DRAFT INTERNATIONAL STANDARD

ISO/DIS 3382-3

ISO/TC **43**/SC **2**

Secretariat: **DIN**

Voting begins on:
2021-01-29

Voting terminates on:
2021-04-23

Acoustics — Measurement of room acoustic parameters —

Part 3:
Open plan offices

Acoustique — Mesurage des paramètres acoustiques des salles —

Partie 3: Bureaux ouverts

ICS: 91.120.20

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/DIS 3382-3:2021(E)

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Published in Switzerland

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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 *[or Project Committee]* ISO/TC 43, *Acoustics*, Subcommittee SC 2, *Building acoustics*.

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;

— use of omnidirectional sound source emphasized;

— measurement conditions (Clause 4) have been clarified;

— determination of single-number quantities (Clause 5) clarified;

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

— new Clause 6 Precision and a new informative Annex Accuracy added;

— STI is determined in conformance of IEC 20268-16 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

Noise and lack of speech privacy are among the most dissatisfactory environmental factors 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 productivity, 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].

This part of ISO 3382 specifies a measurement method, which results in 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 quantities in part 2 of this standard focus on temporal decay of sound.

The concept "open-plan offices" covers large office spaces where large number of occupants can work in well-defined workstations. A large share of flexible offices and activity-based offices belong to the open-plan office concept of this standard. Open-plan offices can also be found in libraries, hospital wards, industrial workplaces, and schools. According to [4], many of the single-number quantities provided by this standard are associated with the perceived noise disturbance in open-plan offices.

Room acoustic quality can be affected by the amount and positioning of absorption materials, room geometry, workstations, screens, other furniture, and background noise level, i.e. sound masking. Current literature gives good advice how the room acoustics should be designed to reach good room acoustic quality as it is defined in this standard [5,6,7].

The method describes the acoustic performance of the open-plan office in a standardized condition where a single occupant is speaking with normal speech effort. The background noise caused by building appliances or electronic masking sound is considered. 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 parts 1 and 2 of this standard. The actual noise conditions during use of the space do not belong to the scope of this standard. Although the activity noise caused by occupants can be significantly larger than the background noise from building appliances or sound masking, activity noise is beyond the scope of this standard. Presentation of acoustic design guidelines is also beyond the scope of this part of ISO 3382-3.

Acoustics — Measurement of room acoustic parameters —

Part 3:
Open plan offices

1 Scope

This document specifies methods 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.

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*

ISO 3740, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards*

IEC 60268-16:2011, *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 http://www.electropedia.org/

3.1
Omnidirectional sound source
OSS
a sound source which radiates sound evenly to all directions.

3.2
spatial distribution of the A-weighted SPL of speech
curve which shows how the A-weighted sound pressure level (SPL) decreases as a function of the distance from the middle point of the OSS emitting noise with the sound power level of normal speech within 125 Hz to 8 000 Hz.

3.3
spatial decay rate of speech
$D_{2,S}$
rate of spatial decay of A-weighted SPL of speech per distance doubling in decibels

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

3.4
Speech level at 4 m distance
$L_{p,A,S,4m}$
nominal A-weighted SPL in decibels at the distance of 4,0 m from the middle point of the OSS emitting noise with the sound power level of normal speech within 125 Hz to 8 000 Hz

Note 1 to entry: The quantity describes the A-weighted SPL of speech at a distance within which the nearest workstation is nearly always located. Small value means strong room acoustic attenuation near the OSS.

3.5
comfort distance
r_C
distance from the speaker in meters where the A-weighted SPL of speech falls below 45 dB when the OSS is emitting noise with the sound power level of normal speech within 125 Hz to 8 000 Hz

Note 1 to entry: Comfort distance reduces with increasing D2,S and decreasing Lp,A,S,4m.

3.6
background noise level
$L_{p,B}$
unweighted mean SPL of background noise in decibels present at the workstations along the measurement path during working hours when occupants are absent

Note 1 to entry: Background noise is measured in octave bands within 125 Hz to 8 000 Hz.

3.7
speech transmission index
STI
a proportional number representing the transmission quality of speech. STI has a value between 0.00 and 1.00.

[SOURCE: IEC 60268-16:2011]

Note 1 to entry: The value of STI is associated with subjective speech intelligibility.

3.8
spatial distribution of the speech transmission index
curve which shows how the STI decreases as a function of the distance from the OSS.

3.9
distraction distance
r_D
distance from the OSS in meters where the STI falls below 0,50.

Note 1 to entry: to entry.Distraction distance reduces with decreasing r_C and increasing $L_{p,B}$. Small value indicates high speech privacy. When the speaker is located beyond the distraction distance from the occupant, occupant's work performance is expected to be better than at shorter distances (see Annex A).

3.10
Workstation
Workstation is a furniture ensemble containing one ergonomically adjustable chair and a working table having a minimum floor area of 70x70 cm. The height of tabletop can be adjusted to a height of 75 cm from the floor. Workstation can contain also other components, such as screen(s), storage unit(s), display units, or luminaire.

4 Measurement conditions

4.1 Equipment

4.1.1 Sound source. Omnidirectional sound source (abbreviated by OSS) shall be used in all measurements. This source type is used since occupants in an open-plan office do not speak in an exactly fixed direction. The requirements given in ISO 3382-1 for the OSS within 125 – 4000 Hz shall be fulfilled for measurements to be in accordance with this part of ISO 3382.

