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Acoustics — Measurement of room acoustic parameters —

Part 3: Open plan offices

Acoustique — Mesurage des paramètres acoustiques des salles — Partie 3: Bureaux ouverts

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 126, *Acoustic properties of building products and buildings,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 3382-3:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

— new single-number quantity, comfort distance, added, and privacy distance removed;

— sole use of omnidirectional sound source in all measurement phases emphasized;

— definitions (Clause 3), measurement conditions (Clause 4), and determination of single-number values (Clause 5) clarified;

— use of impulse response method better described and a new Annex B added;

— Clause 6 “Precision” and an informative Annex D were added;

— STI is determined in conformity with IEC 60268-16 using weighting factors α and β for male gender;

A list of all parts in the ISO 3382 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Open-plan office is a large and open office space where large number of occupants can simultaneously work in well-defined workstations. Both flexible offices and activity-based offices often involve spaces that resemble open-plan offices. Open working areas, which can be considered as open-plan offices, can also be found in many libraries, hospital wards, industrial workplaces, and schools.

Noise and lack of speech privacy are among the largest contributors to environmental dissatisfaction in open-plan offices[1]. Colleagues' speech is the main source of office noise. Inadequate room acoustic design of the office is one reason to the perception of noise and lack of speech privacy. Distraction due to colleagues' speech weakens the ability to concentrate and reduces work performance, especially in tasks requiring cognitive resources. Insufficient speech privacy prevents confidential conversations. Several experimental studies suggest that distraction can be reduced by reducing speech intelligibility[2] [3]. A large field survey supports that reduced speech intelligibility is associated with reduced noise disturbance[4]. According to Reference [4], many of the single-number quantities described in this standard are associated with the perceived noise disturbance in open-plan offices.

The outcomes of this method describe the acoustic performance of the open-plan office in a standardized condition where a single occupant is speaking with normal speech effort[5]. The background sound caused by building appliances or sound masking system is considered in the measurements. The measurements are conducted in an unoccupied open-plan office because the method concerns the permanent building properties and stable room acoustic conditions as well as ISO 3382-1 and ISO 3382-2. The activity sound caused by the occupants does not belong to the scope of this standard, although the level of activity sound can be significantly larger than the level of background sound.

The method uses omnidirectional sound source to provide reproducible results between measurement operators. Furthermore, the speaking direction of occupant in the office workstation is not always known nor constant in time. The use of directional sound sources would lead into different results between measurement operators due to different choices of source direction and source directivities.

Room acoustic quality can be affected by the amount and positioning of wall and ceiling sound absorption materials, room geometry, workstations, screens, other furniture, floor coverings, and background sound level (e.g., masking sound). Presentation of acoustic design guidelines is beyond the scope of this document because literature gives sufficient advice how to reach good room acoustic quality[5][6][7].

Acoustics — Measurement of room acoustic parameters —

Part 3:
Open plan offices

1 Scope

This document specifies a method for the measurement of room acoustic parameters in unoccupied open-plan offices. It specifies measurement procedures, the apparatus needed, the coverage required, the method for evaluating the data, and the presentation of the test report.

This document describes a group of single-number quantities indicating the room acoustic performance of an open-plan office in a condition when one person is speaking. They focus on spatial decay of speech while the quantities in ISO 3382-2 focus on temporal decay of sound.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3382-1, *Acoustics — Measurement of room acoustic parameters — Part 1: Performance spaces*

IEC 60268-16, *Sound system equipment — Part 16: Objective rating of speech intelligibility by speech transmission index*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
omnidirectional sound source
OSS
sound source which radiates sound evenly to all directions

3.2
spatial decay rate of speech
$D_{2,S}$
rate of spatial decay of A-weighted sound pressure level (SPL) of speech per distance doubling in decibels

Note 1 to entry: $D_{2,S}$ describes how fast the A-weighted SPL of speech attenuates in the open-plan office when the distance to OSS increases. Large value means strong room acoustic attenuation. In free field, $D_{2,S}$ = 6 dB.

3.3
speech level at 4 m distance
$L_{p,A,S,4m}$
A-weighted SPL of speech in decibels at the distance of 4,0 m from the middle point of the OSS

Note 1 to entry: Distance between nearby workstations is usually less than 4,0 m. Small value means strong room acoustic attenuation near the OSS.

3.4
comfort distance
r_C
shortest distance from the middle point of the OSS where the A-weighted SPL of speech is lower than 45 dB

Note 1 to entry: Comfort distance reduces with increasing $D_{2,S}$ and decreasing $L_{p,A,S,4m}$.

3.5
background noise level
$L_{p,B}$
unweighted SPL of background noise in decibels at the workstations along the measurement path during working hours when occupants are absent

3.6
speech transmission index
STI
quantity describing the transmission quality of speech from speaker to listener

Note 1 to entry: STI is based on IEC 60268-16.

