SLOVENSKI STANDARD
SIST EN 17479:2022

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Varovala sluha - Navodila za izbiro ustreznih preskusnih metod za individualno prilagajanje

Hearing protectors - Guidance on selection of individual fit testing methods

Gehörschützer - Leitfaden zur Auswahl von Prüfverfahren für die individuelle Passung

Protecteurs individuels contre le bruit - Recommandations relatives au choix des méthodes individuelles de contrôle de l'ajustement

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Hearing protectors - Guidance on selection of individual fit testing methods

Protecteurs individuels contre le bruit - Recommandations relatives au choix des méthodes individuelles de contrôle de l'ajustement

Gehörschützer - Leitfaden zur Auswahl von Prüfverfahren für den individuellen Sitz

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European foreword

This document (EN 17479:2021) has been prepared by Technical Committee CEN/TC 159 “Hearing protectors”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2022, and conflicting national standards shall be withdrawn at the latest by May 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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Introduction

The need for the use of hearing protectors is obvious nowadays. Appropriate hearing protection is chosen based on different selection criteria such as required sound attenuation, comfort, workplace environment and a possible need for communication, audibility of important sounds etc. Different selection criteria for hearing protector selection are given in EN 458:2016 “Hearing protectors — Recommendations for selection, use, care and maintenance — Guidance document” [4].

As appropriate sound attenuation should be key in this selection process, this should be compared to the user’s need in two steps. Firstly, appropriate hearing protection should be selected based on the attenuation data from the REAT test according to EN ISO 4869-1:2018 [7] and EN ISO 4869-2:2018 [8], as provided by the manufacturer. Secondly, by using individual fit testing methods the effective attenuation can be assessed (e.g. acoustic or pressure sealing, personal attenuation rating, etc.).

In addition, the effective attenuation can be estimated and compared to the required sound attenuation. Whilst fit testing can play a valuable role in the selection and usage, it is no substitute for conformity testing.

Fit testing can also be used to increase the awareness of the user on the importance of a proper fit. It can help the user achieve a fit that maximizes the likelihood of that user receiving the expected level of protection. It could also form part of the training for safety engineers, healthcare specialists and supervisors, to provide a good understanding of the importance of a proper fitting and it can also be a helpful training aid for the user.

This document gives practical guidance for the appropriate selection of fit testing methods, their uses and limitations.

This document does not specify the technical requirements for manufacturing fit testing equipment.

1 Scope

This document gives guidelines for the appropriate selection of fit testing methods and measurement, and provides practical guidelines on fit testing methods, their uses and limitations.

This document does not specify the technical requirements for manufacturing fit testing equipment.

2 Normative references

There are no normative references in this document.

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
fit testing
<hearing protectors> procedure for checking that a specific hearing protector is suitable for use by a specific individual by assessing the physical fit, seal, sound attenuation or other properties of the hearing protector

3.2
repeatability
closeness of the agreement between the results of successive measurements of the same test item carried out under the same conditions of measurement

Note 1 to entry: These conditions are called repeatability conditions.

Note 2 to entry: Repeatability conditions include:

— the same measurement procedure;

— the same observer;

— the same measuring instrument, used under the same conditions;

— the same location;

— repetition over a short period of time.

Note 3 to entry: Repeatability may be expressed quantitatively in terms of the dispersion characteristics of the results.

[SOURCE: ISO/IEC Guide 98-3:2008, B.2.15, modified: “(of results of measurements)” deleted in term designation and “measurand” replaced by “test item”.]

3.3
reproducibility
closeness of the agreement between the results of measurements of the same test item carried out under changed conditions of measurement

Note 1 to entry: A valid statement of reproducibility requires specification of the conditions changed.

Note 2 to entry: The changed conditions may include:

— principle of measurement;

— method of measurement;

— observer;

— measuring instrument;

— reference standard;

— location;

— provision of suitable facility (e.g. sound booth);

— conditions of use;

— time.