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 Analyzer. The octave-band filters of the analyzer or analyzer software shall comply with IEC 61260. If the signal is recorded, e.g., by using analogue or digital recorders for off-line processing, it shall be ensured that the whole instrumentation complies with the above-mentioned requirements.

4.1.4 Calibrator. Before and after each measurement series, the acoustical sensitivity of the measurement system shall be checked using a sound calibrator that complies with IEC 60942. The results of the calibration checks shall be documented. A difference of more than 0,5 dB between calibration checks shall be a cause to repeat measurements. It is recommended that the calibration be checked whenever batteries or open-plan office are 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 important to carefully report these factors along with the measurement results.

Background noise means all stationary 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, or an 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 should 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 in any measurement position. Windows and balcony doors shall be closed. All measurements shall be conducted when the occupants are absent. Only the measurement technician can be present in the open-plan office.

If the table heights are electrically adjustable, the tabletop height is set to 75±5 cm from the floor in the workstations located along the measurement path.

4.2.2 Room acoustic zones

If the open-plan offices can contain two or more zones where the absorption treatments and/or furniture layouts are different, the measurements shall be conducted in each zone and the reported single-number quantities are determined for each zone separately.

At least two separate measurement paths shall be used per open-plan office zone. If only one measurement path is possible, measurements shall be conducted in both directions along the same 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.

If the zone contains regular furniture (usually screen or storage unit) between workstations, the measurement path should be chosen in such a way that there is an obstacle between the OSS and the first measurement position.

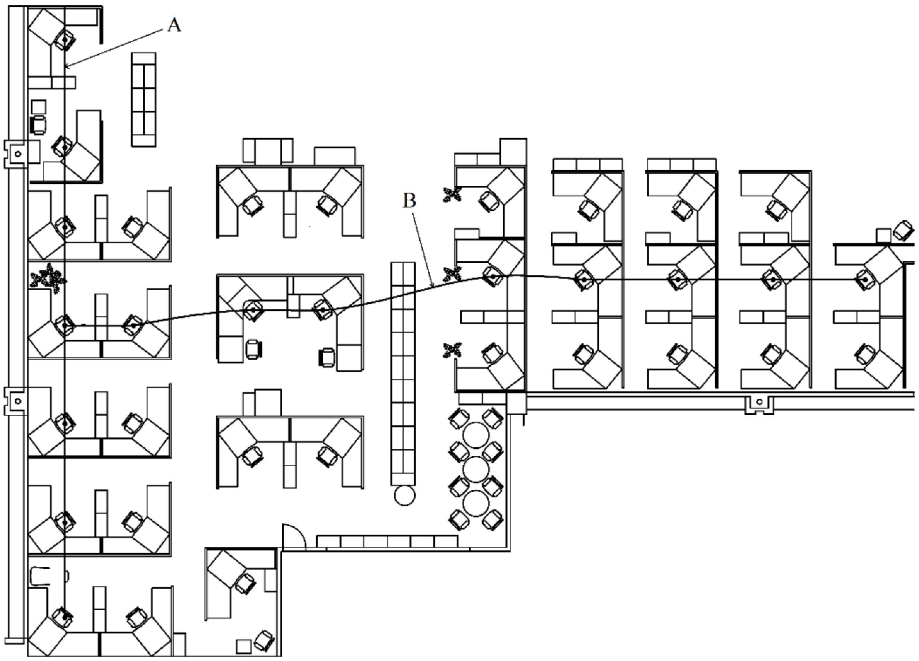
The OSS is located at the workstation at one end of the path. The OSS shall be located at the position of a sitting occupant's head in a workstation. The middle point of the OSS shall be at the height of 1,2 m above the floor. The position of the OSS shall be at least 0,4 m from the nearest table and at least 1,0 m from walls and other reflecting surfaces.

All workstations shall be measured along the measurement path and considered in the analysis. The number of measurement positions on a path shall be at least 4. 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 6 to 10.

The reference position shall be located at the distance of 1,0 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 needs not to locate in the direction of the measurement path if an obstacle prevents the abovementioned condition. The reference position enables a post check of the actual sound power level of the OSS. Although the position is not utilized in the determination of the single-number quantities, the result 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 quantities, shall locate in workstations along the measurement path at the position of a sitting occupant's head at the height of 1,2 m above the floor. The second measurement position shall locate in the workstation nearest to the OSS. Standing occupants are not considered in this part of ISO 3382. The position of microphone shall be at least 0,4 m from tables and at least 1,0 m from walls and other reflecting surfaces.

Even if electric tables enable working in standing position, both OSS and microphones shall be installed at a height of 1.20 m height from the floor.



Key

A straight measurement path

B 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 measurements are conducted in an open-plan office where the workstations and other furniture have not yet been installed, the number of measurement positions and positions of both OSS and microphone shall the same as above. The measurement positions shall be chosen using typical mutual workstation distances. The measurement positions could be located, e.g., at distances 1,0 m, 2,5 m, 5,0 m, 7,5 m, 10,0 m, 12,5 m, 15,0 m, and 17,5 m from the OSS.

4.2.4 Measurement quantities

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

— distance to the OSS disregarding the obstacles, r;

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

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

— STI;

The accuracy of distance measurement shall be less than 0,10 m. Distances should be based on physical measurements on site. A laser distance meter is preferred. If the distance cannot be measured due to e.g. obstacles on measurement path, and the distances 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.

The distance means the straight distance from the midpoint of the OSS to the midpoint of the microphone.