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Standard Guide for Open Office Acoustics and Applicable ASTM Standards[1]

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INTRODUCTION

~~There are no full height partitions in an open-plan office to block sound transmission between adjacent work stations. Instead, partial height barriers, a sound absorbing ceiling and absorption on vertical surfaces are used to provide sound attenuation between individuals. These, in combination with work station layout and appropriate levels of broad band masking sound are used to obtain acceptable degrees of acoustical privacy.~~Office environments include open and closed spaces with varying acoustical performance requirements depending on space function and occupant needs. Sound control tools and methods are identified which combine to provide appropriate amounts of speech privacy, freedom from distraction and acoustic comfort whether in focus, private, collaborative or other office areas.

1. Scope

1.1 This guide discusses the ~~acoustical~~ principles and interactions that affect the acoustical ~~environment and acoustical privacy in the open office. In this context, it~~ performance of open and closed offices. It describes the application and use of the relevant series of ASTM ~~standards that apply to the open office.~~standards.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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
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
E795 Practices for Mounting Test Specimens During Sound Absorption Tests
E1007 Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures
E1110 Classification for Determination of Articulation Class
E1111 Test Method for Measuring the Interzone Attenuation of Open Office Components
E1130 Test Method for Objective Measurement of Speech Privacy in Open Plan Spaces Using Articulation Index
E1179 Specification for Sound Sources Used for Testing Open Office Components and Systems
E1414 Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum

[1] This guide is under the jurisdiction of ASTM Committee E33 on Building and Environmental Acoustics and is the direct responsibility of Subcommittee E33.02 on ~~Open Plan Spaces~~Speech Privacy.

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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.

E1573 Test Method for Measurement and Reporting of Masking Sound Levels Using A-Weighted and One-Third-Octave-Band Sound Pressure Levels
E2638 Test Method for Objective Measurement of the Speech Privacy Provided by a Closed Room
E2964 Test Method for Measurement of the Normalized Insertion Loss of Doors

3. Summary of Guide

3.1 *Acoustical ~~Privacy—~~Performance—*~~The attenuation of sound between neighboring work stations in an open-plan office is typically much less than that potentially available between closed-plan offices. Nevertheless,~~ Acoustics in open and closed office spaces must be considered during the design stage in order to provide occupants with an appropriate degree of speech intelligibility and speech privacy while minimizing noise distraction as appropriate for the space usage. Speech privacy and distraction are controlled by the ratio of intruding voice level to background sound. In the open plan, a degree of ~~acoustical privacy~~ speech privacy, noise control and comfort can be achieved if component selection and interaction are understood. A successful open plan office is the result of careful coordination of ~~the several components, ceiling, wall treatments,~~ many components, including those which influence the transmission of sound, such as the ceiling, furniture and furnishings, flooring, wall treatments and lighting; the heating, ventilating and air-conditioning ~~system, and masking sound system.~~system which limits maximum background noise levels and the sound masking system which controls minimum background sound levels. (See Section ~~7~~6.) In closed plan offices, many of the same considerations are taken into account with the important addition of partition construction methods.

~~3.1.1 This guide delineates the role and interaction of the several components and the application of the relevant ASTM Standards.~~

3.2 This guide delineates the role and interaction of these components and the application of relevant ASTM Standards.

4. Significance and Use

4.1 This guide is intended for the use of architects, engineers, office managers, and others interested in designing, specifying, or operating ~~open offices.~~office environments.

4.2 It is not intended to be applied to other ~~than office~~ environments, for example, open plan schools.

4.3 While this guide attempts to clarify the many interacting variables that influence ~~office privacy,~~acoustical performance, it is not intended to supplant the experience and judgment of experts in the field of acoustics. Competent technical advice should be sought for success in the design of ~~open~~ offices, including comparisons of test results carried out according to ASTM standards.

