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Date: 14 November 2024

Origin: European

Latest date for receipt of comments: 07 January 2025

Project No. 2023/02840

Responsible committee: PH/7 Hearing protectors

Interested committees:

Title: Draft BS EN 458 BS Hearing protectors - Recommendations for selection, use, care and maintenance - Guidance document.

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

**Hearing protectors - Recommendations for selection, use,
care and maintenance - Guidance document**

Protecteurs individuels contre le bruit -
Recommandations relatives à la sélection, à
l'utilisation, aux précautions d'emploi et à l'entretien -
Document guide

Gehörschützer - Empfehlungen für Auswahl, Einsatz,
Pflege und Instandhaltung - Leitfaden

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 159.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 458:2024) has been prepared by Technical Committee CEN/TC 159 “Hearing protectors”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 458:2016.

The main changes compared to the previous edition are listed in Annex I.

Introduction

This document is intended to guide employers, supervisors and safety advisors. Additionally, this document gives information to all who need to use hearing protectors.

Hearing protectors are intended to protect against the risk of harmful noise and are elevated into the highest risk Category III under the Personal Protective Equipment Regulation (EU) 2016/425, which can cause irreversible health effects or can be potentially life threatening. They are intended to reduce the harmful effects that sound and noise can have on the hearing of an individual worker. Requirements for hearing protection products are given in the EN 352 series.

Guidance is provided on how to best select, use and maintain such devices. Calculation procedures to estimate the residual noise exposure level, when a certain hearing protector is used, are also provided.

National bodies can develop their own local application documents based on this document.

Hearing protectors are generally available in two main forms: earmuffs and earplugs. Both forms are available with additional features and functions. All have their advantages and disadvantages in terms of attenuation, comfort, ease of use, communication facilities and cost.

In hearing conservation programmes noise hazard areas are identified and the personal noise exposure is assessed. Before a suitable hearing protector is considered, priority should be given to reducing noise at source and/or reducing the exposure time.

If the use of a hearing protector is found necessary or advisable, choosing optimum devices is a complex task. The most important aspects for hearing protector performance include sufficient attenuation and usage during the entire exposure period.

It is often desirable to retain the ability to hear speech and warning signals. If the hearing protector is a passive device only, the hearing protector should not provide excessive attenuation (over-protection), which can create a feeling of isolation and difficulties with perception of important sounds. In particular, this needs attention at moderate noise levels.

Hearing protectors are supplied with attenuation data in various formats. The attenuation is expressed in decibels and has been derived from laboratory tests. It is important to note that these data have been achieved under controlled laboratory conditions using trained test subjects. Under real working conditions, the attenuation achieved by the user can be lower than that generated by the laboratory testing.

The performance of hearing protectors is subject to natural variability in the anatomy amongst users. Correct fitting, training, regular inspection and user motivation are important to obtain the desired protection. Due to the natural variability, it is not possible to calculate the exact attenuation that a certain hearing protector will give for an individual. If a more accurate prediction is required, an individual fit test is strongly recommended. At high noise level exposures it is advisable to seek expert advice. In some cases dual protection i.e. the use of an earmuff and an earplug combination, can be required.

For hearing protectors to be effective they should be used at all times when the user is in a potentially hazardous noise environment. When selecting hearing protectors, attention should be given to factors influencing comfort and user preference.

This document also provides advice on how to consider sustainability.

1 Scope

This document gives recommendations for the selection, use, care and maintenance of hearing protectors.

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.

EN 352-6, *Hearing protectors — Safety requirements — Part 6: Earmuffs with safety-related audio input*

EN 352-8, *Hearing protectors — Safety requirements — Part 8: Entertainment audio earmuffs*

EN 352-9, *Hearing protectors — Safety requirements — Part 9: Earplugs with safety-related audio input*

EN 352-10, *Hearing protectors — Safety requirements — Part 10: Entertainment audio earplugs*

3 Terms and definitions

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

ISO and IEC maintain terminology 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 daily noise exposure level

$L_{EX,8h}$

A-weighted noise exposure level normalized to a nominal 8 h working day according to EN ISO 9612

3.2 peak sound pressure level

$L_{p,Cpeak}$

C-weighted instantaneous peak sound pressure level according to EN ISO 9612

3.3 national regulation level

L'_{NR}

daily noise exposure level ($L_{EX,8h}$) effective to the ear according to national regulations

Note 1 to entry: National laws or regulations determine the levels of exposure at which hearing protectors shall be provided or used.

3.4 national peak regulation level

$L'_{NR,peak}$

peak pressure level $L_{p,Cpeak}$ effective to the ear according to national regulations

Note 1 to entry: National laws or regulations determine the levels of exposure at which hearing protectors shall be provided or used.

