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Acoustics — Measurement of speech level reduction of furniture ensembles and enclosures —

Part 1: Laboratory method

Acoustique — Mesure de la réduction du niveau de la parole par les ensembles de meubles et les enceintes —
Partie 1: Méthode de laboratoire

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Foreword

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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).

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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*.

A list of all parts in the ISO 23351 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

An increasing number of office occupants are working in open-plan offices and activity-based offices. Occupants attempting to concentrate on independent tasks are easily distracted by surrounding speech. In addition, many communications require speech privacy, which is difficult to achieve in an occupied office without moving to a place providing enhanced sound isolation to the surrounding spaces.

Examples of furniture ensembles are conventional workstations, working pods, meeting pods, partially enclosed sofa groups and partially enclosed chairs. Examples of enclosures are mobile phone booths for a single occupant, mobile working booths for 1 to 2 occupants and mobile meeting booths for up to 6 occupants. Enclosures are usually equipped with a door, electric outlets, lighting, glazing and a ventilation fan.

Both furniture ensembles and enclosures (herein called "product") are assembled on site using elements which can be transferred into any room through normal-sized passage doors. They are not fixtures and they are usually purchased and owned by the user. They are not treated as a fixed part of the building and, therefore, they are beyond the scope of building regulations. Products are typically assembled in a finished room and not during the construction of the building.

The diversity and the market of above-mentioned products has grown. However, present acoustic test standards, such as ISO 354, ISO 11654 or ISO 20189, cannot be applied to describe the acoustic performance of these products because they have a special purpose of providing local enhanced speech privacy for a single occupant or a group of occupants. In addition, the products can be either open, partially enclosed or fully enclosed with a door. Both open and enclosed products should preferably be tested with the same method since the market needs a procedure to compare different products, which are designed for the same purpose. Therefore, the application of existing standards describing sound insulation measurements, such as ISO 10140-2, ISO 16283-1, ISO 10052, ISO 11546-1 or ISO 11957, are not applicable. There are also methods for describing the properties of screens (see ISO 10053, ISO 11821, or ISO 10847) but they are not applicable for describing the acoustic performance of an entire workstation nor an enclosure. The lack of a harmonized test standard which would be suitable for both furniture ensembles and enclosures has caused confusion and frustration among acousticians, furniture manufacturers, office designers and users.

This document provides a method to determine the potential for speech level reduction of furniture ensembles and enclosures which are intended to provide increased speech privacy for an occupant speaking inside the product. The main outcome of this document is a single-number quantity, the speech level reduction. It is tied to standard effort speech because it is the most probable sound produced inside a product. The speech level reduction describes how much the A-weighted sound power level of occupant's speech is reduced when the speaking occupant moves inside the product. The speech level reduction is a standardized technical value which can be used to compare the acoustical effect of different products in regard of their abilities to reduce the A-weighted sound power level of speech. It enables ranking of alternative products.

The level reduction obtained by this document is independent from the environment because it is based on repeated sound power level measurements. However, the reduction of sound pressure level in situ in a specified position can be larger than the level reduction obtained by this method if the room contains large amounts of sound absorption materials and/or screens, or if the openings of the product are oriented to the opposite direction than the position under interest.

Acoustics — Measurement of speech level reduction of furniture ensembles and enclosures —

Part 1: Laboratory method

1 Scope

This document specifies a laboratory method to facilitate the comparison of furniture ensembles and enclosures with respect to their ability to reduce the speech level of the occupant speaking inside the product.

In this method, the sound power level is measured in two scenarios: 1) without the product, and 2) with the product. During scenario 1), the test signal is produced by the sound source in an empty room while the product is absent. During scenario 2), the test signal is produced by the sound source inside the product in the occupant's position. Level reduction is the difference of the sound power levels measured in the two scenarios in 1/1-octave frequency bands from 125 Hz to 8 000 Hz. Speech level reduction is a single-number quantity that expresses the corresponding reduction in A-weighted sound power level of standard speech within the entire frequency range from 125 Hz to 8 000 Hz.

The method is applicable for entire furniture ensembles or enclosures, which form a unity that serves one or several occupants, and which are also used to provide improved speech privacy.

This method is not intended for single components used in workstations, such as a screen, a storage unit, a table, a luminaire, a cupboard, a bookshelf, a standard chair, a wall absorber or a ceiling absorber.