Note 3 to entry: Reproducibility may be expressed quantitatively in terms of the dispersion characteristics of the results.

Note 4 to entry: Results are here usually understood to be corrected results.

[SOURCE: ISO/IEC Guide 98-3:2008, B.2.16, modified: "(of results of measurements)" deleted in term designation and "measurand" replaced by "test item".]

3.4
personal attenuation rating
PAR
individual attenuation given as a single value in dB that a user obtains for the fit of the hearing protector that was tested

Note 1 to entry: The PAR can be either the combined left-right (binaural) or separate left-right ear value.

Note 2 to entry: The calculation procedure is not standardized and is specified by the manufacturer for a specific fit testing method.

3.5
real-ear attenuation at threshold method
REAT method
test procedure for determination of the sound attenuation of a hearing protector

Note 1 to entry: The measurement of sound attenuation is described in EN ISO 4869-1 [7].

3.6
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 this document, the threshold of hearing is measured with the hearing protector (occluded threshold of hearing) and without the hearing protector (open threshold of hearing).

[SOURCE: EN ISO 4869-1:2018, 3.7, modified: "ISO 4869-1" replaced by "this document" in Note 1 to entry. "the hearing protector (occluded threshold of hearing)" and "(open threshold of hearing)" added in Note 1 to entry. Last sentence of Note 1 to entry of EN ISO 4869-1:2018, 3.7 deleted.]

3.7
surrogate hearing protector
hearing protector modified by the manufacturer of the fit testing system that has been demonstrated when used in the fit testing system to yield attenuation equivalent to the standard hearing protectors that it represents

Note 1 to entry: Surrogate hearing protectors include surrogate samples, surrogate earplugs and surrogate earmuffs.

[SOURCE: ANSI S12.71-2018, 3.20, modified: "FAES for estimates using its system" replaced by "fit testing system" and "estimation system" replaced by "fit testing system". Note 1 to entry added.]

3.8
insertion loss
algebraic difference, in decibels, between the one-third-octave-band sound pressure level measured by the microphone of the acoustic test fixture with the hearing protector absent and the sound pressure level with the hearing protector present

[SOURCE: EN ISO 4869-3:2007, 3.5]

3.9
noise reduction
difference between sound pressure levels external to and under the hearing protector, generally measured simultaneously

[SOURCE: ANSI S12.42-2010, 3.20, modified: "The arithmetic" at the beginning of the definition deleted, "in decibels" deleted, "external to and under the hearing protector" moved forward after "sound pressure level" and "generally" added.]

4 Individual fit testing methods

4.1 General

The fit testing methods can be categorized in three different ways:

— mechanical or acoustic tests according to a physical principle;

— subjective (sound detection at the threshold of hearing or loudness balancing) or objective (measuring) tests;

— tests for one specified product only or for a range of different hearing protectors.

Each test method will have a different pass/fail criterion. Refer to the manufacturer for further information.

In this document, the wording “time required” takes into consideration:

— fitting of the hearing protector on the user;

— fitting of the appropriate test equipment;

— measurement of both ears;

— data analysis.

NOTE The initial setup of the test apparatus is not included.

4.2 Test methods

Currently available tests comprise:

Method 1: Sound-level measurements with microphone in real ear (MIRE)

This is an objective acoustic test method where a sound field is generated. With two microphones the sound pressure levels outside of the hearing protector and underneath the hearing protector are measured under noise load, usually simultaneously (noise reduction). With specifically determined correction factors it is possible to derive sound attenuation values in correspondence with REAT.

— Method 1a: Sound field generated by a headset.

— Method 1b: Sound field generated by a loudspeaker (free field).

Method 2: Audiometric method (determination of the threshold of hearing with and without hearing protector)

This is an acoustic test method. The thresholds of hearing with and without hearing protector are determined in a subjective measurement. The difference of the two measured thresholds of hearing is the sound attenuation.