5. General ~~Open~~ Office Acoustical Considerations

~~5.1 *Introduction—Attenuation with Distance*—In almost any enclosed space, there is some reduction of sound level with distance. In many typical spaces, this decrease of sound level with distance is affected by sound reflections from the ceiling, the walls, and floor. In the open plan office the goal is to maximize this loss with distance in order to improve acoustical privacy. This requires a highly absorbent ceiling, some absorption on the floor, and careful treatment of nearby vertical surfaces. The ideal is to approach the conditions of the outdoors, where there are no reflecting surfaces.~~

~~5.2 Attaining acoustical privacy between work stations, open or closed plan, is determined by the degree to which the intruding sounds from adjacent work stations exceed the ambient sound levels at the listener's ear.~~

5.1 *Signal to Noise Ratio—*~~The sound pressure levels arriving at the listener's ear from sources in adjacent work stations depend on the following:~~Noise intrusion and the level of acoustical privacy between work spaces, in either open or closed plan, is determined by the degree to which the sounds from a nearby work space exceed the background sound levels. It is essential that both the spread of sound from voices and other sources and the background sound are carefully controlled. The following attributes apply regardless of the source of the intruding sound.

5.1.1 The sound source amplitude, directivity, and orientation.

5.1.2 The total attenuation of the sound due to a combination of distance and shielding by intervening ~~barriers.~~barriers and attenuation due to sound absorptive surfaces.

5.1.2.1 *Absorption*—In the open plan office, the goal is to maximize attenuation with distance in order to improve sound isolation. This may require a highly absorptive ceiling, some absorption on the floor, and careful treatment of some vertical surfaces. Where the highest level of sound attenuation is required, the ideal is to approach the conditions of the outdoors, where there are no reflecting surfaces. In both open and closed spaces, absorption reduces sound reflection and reverberation which contributes to acoustic comfort.

5.1.2.2 *Sound Barriers*—Sounds passing through, over or around a physical barrier will be reduced in level. Barriers, such as walls, windows, doors and workstation partitions are an essential part of both open and closed plan acoustical design. The acoustical performance of each will depend on their design and construction.

5.1.3 The ~~reinforcement of the direct~~ strengthened spread of sound due to reflections from office surfaces such as the ceiling, furniture panels, light fixtures, walls, and windows.

5.1.4 The level and spectrum of ~~ambient~~background sound at the listener's ~~ear. This will often be generated and controlled by a sound masking sound system, but in certain positions and frequency ranges, heating, ventilating, and air conditioning equipment~~

~~(HVAC) may contribute significantly to the ambient sound level.~~ear generated by sources other than speech. To ensure predictable levels of speech privacy where insufficient levels of continuous minimum background sound exist, electronic sound masking systems offer the best means of raising the ambient sound level in a tunable (optimized) manner.

5.2 *Density*—~~The attributes in~~Occupant density affects ~~5.3.1 through~~ both ~~5.3.4 apply regardless of the source of the intruding sound. In the open plan, both office equipment and speech are the dominant intruding sources. In many cases, the provision for acceptable speech privacy is the major concern.~~ the number and proximity of people in a given space. Higher density results in both greater noise and distraction from increased quantity of conversation and activity.

5.3 *Layout*—~~Office layout should~~ The open office layout must consider needs for isolation and concentration or collaboration and ease of communication between workstations as appropriate. Where the need for concentration is of higher importance, the layout can be designed to ~~avoid obvious noise intrusion possibilities. Individual~~ assist in minimizing noise intrusion. For example, individual work stations should be positioned relative to columns, walls, and each other to avoid uninterrupted sound paths between contiguous work stations. Occupant orientation is also important, because there is a significant difference ~~between~~in the sound level when a talker faces a listener versus the talker facing away from the listener, of the order of 9 ~~dB.~~dBA. In a closed plan space, door openings on either side of a corridor should be staggered.

5.4 ~~*Loud Noises—*~~*Undivided Workspaces*— ~~Distractions caused by raised voices or loud office equipment usually cannot be controlled by normal open office constructions. It is recommended that some closed plan spaces be provided to contain such loud equipment or enclose noise sensitive spaces such as conference rooms.~~Collaborative open office design has all but eliminated vertical barriers in order to foster communication and interaction between coworkers. For job functions requiring freedom from distraction in the open plan, it may be achieved with the inclusion of appropriate sound barriers. In open spaces with workstation partitions below seated head height, acoustical performance may be improved by the addition of acoustical absorption and sound masking, but an expectation of speech privacy or significant noise isolation is unrealistic in this circumstance.