3.7
distraction distance
r_D
shortest distance from the middle point of the OSS where the STI is lower than 0,50

Note 1 to entry: Distraction distance reduces with decreasing r_C and increasing $L_{p,B}$. Smaller values are associated with higher levels of speech privacy. Annex A gives a psychological reasoning of distraction distance.

3.8
workstation
furniture ensemble containing at least one chair and one table having a minimum size of 70 cm x 70 cm

Note 1 to entry: Workstation can also contain other components, such as table-mounted or floor-mounted screens, storage units, display units, or luminaires.

3.9
sound masking system
centralized or networked electronic system used to produce spatially constant background sound in the workstation area

4 Measurement conditions

4.1 Equipment

4.1.1 Sound source, OSS shall be used in all measurements. The requirements given in ISO 3382-1 for the OSS within 125 Hz to 4 000 Hz shall be fulfilled for measurements to be in accordance with this document.

NOTE There are no requirements for the 8 000 Hz octave band.

4.1.2 Microphone, SPLs in each octave band and at each microphone position shall be measured using a sound level meter meeting the requirements of IEC 61672-1, class 1. The microphone shall be omnidirectional considering any supplementary equipment connected to it.

4.1.3 Analyser, the octave-band filters of the analyser or analysis software shall comply with IEC 61260. If the signal is recorded, the recording device shall have the characteristics described in ISO 3382-1.

4.1.4 Calibrator, the acoustical sensitivity of the measurement system shall be checked using a sound calibrator that complies with IEC 60942. This is done both before and after each measurement series. The results of the calibration checks shall be documented. A difference of more than 0,5 dB between calibration checks shall be an argument to repeat measurements. It is recommended that the calibration is checked when batteries of the measurement equipment or open-plan office is changed.

4.2 Measurement procedure

4.2.1 Measurement conditions

Measurements can be conducted in open-plan offices of any kind and with any configuration of ceiling absorbers, wall absorbers, sound masking systems, floor coverings, fixed partitions, workstations, screens, storage units, and other furniture, whether they are fixed or mobile. The results are valid only to the specified configuration which prevails during the measurement. Therefore, it is mandatory to report the abovementioned configurations along with the measurement results.

Background noise means all continuous or non-transient sounds, which are present during normal working hours and are not caused by the occupants. Such sounds are, e.g., heating, ventilation, and air conditioning (HVAC) devices, environmental noise caused by sources outside the building, and electronic sound masking system.

The HVAC devices shall operate on the same power as during typical working hours. If the office is equipped with a sound masking system, it shall be switched on during the measurement. Sound masking shall operate at the same level and with the same spectrum as during typical working hours. Adaptive masking systems can be tested separately for minimum and maximum levels. Appliances such as refrigerators, printers, coffee machines, radios, and video projectors shall be shut down if they increase the background noise level in any measurement position. Windows and balcony doors shall be closed. Occupants shall not be present in the workstations involving measurement positions or OSS.

If the table heights are electrically adjustable, the tabletop height shall be set to (75 ± 5) cm from the floor corresponding to the tabletop height of a sitting occupant. The setting shall be made in the workstations located along the measurement path and in the workstation containing the OSS.

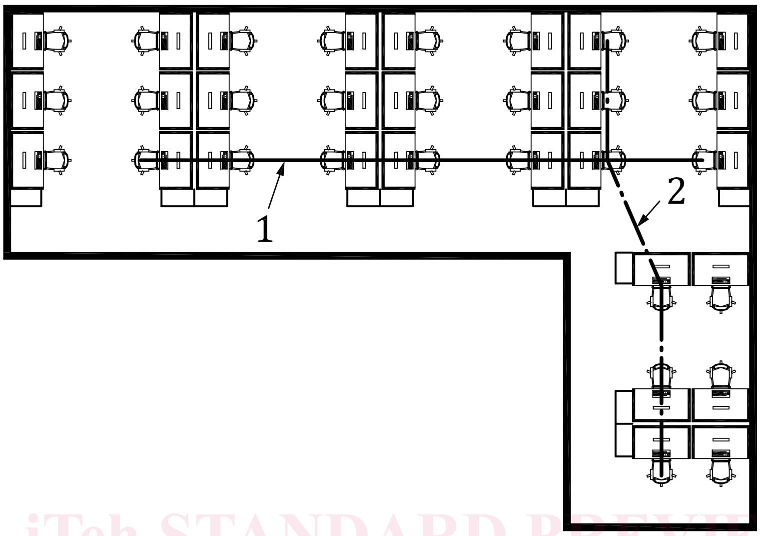
4.2.2 Acoustic zones and measurement paths

Acoustic zone means an area in the open-plan office, where the absorption treatment, room height, and workstation layout are similar. Open-plan office can contain one or several acoustic zones. If the open-plan office contains two or more acoustic zones, the measurements should be conducted in each of them. Separate results are reported for each acoustic zone, where measurements have been conducted.

