure the electrical signal fed to the source and maintain it at the same level during the measurement of the sound transmitted beyond the test specimen. This may be accomplished by measuring the voltage fed to the loudspeaker.

NOTE 7—Some precision sound level meters are capable of being used as wide-band voltmeters by removing the microphone and driving them directly with an electrical signal. (Consult instruction manual for applicability.)

11. Calculation

11.1 Determine the interzone attenuations for each receiving position in each one-third octave band by calculating the difference, rounded to the nearest decibel, between the reference sound pressure level and the level measured at the receiving position.

11.2 Calculate the nominal interzone attenuations for each of the 2.4, 2.7, 3.0, 3.3, 3.6, and 3.9-m (8, 9, 10, 11, 12, and 13-ft) positions. (See 3.2.3.)

12. Single Number Classification

12.1 The articulation class (AC) shall be calculated in accordance with Classification E 1110 for the 2.4, 2.7, 3.0, 3.3, 3.6, and 3.9-m (8, 9, 10, 11, 12, and 13-ft) nominal interzone attenuations and reported with the distance clearly identified.

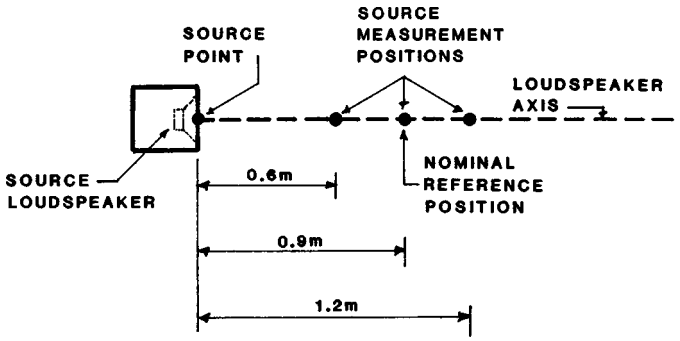


FIG. 2 Measurement Positions for Reference Levels

The minimum of these six AC values may be reported as the "minimum articulation class" without a qualifying distance.

13. Report

13.1 The report shall include a statement, if true in every respect, that the tests were conducted in accordance with the provisions of this test method. Any deviations from this test method shall be fully reported.

13.2 A complete description of the assembly under test shall be given, including all of the essential construction and dimensions. The test report shall indicate if this description has not been determined by direct examination. The report shall clearly indicate whether the specimen was tested as a wall finish or furniture panel.

13.3 Tabulate the measured interzone attenuations calculated in 11.1 to the nearest 1 dB for all positions and frequencies examined.

13.4 Report the nominal interzone attenuations calculated in 11.2 and the articulation class values calculated in 12.1. If the minimum articulation class is reported, also note the corresponding distance.

13.5 Where both faces of a specimen are tested as in 8.4, the measured interzone attenuations, nominal interzone attenuations, and articulation class values shall be reported separately for each face.

14. Precision and Bias

14.1 The precision associated with the measurement of sound pressure levels depends on the nature of the instrumentation used; for example, sound level meter, level recorder, or digital analyzer.

14.2 The bias of level measurements and differences is determined by the bias of all the associated instrumentation. Any inaccuracies in this area should be made negligible by careful calibration.

14.3 The precision of this test method should be determined annually by the testing laboratory by performing several tests on a single specimen. The specimen should be removed and reinstalled after each test. Where tests are performed in front of an absorbing wall (as in 8.2), interzone attenuations in the absence of any specimen should also be measured. In a laboratory routinely carrying out tests under this test method, such precision checks should be carried out within 6 months of any tests.

14.4 Studies are planned to evaluate the reproducibility of this test method.

15. Keywords

15.1 acoustical component; architectural acoustics; component test; furniture panel; interzone attenuation; open office; open office component; open-plan space; sound reflection; speech privacy; wall finish

ANNEX

(Mandatory Information)

A1. GUIDE FOR ACCREDITATION OF TESTING LABORATORIES

A1.1 Scope

A1.1.1 This annex provides guidelines for agencies evaluating testing laboratories for the purpose of granting accreditation for this test method.

A1.2 Referenced Documents

A1.2.1 *ASTM Standards*:

C 634 Terminology Relating to Environmental Acoustics[3]

E 548 Guide for General Criteria Used in Evaluating Laboratory Competence[5]

A1.3 Terminology

A1.3.1 *Descriptions of Terms Specific to This Annex*—The acoustical terminology used in this annex is consistent with Terminology C 634 and Guide E 548.

A1.4 Organization of the Agency

A1.4.1 A description of the organization shall be given following the requirements of Guide E 548.

A1.5 Human Resources of the Agency

A1.5.1 A description of the agency personnel responsible for testing shall be supplied following the requirements of Practice E 548.

A1.6 Facility Requirements

A1.6.1 The laboratory shall produce test data demonstrating compliance with the requirements of 7.2, 7.2.1, 7.3, and 7.5.

A1.7 Source Requirements

A1.7.1 The laboratory shall produce test data demonstrating compliance with 6.1.

A1.8 Requirements for Analysis and Measurement

A1.8.1 The laboratory shall have evidence that the microphones used meet the requirements of 6.2 and 10.1.

A1.8.2 The laboratory shall have evidence that the instruments meet the requirements of 6.3.

A1.8.3 The laboratories shall have evidence that the filters used meet the requirements of 9.2.

A1.8.4 The laboratory shall produce test data to show that background noise levels for the facility will meet the requirements of 9.1.1.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

A1.9 Precision and Bias

A1.9.1 Calibration records shall be produced to demonstrate compliance with 14.2.

A1.9.2 The data obtained from the procedure in 14.3 shall be produced to demonstrate that the requirements of 14.3 are satisfied.

A1.10 General

A1.10.1 Instruments, techniques, and individual capabilities may vary between testing laboratories. The accrediting agency should ensure that its accrediting personnel are competent to deal with and correctly evaluate unusual instruments or techniques.