— Method 2a: Sound field generated by a headset.

— Method 2b: Sound field generated by a loudspeaker.

Method 3: Audiometric-based method (determination of the threshold of hearing with and without hearing protector)

This is an acoustic test method. The thresholds of hearing with and without hearing protector are determined in a subjective measurement. The principle is similar to method 2, but instead of an audiometer a custom-built device especially for fit testing is used.

— Method 3a: Sound field generated by a headset.

— Method 3b: Sound field generated by a loudspeaker.

NOTE The thresholds determined are not the thresholds of hearing measured by audiometric method.

Method 4: Loudness balancing method

This is an acoustic test method. The test subject balances the loudness between the two ears with one or two earplugs and without any earplug in a subjective measurement.

Method 5: Acoustic leakage test

This is an acoustic test method. A sound pressure level is generated and measured by a loudspeaker and a microphone directly inside the earplug in the ear canal. The frequency characteristics of the sound in the ear canal contains objective information on the fitting of the earplug.

Method 6: Air leakage test

This is a non-acoustic test method, based on an air pressure measurement. The leakage of a custom moulded earplug in the ear canal is objectively determined by the decay of a small over-pressure behind the earplug or by measuring the maximum achievable over-pressure for a given maximum pressure of the pump.

4.3 Reference method for sound attenuation measurements of hearing protectors

The reference method for determining the sound attenuation of hearing protectors is the so-called REAT method ("real-ear attenuation at threshold") in accordance with EN ISO 4869-1:2018 [7]. It is also used in the type examination test as specified in EN 352-1:2020 [1], EN 352-2:2020 [2] and EN 352-3:2020 [3]. Here, the threshold of hearing of the subject is measured twice in a diffuse sound field: once with and once without hearing protector. The measurement is performed with one-third-octave-band noise at the octave band centre frequencies between 125 Hz (optionally 63 Hz) and 8 000 Hz. The threshold of hearing is usually determined via a bracketing method (e.g. by the Békésy method as described in ANSI S3.20 [15]). The REAT method provides information on a sample of 16 subjects (mean, standard deviation) and requires according to the specifications of the standard very low ambient noise levels and a diffuse sound field.

NOTE The methods described in 4.2 that give sound attenuation data can have results that differ from the values obtained in the laboratory tests. These numbers are the mean values of subjective, binaural tests at the threshold of hearing. For each product, it is necessary to define limits of the sound attenuation from the individual fit testing that are in accordance with the REAT data.

4.4 Description of different fit testing methods

4.4.1 Sound-level measurements with microphone in real ear (MIRE) (method 1)

4.4.1.1 General

The MIRE method involves measurement of sound pressure levels inside and outside of the protected ear. The sound field is generated either by a headset or by a loudspeaker.

The difference between the level in the ear underneath the hearing protector and outside the protected ear is determined directly in one measurement with the use of two microphones (noise reduction). The sound attenuation of a hearing protector can be determined from the difference of the two sound pressure levels. The first microphone is inserted in the hearing protector from the outside (e.g. a tube microphone) and the second one is placed outside of the ear (if applicable, under the headset that generates the test sounds). If the result of the MIRE measurement needs to be equated to the labelled data, the whole system (including the sound field) shall be calibrated in relation to REAT (labelled) subjective attenuation data.

NOTE 1 The basic method of taking measurements in the ear canal is described in EN ISO 11904-1:2002 [12].

NOTE 2 'Noise reduction' as measured by MIRE does not correspond directly to 'insertion loss' as measured by REAT (labelled sound attenuation values). REAT measurements are based on the subjective difference in threshold of hearing (with and without hearing protector), while MIRE measurements are based on the objective difference in sound pressure levels (outside the protected ear and underneath the hearing protector). If correction values for calibration of 'noise reduction' to REAT values are used, they need to be adjusted per product.