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 3741, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

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
artificial mouth
instrument primarily used as the sound source inside the test specimen for measuring the *level reduction* (3.4)

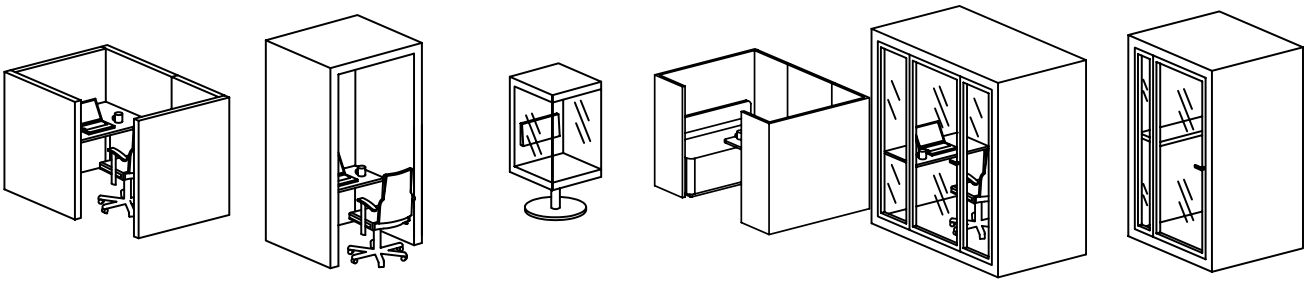
Note 1 to entry: Requirements for an artificial mouth are specified in ITU-T P.51.

3.2
enclosure
single object used, for example, in offices to provide local places with enhanced sound insulation

Note 1 to entry: See examples in Figure 1 e) and f).

Note 2 to entry: An unambiguous position of the occupant shall be identifiable.

EXAMPLE Enclosures can be mobile phone booths for a single occupant, mobile working booths for 1 to 2 occupants, and mobile meeting booths for up to, for example, 6 occupants.



a) Workstation with open ceiling **b) Workstation with closed ceiling** **c) Partially closed chair** **d) Sofa group for meetings** **e) Mobile working booth** **f) Mobile phone booth**

NOTE The occupant is sitting in Figure 1 a) to e) and standing in Figure 1 f).

Figure 1 — Examples of furniture ensembles

3.3
furniture ensemble
setup of furniture consisting of items such as tables, screens, storage units, connected sofas or any specified combination considered as a single object

Note 1 to entry: Furniture ensembles can also be called partial *enclosures* (3.2).

Note 2 to entry: Examples for furniture ensembles are given in Figure 1 a) to d).

EXAMPLE Furniture ensembles can be conventional workstations (consisting of, for example, screen(s), storage unit(s) and a table), working pods, meeting pods, partially enclosed sofa groups and partially enclosed chairs. An unambiguous position of the occupant shall be identifiable.

3.4
level reduction
D
frequency-dependent measure describing how much the sound power level is reduced by the test specimen in 1/1-octave frequency bands from 125 Hz to 8 000 Hz

Note 1 to entry: Level reduction is determined as the difference between the sound power level radiated by a reference box without and with the test specimen. For the determination of sound power levels, see ISO 3741.

3.5
omnidirectional sound source
instrument used as the sound source inside the test specimen for measuring the *level reduction* (3.4)

Note 1 to entry: The directivity of the omnidirectional sound source fulfils the specifications given in ISO 3382-1.

Note 2 to entry: An omnidirectional sound source is used when the relative criteria for background noise cannot be met with an *artificial mouth* (3.1).

3.6
reference box
smallest box-shaped surface within which the test specimen is located during the test

3.7
speech level reduction
$D_{S,A}$
reduction of A-weighted *sound power level of speech* (3.8) caused by the test specimen

3.8
sound power level of speech
$L_{W,S,1}$
sound power level of normal effort genderless speech

Note 1 to entry: Genderless speech is the mean of female and male speech.

4 Measurement conditions

4.1 Test room

The test is conducted in a reverberation room. The criteria for the test room are given in ISO 3741.

4.2 Test specimen

A product tested according to this document shall have a predefined size, geometry and material listing. The position(s) of the occupant(s) shall be clearly identifiable.

The test specimen shall be tested at least in two positions in the test room. The distance between the two positions shall be at least 1,7 m. The distance is measured from the middle point of the test specimen. The reported level reduction is the arithmetic average of the position-specific level reduction values.

The test specimen shall be installed in the same manner as it would be typically installed for an occupant's use. Operable parts, such as doors or windows, shall be in normal operable condition. The pressure loss of ventilation openings shall be the same as in normal operation conditions.

If the test specimen involves operable components such as doors or windows, these components shall be opened and closed at least five times immediately before the testing to ensure that they operate properly.

If the test specimen has several evident operating conditions due to, for example, operable doors or windows, or adjustable ventilation openings, they can be optionally tested in different positions if the subscriber of the test finds it relevant. The operating condition(s) shall be unambiguously stated in the test report.

A workstation shall be tested in such a way that it involves all components that are used in the specific workplace configuration.

If the test specimen consists of several components, such as a user-specific workstation involving, for example, a table, a chair, several pieces of screens and a storage unit, all the components shall be installed according to the specified way, which conforms to the intended final configuration of the workstation.

If the test specimen involves fixed accessories which can affect the sound propagation inside the test specimen, such as computer monitors or chairs, they shall be installed during the test. Additional accessories not included with the typical installation of the product (i.e. accessories typically brought by the occupant) are not installed during the test.

The test specimen shall be unoccupied during the test. A dummy torso shall not be installed to the occupant's position.

