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Acoustics — Hearing protectors —

Part 1: Subjective method for the measurement of sound attenuation

Acoustique — Protecteurs individuels contre le bruit —

Partie 1: Méthode subjective de mesurage de l'affaiblissement acoustique

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise.*

This second edition cancels and replaces the first edition (ISO 4869-1:1990), which has been technically revised.

The main changes compared to the previous edition are as follows:

The revision includes changes mainly of the sound field requirements, specification of test equipment, test procedures and instructions to the test subjects, and uncertainty of the measurements. The sound field requirements are based on published and unpublished laboratory experience, especially [10] and [11] in the Bibliography.

A list of all parts in the ISO 4869 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

Hearing protectors are commonly used to reduce the noise to which the ear is exposed. Hearing protectors are manufactured as earplugs, earmuffs or helmets. A standardized method of sound attenuation measurement allows comparison of performance data obtained in different locations under similar conditions.

Acoustics — Hearing protectors —

Part 1: Subjective method for the measurement of sound attenuation

1 Scope

This document specifies a subjective method for measuring sound attenuation of hearing protectors at the threshold of hearing. The method is a laboratory method designed to yield reproducible values under controlled measurement conditions. The values reflect the attenuating characteristics of the hearing protector only to the extent that users wear the device in the same manner as did the test subjects.

For a more representative indication of field performance the methods of ISO/TS 4869-5 can be used.

This test method yields data which are collected at low sound pressure levels (close to the threshold of hearing) but which are also representative of the attenuation values of hearing protectors at higher sound pressure levels. An exception occurs in the case of amplitude-sensitive hearing protectors for sound pressure levels above the point at which their level-dependent characteristics become effective. At those sound pressure levels the method specified in this document is inapplicable, as it will usually underestimate sound attenuation for these devices.

NOTE Due to masking from physiological noise in the occluded ear tests, sound attenuations below 500 Hz can be overestimated by a few decibels.

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 8253-2, *Acoustics — Audiometric test methods — Part 2: Sound field audiometry with pure-tone and narrow-band test signals*

IEC 60263, *Scales and sizes for plotting frequency characteristics and polar diagrams*

IEC 61260-1, *Electroacoustics — Octave-band and fractional-octave-band filters — 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
hearing protector
device worn by a person to prevent harmful effects from noise and other loud acoustic stimuli

Note 1 to entry: Hearing protectors can include electronic devices for communication, or devices designed to play an active role in the reduction of the noise level between the hearing protector and the eardrum.

3.2
earmuff
hearing protector consisting of an ear-cup to be pressed against each pinna (supra-aural) or of an ear-cup to be pressed against the head, around the pinna (circumaural)

Note 1 to entry: The ear-cups can be pressed against the head with a special headband or neck band or by means of a device attached to a safety helmet or other equipment.

3.3
earplug
hearing protector worn within the external earcanal (aural) or in the concha against the entrance to the external earcanal (semi-aural)

3.4
helmet
device which covers a substantial part of the head

3.5
hearing level (of a pure tone)
difference between the sound pressure level of this pure tone produced by the earphone in a specified ear simulator or acoustic coupler and the appropriate reference equivalent threshold sound pressure level at a specified frequency, for a specified type of earphone and for a specified manner of application

Note 1 to entry: Values of reference equivalent threshold sound pressure levels are specified in ISO 389-1.

3.6
hearing threshold level (of a given ear)
threshold of hearing expressed as hearing level at a specified frequency and for a specified type of earphone

Note 1 to entry: For appropriate test conditions, see, for example, ISO 8253-1.

3.7
threshold of hearing
lowest sound pressure level at which, under specified conditions, a person gives a predetermined percentage of correct detection responses on repeated trials

Note 1 to entry: For the purpose of ISO 4869-1, the threshold of hearing is measured with and without the hearing protector. For appropriate test conditions, see ISO 8253-2.

3.8
sound attenuation
difference between the threshold of hearing with and without the hearing protector in place for a test subject for a given test signal

Note 1 to entry: The sound attenuation is given in decibels.

3.9
pink noise
random noise signal with a spectral density that decreases by 3 dB per octave, giving constant energy per octave

Note 1 to entry: The definition is often phrased as 'noise whose power spectral density is inversely proportional to frequency'.

[SOURCE: ISO 7240-24:2016, 3.1.11; modified: added Note 1 to entry]

3.10
reference point
fixed spatial position within the test chamber to which all objective measurements of the sound field characteristics are referenced and which coincides with the midpoint of a line connecting the test subject's earcanal openings when the test subject is seated for measurements

3.11
reverberation time
time required for the sound pressure level to decrease by 60 dB after the sound source has stopped

Note 1 to entry: See ISO 354 for information about measurement of reverberation time.

4 Measurement of the sound attenuation of hearing protectors

4.1 Test signals

The test signals shall consist of pink noise filtered through one-third-octave bands with centre frequencies in accordance with IEC 61260-1. Tests shall be performed at the following centre frequencies:

125 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz, 4 000 Hz, 8 000 Hz.