5.5 ~~*Problem Noise Sources—*~~*Intrusive Noises*—~~Computers, business machines, copiers, typewriters, and other noise generating devices~~ Distraction caused by raised voices or noisy equipment may not be sufficiently controlled by open office constructions. Spaces requiring increased speech privacy and noise isolation such as conference rooms should be designed using appropriately higher sound isolation criteria. Noise generating devices and occupant functions should be located in isolated ~~(enclosed)~~enclosed rooms or areas to minimize ~~their~~ noise intrusion into ~~the work station. Where this is impractical, care should be exercised in eliminating or minimizing the noise generation aspects. Telephones and "speaker phones" are a frequent problem. The former should be equipped with flashing lights, rather than ringers (audible annunciators). Large typing pools or word processing~~ other work spaces. For example, speaker phones and call centers can generate ~~A-weighted sound levels up to 80 dB. These activities~~ high sound levels. These should be contained in special work areas affording adequate noise isolation from the surrounding ~~open plan spaces.~~spaces. Care should be exercised in eliminating or minimizing the noise generation aspects. Open office etiquette guidelines should be established and enforced.

~~5.8 *Undivided Workspaces*—Acoustical comfort may be improved in undivided workspaces such as "bull-pen" offices, drafting rooms, and typing pools by the addition of acoustical absorption to horizontal and vertical surfaces, but no such treatment alone will provide speech privacy.~~

5.6 *Component Testing*—ASTM test methods exist for testing components and systems for open plan offices. These include measuring the attenuation between work stations by the ceiling ~~path ,~~ path, the effect of barriers such as furniture panels, the effect of flanking or reflections from vertical surfaces (see Test Method E1111), measurement of masking sound in the open office (see Test Method E1573), and the determination of the articulation class (see Classification E1110~~),~~) that is a single number rating of system component performance. Articulation class does not account for the effect of masking sound.

5.7 *Objective ~~Determination~~Measurement of Speech Privacy*—Test Method E1130 describes a method of objectively measuring the speech privacy in open plan ~~offices. It is based on a determination of the~~offices, using the articulation index (AI). Test Method E2638 ~~articulation index.~~describes a method of objectively measuring the speech privacy in enclosed rooms, using the speech privacy class (SPC). AI and SPC results are applicable only between the two measurement positions and cannot be used to generalize over wide areas as there are many factors which will affect the speech privacy levels from one location to the next.

~~5.10.1 *Articulation Index*—The articulation index (AI) is a computational method for predicting the intelligibility of speech for groups of talkers and listeners. The AI is a weighted fraction representing, for a given speech frequency band and noise condition, the effective proportion of the standard speech signal that is available at the listener's ear for conveying speech intelligibility.~~

~~5.10.1.1 The articulation index ranges from 0.00 to 1.00, with 0.00 representing zero intelligibility and 1.00 complete intelligibility.~~

~~5.10.1.2 Speech privacy may be described as *confidential* when speech may be detected but not understood.~~

~~5.10.1.3 Speech privacy may be described as *normal* or *non-intrusive* when effort is required to understand the intruding speech. Normal speech privacy may also be described as the absence of distraction.~~

~~5.10.1.4 Confidential speech privacy occurs at an AI of 0.05 or less. Speech becomes more readily understood with AI values greater than 0.20; at values greater than 0.40 there is essentially no privacy.~~

~~NOTE 1—Additional research is needed to verify the relation between the AI and the subjective judgement of *normal* privacy in the open plan. (See the appendix of Test Method E1130.)~~

6. Components of ~~the Open Plan~~ Open Office and Closed Office Acoustical Environment

6.1 ~~*Ceilings:*~~ *Ceiling Systems, Open Plenum Systems, and Integrated Devices:*

~~6.1.1 The sound absorbing characteristics required of the ceiling plane for open plan systems are different than those for private offices or conference rooms. In open plan spaces, sound from the source not controlled by part-height space dividers travels toward the ceiling plane, where part can be reflected back into the adjacent work space. To minimize the reflected sound, the ceiling must absorb most of it. In private offices or conference rooms, some lesser absorption or greater reflection may be desirable.~~

~~6.1.2 The sound barrier characteristics of the ceiling plane helps provide spatially uniform masking sound from loudspeakers located in the ceiling plenum. If the sound barrier performance is low or variable, it may lead to the perceptions of "hot spots" in the masking sound. Some masking system designs may compensate for these deficiencies or variations.~~

~~NOTE 2—There is currently no accepted objective method of specifying single-pass sound barrier performance of ceiling materials.~~