Electrical cables needed during the test between the sound source (located inside an enclosure) and the reverberation room shall not affect the level difference of the test specimen. The level difference of a tightly sealed enclosure can reduce significantly if a cable passes, for example, across a door seam. Therefore, the electrical outlet inside the test specimen is primarily used if it is available. Furthermore, the signal generator and the amplifier may be located inside the specimen to avoid the need to pass the signal cable, for example, across a door seam.

Many enclosures involve internal noise sources, such as a ventilation fan, which increase the background noise of the reverberation room. Internal noise sources may activate automatically when the electricity is connected to the enclosure. The electricity is usually switched on during the measurements to provide electricity for the sound source and signal generator located inside the enclosure. Care shall be taken that the internal noise sources produce the same sound pressure level during all sound pressure level measurements. If the internal noise sources are on during the sound pressure level measurement with sound source on, the internal noise sources shall be also on during the sound pressure level measurement of background noise of the room with sound source off. If the sound pressure level of the internal noise sources is not constant (e.g. rotation speed of fan may depend on carbon dioxide concentration), it is recommended that the internal noise sources are shut down during the whole test.

According to ISO 3741, it is allowed that the size of the test specimen be up to 5 % of the test room volume. Furthermore, the test specimen shall not be closer than 1 m to any room boundary, room diffuser or microphone during the measurements.

4.3 Equipment

4.3.1 Sound source

The sound source shall produce wide-band steady-state noise with constant acoustic output power. The sound pressure level of the sound source shall be high enough to meet the relative criteria of ISO 3741 for background noise.

An artificial mouth is primarily used as the sound source. However, the sound power level of an artificial mouth may not be sufficient for the testing of enclosures having high level reduction. An omnidirectional sound source shall be used if the relative criteria of ISO 3741 for background noise cannot be met with the artificial mouth in every 1/1-octave frequency band from 125 Hz to 8 000 Hz.

An artificial mouth shall be used during the measurement of a furniture ensemble which is not totally enclosed from the surrounding room. Examples of such products are shown in Figure 1 a) to d). Such products can produce a specific acoustic radiation pattern to the surrounding room in the actual condition because some parts of the envelope are sound insulating and/or sound absorbing while the other parts of the envelope are open and transmit sound perfectly. The directivity of an artificial mouth resembles the directivity of the occupant's speech. Using an artificial mouth guarantees that the sound field incident to the envelope of the furniture is realistic.

An omnidirectional sound source can be used when enclosures with high level reduction are tested. Examples of such products are shown in Figure 1 e) to f). The sound power incident on interior surfaces of the enclosure's envelope is relatively constant due to inevitable modes and associated reverberation inside the enclosure. Therefore, the test result is expected to be similar with an artificial mouth and with an omnidirectional sound source.

The position and the direction of the sound source is determined according to the typical use of the test specimen. The sound source shall be located in the most probable position of the occupant's mouth. When an artificial mouth is used, it shall be oriented towards the most probable direction of the occupant using the furniture ensemble or an enclosure under test. A different position can be used by agreement between the parties involved in the test. The position and the direction shall be exactly reported in the test report. The recommended height of the acoustical centre of the sound source is 1,20 m for a seated occupant and 1,55 m for a standing occupant. The distances are measured from the floor of the test specimen. Other heights can be used if they are more appropriate for the intended use of the product.

The position of the sound source shall be the same during the measurements of $L_{W,P,1}$ and $L_{W,P,2}$ [see Formula (1)] with respect to room boundaries (see Figure 2). If an artificial mouth is used, the orientation shall be also the same during the measurements of $L_{W,P,1}$ and $L_{W,P,2}$ with respect to room boundaries.

If the test specimen involves several occupant positions, all positions are measured separately and the arithmetic mean of the position-specific level reductions shall be reported.

Measurement of $L_{W,P,1}$ shall be conducted using a single position of the sound source per test specimen position. Even if the test specimen involved several occupant positions (sound source positions), the measurement of $L_{W,P,1}$ does not need to be replicated for each occupant position.

The sound power level of the sound source without the test specimen, $L_{W,P,1}$, should be measured both before and after the measurement of $L_{W,P,2}$ to ensure that the sound power level of the sound source has remained constant during the series of measurements.

4.3.2 Measurement equipment

The sound pressure levels shall be measured using equipment in accordance with ISO 3741.

Before and after each series of measurements, a sound level calibrator in accordance with ISO 3741 shall be applied to verify the calibration of the entire measurement chain at one or more frequencies within the frequency range of interest.

If the signal is recorded for off-line processing, it shall be ensured that the instrumentation as a whole complies with the requirements of 4.3.1 and 4.3.2.

4.4 Microphone positions

The number of microphone positions shall be in accordance with ISO 3741. All microphone positions shall be located outside the reference box enclosing the test specimen. The minimum distance between a microphone position, reference box and room boundary shall be in accordance with ISO 3741.

The test specimen shall be oriented so that there are no direct sound paths between source and receiver positions. Direct sound path is strong in the direction of the frontal axis of the artificial mouth and in the direction of openings of the specimen. Figure 2 is an example of good arrangement where the artificial mouth is oriented towards the corner and not towards the middle of the room where microphone positions are usually located.