Measurements at an additional centre frequency of 63 Hz are optional.

4.2 Test site

4.2.1 General

The sound field at the test site shall have sound incidence from many directions. Such a sound field is adequately approximated when the requirements of 4.2.2, 4.2.3 and 4.2.4 are met. The measurements of the sound field shall be conducted with the test subject and the subject's chair absent.

4.2.2 Sound pressure level and sound pressure level variation

a) The sound pressure level at all test frequencies measured with an omnidirectional microphone at positions 15 cm from the reference point on the front-back, right-left and up-down axes shall deviate by no more than ±2,5 dB from the sound pressure level at the reference point. In addition, the difference between the right-left positions shall not exceed 3 dB. The orientation of the microphone shall be kept the same at each position.

b) The directionality of the sound field shall be evaluated at the reference point for test signals with centre frequencies greater than or equal to 500 Hz. The measurements shall be conducted with a directional microphone with a typical free-field polar response at the one-third-octave test signals of at least 10 dB front-to-side rejection for a cosine microphone, or at least 10 dB front-to-back rejection for a cardioid microphone. The microphone shall be rotated at the reference point through 360° in the horizontal plane. The variation of the observed sound pressure levels in each test signal shall remain within the variation allowed in Table 1. The sound pressure levels can also be obtained by measuring at fixed 15 degree increments as the microphone is rotated.

Table 1 — Allowable variation of sound-field sound pressure levels for corresponding directional microphone free-field rejection

Microphone free-field rejection (FFR) dB	Allowable field variation dB
25 ≤ FFR	20
20 ≤ FFR < 25	15
15 ≤ FFR < 20	10
10 ≤ FFR < 15	5
FFR < 10	Microphone not suitable

NOTE The variation in microphone response as the microphone is rotated in a random incidence field is related to the directional characteristics of the microphone and the degree of randomness of the field being measured. Therefore, the allowable sound field response variations are related to the free-field directional response characteristics of the microphone. The microphone characteristics can be obtained from the microphone manufacturer or by measurement in a free field.

4.2.3 Reverberation time

The reverberation time in the test space, with the test subject and the test subject's chair absent, shall not exceed 1,6 s for each of the test signals.

4.2.4 Ambient noise level

The ambient noise level at the test site in the test room shall not exceed the values given in Table 2. The ambient noise level shall be determined by measuring the sound pressure level with the test subject absent.

When the lowest test signal centre frequency is 125 Hz, the ambient noise requirement shall be met down to and including 63 Hz. When the lowest test signal centre frequency is 63 Hz, the ambient noise requirement shall be met down to and including 31,5 Hz.

NOTE The ambient noise level includes the noise present in the room and the possible noise from the test equipment while it is on and running, but in the absence of the test signals.

Table 2 — Maximum permissible ambient sound pressure level

Centre frequency Hz	One-third-octave-band sound pressure level (reference = 20 µPa) dB
31,5	57
40	43
50	31
63	25
80	21
100	18
125	14
160	11
200	9
250	6
315	4
NOTE The levels are set in relation to ISO 8253-1 for the purpose of testing down to –10 dB hearing threshold level.	

Table 2 *(continued)*

Centre frequency Hz	**One-third-octave-band sound pressure level** (reference = 20 µPa) dB
400	3
500	2
630	1
800	1
1 000	1
1 250	1
1 600	2
2 000	2
2 500	1
3 150	−1
4 000	−4
5 000	−2
6 300	3
8 000	10
10 000	20

NOTE The levels are set in relation to ISO 8253-1 for the purpose of testing down to −10 dB hearing threshold level.

4.3 Test equipment

4.3.1 The test equipment shall be capable of producing a test signal at the test site from 112 Hz (or 56 Hz if the 63 Hz test signal is used) to 9 000 Hz.

NOTE 1 112 Hz is the lower limiting frequency of the 125 Hz one-third-octave band and 9 000 Hz is the upper limiting frequency of the 8 000 Hz one-third-octave band.

The test equipment shall be able to generate test signal sound pressure levels at the reference point, for any test signal, that vary from at least 10 dB above the subject's occluded threshold of hearing to 10 dB below the subject's open threshold of hearing. An example is given in Annex C. The band levels shall be measured using filters complying with IEC 61260-1. During the test, the sounds shall be reproduced without audible distortion, buzzing, crackle, or rattle.

When the test equipment generates one-third-octave-band test signals at the maximum sound pressure levels (Annex C) the levels of the other one-third-octave bands shall be at least 40 dB down from the maximum level – at octave steps – from one octave below the test signal down to 31,5 Hz, and from one octave above the test signal up to 16 kHz.

NOTE 2 Due to internal noise restrictions in the sound pressure level measurement equipment, low sound pressure levels can be calculated on the basis of electrical measurements.

4.3.2 Attenuators shall have a range of at least 90 dB for each test signal. Attenuator steps shall be 2,5 dB or smaller.

4.3.3 The difference in output between any two attenuator settings, measured with a single one-third-octave-band test signal (see 4.1), shall not differ from the indicated difference by more than 2 dB over