If a tube microphone or an electrically connected microphone is inserted in the ear canal and a wire or tube is placed alongside the earplug, there is a possibility of a leak. This could compromise the seal of the earplug and result in inaccurate measurements.

NOTE 3 It is also possible to measure 'insertion loss' using MIRE by using one microphone only placed in front of the eardrum and measuring sequentially with and without the hearing protector in place.

If, in case of a single-channel earplug with filter, the filter is removed for the measurement to insert the microphone into the earplug and the ear canal, only the fit of the earpiece alone is measured not the sound attenuation of the product as a whole. In that case, the filter should be measured in a separate measurement. For earplugs with no channel (foam, flanged and banded earplugs), surrogate earplugs can be used to perform the measurement.

4.4.1.2 Sound field generated by a headset (method 1a)

In principle, it is possible to test any earplug that can be worn under a headset. However, this method requires earplugs with a separate channel to incorporate the microphone for the measurement under the earplug.

Characteristics:

— method: objective;

— test signals: broadband noise (e.g. 80 dB(A), maximum level 95 dB(A) for safety reasons);

— *f*: 125 Hz to 8 000 Hz;

— maximum background noise: 70 dB(A);

— sound field: headset;

— time required: 5 min;

— principle: sound level difference.

4.4.1.3 Sound field generated by a loudspeaker (free field) (method 1b)

The sound attenuation of a hearing protector can be determined in the sound field of a loudspeaker. Corrections for the microphone positions and the sound field are incorporated. This method has the advantage that earmuffs and all types of earplugs can be tested, also bulky types that would not fit under a headset. As described in 4.4.1.2 sometimes only specially modified hearing protectors with an inserted microphone can be used.

Characteristics:

— method: objective;

— test signals: broadband noise (e.g. 80 dB(A), maximum level 95 dB(A) for safety reasons);

— *f*: 125 Hz to 8 000 Hz;

— maximum background noise: 70 dB(A);

— sound field: free field;

— time required: 5 min;

— principle: sound level difference.

4.4.2 Audiometric method (determination of the threshold of hearing with and without hearing protector) (method 2)

4.4.2.1 General

This method is similar in principle to the REAT method (see 4.3) and can be realized with the help of an audiometer. Here as well, the threshold of hearing of the test subject is measured with and without hearing protectors. This method requires a quiet environment since it works at the threshold of hearing.

Two aspects of the measurement procedure that can vary are described below:

— The test sounds can be narrow-band noise or pure tones. Since the sound field and (for pure tones) the test noise are different to the laboratory conditions the thresholds of hearing can be expected to have other values. Thus, also the calculated sound attenuation could be different.

— The threshold of hearing can be determined either with ascending levels or by means of an up-and-down (bracketing) method. In the latter, the level is by turns increased and reduced several times, and the threshold of hearing level is narrowed down by the upward and downward excursions.

4.4.2.2 Sound field generated by a headset (method 2a)

It can be used for all types of earplugs that can be worn under a headset.

Characteristics:

— method: subjective;

— test signals: pure tones or narrow-band noise;

— *f*: 125 Hz to 8 000 Hz or selected band(s);

— maximum background noise: 40 dB(A) (based on EN ISO 8253-1:2010);

NOTE See EN ISO 8253-1:2010 [10] for more information on requirements on background noise level in one-third-octave-bands.

— sound field: headset;

— time required: 5 min to 20 min;

— principle: measurement at the threshold of hearing.

4.4.2.3 Sound field generated by a loudspeaker (method 2b)

This method has the advantage that earmuffs and all kinds of earplugs can be tested, also bulky types that would not fit under a headset. The threshold of hearing (open and occluded) is simultaneously measured for both ears. This results in only one attenuation value representing both ears and a shorter measuring time than measuring according to 4.4.2.2.

Characteristics:

— method: subjective;

— test signals: narrow-band noise;

— *f*: 125 Hz to 8 000 Hz or selected band(s);