6.1.1 *General Goals*—~~Lighting fixtures mounted in the ceiling must be chosen with care. Flat, lensed fixtures tend to reflect sound specularly and should be avoided. Parabolic cell fixtures, are preferred because they tend to scatter incident sound. The sound barrier characteristics of the fixtures should also be similar to that of the ceiling, to avoid masking sound "hot spots" underneath them.~~Acoustical ceiling finishes for open-plan and closed offices should be selected to achieve the chosen office acoustics design requirements, including maximum limits for reverberation times. Ceiling finish material options can include suspended acoustic tile ceiling systems, baffles, banners, and clouds. Acoustical ceiling finishes for open-plan offices are additionally chosen to reduce noise levels generated by activities, and to improve speech privacy between work stations by reducing direct and reflected sound propagation. Goals for designs of ceiling finishes in closed offices, meeting rooms, training rooms, and conference rooms include the optimizing of speech intelligibility within the space. Further goals of the design of a continuous suspended ceiling system can be to attenuate sound emitted from plenum-installed ducts and mechanical components, and to attenuate airborne and impact sound generated on the building floor above.

~~6.1.4 Other ceiling elements, such as return air grilles or fixtures, must also be selected with care, to avoid leakage of sound from the masking system or surface reflections of incident sounds.~~

~~6.1.5 In closed plan spaces frequently associated with open plan areas, the absorption characteristics of the ceiling are of less importance than its sound barrier characteristics. An accepted method of specifying this performance is by the two-room method, in Test Method E1414, that evaluates the sound passing through one ceiling into the plenum and then back down through the ceiling into the adjacent space. Where open and closed plan spaces are adjacent, masking sound is frequently useful for providing speech privacy in both spaces. The barrier and absorption characteristics of the ceiling system should be optimized where open and closed spaces will be mixed.~~

6.1.2 *Sound Absorption Rating*—The sound absorption ratings of acoustical ceiling finishes are measured in a laboratory using Test Method ~~E1111~~C423 ~~is the~~ , which determines a single number rating, the sound absorption average (SAA). Test Method E795~~preferred method of determining the~~ describes how these various materials are to be mounted during the absorption testing. For ceiling panels used in open office areas, the preferred laboratory absorption test method is Test Method E1111~~ceiling absorption characteristics.~~ . It is a component test and is restricted to measurement with a fixed-height space divider, fixed sound source height, and microphone positions. A single number rating, ~~convenient for ranking the performance of the ceiling,~~ articulation class, is obtained using Classification E1110. Specification E1179 ~~specifies~~defines the directional characteristics of loudspeakers used in this and similar tests.

~~NOTE 3—Articulation class is the preferred measure of the absorption properties necessary for acceptable open plan ceiling performance; sound absorption ratings derived from reverberation room measurements should not be used.~~

6.1.3 *Sound Isolation Rating*—The airborne sound attenuation between closed offices is an important office design factor. Optimal sound isolation is achieved when demising partitions are designed to extend to the deck above. Closed offices are sometimes designed with partitions that extend only to the installed suspended acoustic tile ceiling system, which provides a common ceiling plenum over the rooms. The sound attenuation between rooms with a ceiling system over a demising partition and a common plenum can be measured in a laboratory using Test Method E1414, which determines a single-number rating, the ceiling attenuation class.

6.1.4 *Lighting*—Light fixtures must be chosen with care. Flat lensed fixtures reflect sound and therefore should be minimized and (if used) not located directly above dividers in open office areas. Suspended light fixtures are an ideal choice, as they allow for a higher percentage of acoustic material to be used in the ceiling, do not degrade the ceiling sound attenuation and provide the opportunity to use open plenum systems such as baffles and clouds.

6.1.5 *Air Distribution System*—When a contiguous plenum exists above a ceiling system, it is often used as a return air plenum. The return air grilles in the ceiling can create significant flanking sound paths that can allow sound transmission between rooms through the ceiling and plenum. Air return baffles (or "boots") can help to maintain the acoustical integrity of the ceiling system.

6.1.6 *Isolation Strategy*—When rooms are enclosed, in part to provide speech privacy, care must be taken to consider the isolation strategy in terms of wall assemblies, plenum barriers, ceiling systems, the prevention of noise flanking paths and the control of the minimum continuous background sound level using sound masking.