At least two separate measurement paths shall be used per acoustic zone. If only one measurement path is possible in a zone, measurements shall be conducted in both directions along this measurement path.

4.2.3 Source and microphone positions

The measurements shall be conducted along a straightest possible path which crosses over workstations, as shown in Figure 1.



Key

1 straight measurement path

2 non-straight measurement path

Figure 1 — Example of a straight and a non-straight measurement path in an open-plan office, where workstations and other furniture are present

(position of the OSS is in the end of a path)

If the acoustic zone contains high piece of furniture (such as screens, dividers, or storage units being higher than 1,20 m) between workstations, the measurement path should be chosen in such a way that there is such a high piece of furniture between the OSS and the first measurement position.

The OSS is located at the workstation at the end of the path. The OSS shall be located at the position of a sitting occupant's head in a workstation. The middle point of the OSS shall be at the height of 1,20 m above the floor. The distance between the middle point of the OSS and a nearest table shall be at least 0,40 m. The distance between the middle point of the OSS and nearest wall of the room shall be at least 1,00 m. Discrepancy from this requirement shall be mentioned in the report.

All workstations along the measurement path shall be measured and considered in the analysis. The number of measurement positions on a path shall be at least four. In other words, measurements according to this standard are only possible if measurement path involves at least five consecutive workstations. The preferred number of successive measurement positions on the path is six to ten. Measurement positions locating farther than 16 m from OSS are not necessary, but they can facilitate the determination of r_D, if it is larger than 16 m.

The reference position shall be located at the distance of 1,00 m from the middle point of the OSS without any separating obstacles, such as a screen, between the OSS and the microphone. The reference position can locate in another direction than the measurement path if an obstacle prevents the abovementioned condition. The reference position is not a measurement position affecting the reported single-number values. It enables a post check of the actual sound power level of the OSS. The value at the reference position can be shown in spatial decay curves of both A-weighted SPL of speech and STI to provide additional information about the acoustic conditions at short conversation distance.

The actual measurement positions, which affect the reported single-number values, shall be located at workstations along the measurement path at the position of a sitting occupant's head, which is 1,20 m above the floor. Standing occupant is not considered in this document. The distance of the microphone positions shall be at least 1,00 m from the nearest wall of the room. Discrepancy from this requirement shall be mentioned in the report. Chairs are moved away from the workstations of the measurement path during the measurements. The first measurement position shall be located at the workstation nearest to the OSS.

It is possible that the measurements need to be conducted in an unfurnished open-plan office, where the workstations and other furniture are absent, but the room surfaces and building services are otherwise finished. This is necessary when the acoustic target values concern the unfurnished open-plan office. In such a case, the number of measurement paths per acoustic zone shall be the same as above. The measurement positions shall be chosen using expected workstation distances. The measurement positions could be located, e.g., at distances 2,5 m, 5,0 m, 7,5 m, 10,0 m, 12,5 m, and 15,0 m from the OSS. It should be noted that the room acoustic performance of an unfurnished open-plan office is usually worse than the performance of the furnished open-plan office.

In furnished flexible work areas without pre-defined workstations, the measurement positions shall be chosen using expected workstation distances.

4.2.4 Measured quantities

At every measurement position, four measurements or determinations are made:

— distance to the OSS disregarding the obstacles, r;

— unweighted equivalent SPL of wide-band noise produced by the OSS, $L_{p,oss}$;

— unweighted equivalent SPL of background noise, $L_{p,B}$;

— STI;

The distance means the horizontal distance from the middle point of the OSS to the middle point of the microphone. The accuracy of distance measurement shall be less than 0,10 m. Distances should be based on physical measurements on site. If the distance cannot be measured due to, e.g., obstacles on measurement path, and the distance must be based on layout drawings, the accuracy of these drawings (open-plan office dimensions, furniture positions) shall be confirmed by physical measurements on site.

$L_{p,oss}$ and $L_{p,B}$ shall be measured in octave bands from 125 Hz to 8 000 Hz. The integration time of equivalent SPL measurements shall be at least 15 s.

5 Determination of single-number values

5.1 Spectrum of normal speech

The sound power level (SWL) of normal effort speech is used to determine the reported single-number values. The values represent normal effort unisex speech (average of female and male speech). The octave band SPL at a distance of 1,0 m from the middle point of the OSS in the free field, $L_{p,S,1m,ff}$, is presented in Table 1. The SWL of normal effort speech is related to the SPL of speech at the distance of 1,0 m in free field by $L_{W,S} = L_{p,S,1m,ff} + 11$ dB. Since the OSS is used in all measurements, the SPL at the distance of 1,0 m from the OSS represent the average sound radiation in all directions from the OSS.

5.2 Spatial decay rate of speech

5.2.1 Conventional method

The conventional method is based on the measurements of SPL produced by the calibrated OSS (abbreviated by "oss" in related subindices). The SWL of the OSS producing wide-band noise, $L_{W,oss}$,