3.5**effective attenuation**

measure of protection afforded by the hearing protector for the user

3.6**A-weighted sound pressure level**
 $L_{p,A}$

sound pressure level with frequency weighting A according to EN 61672-1

3.7**A-weighted sound pressure level effective to the ear**
 $L'_{p,A}$

A-weighted diffuse-field related equivalent sound pressure level under the hearing protector for the external sound pressure level $L_{p,A}$

3.8**C-weighted sound pressure level**
 $L_{p,C}$

sound pressure level with frequency weighting C according to EN 61672-1

3.9**A-weighted equivalent sound pressure level effective to the ear**
 $L'_{p,A,eqT}$

A-weighted diffuse-field related equivalent sound pressure level under the hearing protector for the external sound pressure level for time period T $L_{p,A,eqT}$

Note 1 to entry: For simplicity of notation, the subscript T is omitted throughout the following text.

3.10**effective daily noise exposure level**
 $L'_{EX,8h}$

A-weighted diffuse-field related equivalent sound pressure level under the hearing protector for the external noise exposure level $L_{EX,8h}$

3.11**peak sound pressure level effective to the ear**
 $L'_{p,C,peak}$

C-weighted peak sound pressure level under the hearing protector for the external sound pressure level $L_{p,C,peak}$

3.12**flat frequency response**

attenuation which is constant (or nearly constant) over the frequency range between 125 Hz and 8 000 Hz ($H - L \leq 9$ dB)

Note 1 to entry: See A.1 for explanation of “ H ” and “ L ”.

Note 2 to entry: Slope of the linear regression of mean attenuation values from 125 up to 4 000 fulfils the criterion proposed by Liedtke [4] with a value lower than 3.6 dB, or very approximately $H - L < 9$ dB.

3.13

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

[SOURCE: EN 17479:2021, 3.1]

3.14

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.

[SOURCE: EN 17479:2021, 3.4]

4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

f	centre frequency of the octave band in Hz
$L_{p,eq}$	equivalent sound pressure level
$L_{p,oct}$	sound pressure level for a single octave band
$L_{p,octveq}$	equivalent sound pressure level for a single octave band
PNR	predicted noise level reduction according to EN ISO 4869-2
APV_f	assumed protection value APV_{fB4} according to EN ISO 4869-2
H	high-frequency attenuation value
M	middle-frequency attenuation value
L	low-frequency attenuation value
SNR	Single Number Rating
rms	root mean square
$L_{EX,8h}$	daily noise exposure level
$L_{p,Cpeak}$	C-weighted peak sound pressure level
L'_{NR}	national regulation level
$L'_{NR,peak}$	national peak regulation level
$L_{p,A}$	A-weighted sound pressure level
$L'_{p,A}$	A-weighted sound pressure level effective to the ear
$L_{p,C}$	C-weighted sound pressure level

$L_{p,A,eqT}$	A-weighted equivalent sound pressure level
$L_{p,C,eqT}$	C-weighted equivalent sound pressure level
$L'_{p,A,eqT}$	A-weighted equivalent sound pressure level effective to the ear
NOTE	For simplification of notation, the subscript T is omitted throughout the following text.
$L'_{EX,8h}$	effective daily noise exposure level
$L'_{p,C,peak}$	peak sound pressure level effective to the ear
$L_{C,Fmax}$	maximum value of the sound pressure level with time-weighting F (fast) and frequency weighting C
$L_{A,Fmax}$	maximum value of the sound pressure level with time-weighting F (fast) and frequency weighting A
A_f	frequency weighting A in dB for octave band centre frequency f
L_{crit}	criterion level
L_{max}	maximum input signal level to the protector audio input
V_{crit}	Criterion voltage
V_{max}	maximum rms voltage input to the protector audio input
K	constant for corresponding national regulation level
n	maximum number of hours for use of audio input
PPE	personal protective equipment
ANR	active noise reduction

5 Types of hearing protectors

5.1 Design forms

5.1.1 Earmuffs

Earmuffs consist of cups which fit over the ears and are sealed to the head with soft cushions, usually filled with foam and/or liquid. The cups are usually lined with sound absorptive material. They are connected by a tensioning band (head band), usually made of metal and/or plastic. When the earmuff is used behind-the-head or under-the-chin and has a mass in excess of 150 g, a flexible head strap is fitted to each cup or to the head band close to the cups to support the earmuff. Some earmuffs have one cup intended only for the left ear and the other only for the right ear. Earmuffs can be available in 'medium size range', 'small size range' and 'large size range' types. 'Medium size range' earmuffs will fit the majority of users. 'Small size range' or 'large size range' earmuffs are designed to fit users for whom 'medium size range' earmuffs are not suitable.

Earmuffs are available with head bands, neck bands, chin bands and universal bands. Earmuffs with neck bands and chin bands permit the simultaneous using of a safety helmet. Universal bands can be used over-the-head, behind-the-head or under-the-chin.

Requirements for earmuffs are specified in EN 352-1.

5.1.2 Earmuffs attached to head protection and/or face protection devices

Earmuffs attached to head protection and/or face protection devices (also called mounted earmuffs) consist of individual cups attached to arms that are mounted to a safety helmet or other equipment serving as carrier for the hearing protector, such as rigid head top of a powered and supplied air respirator system. The arms are adjustable so that the cups can be positioned over the ears.

Requirements for earmuffs attached to head protections and/or face protection devices are specified in EN 352-3.

5.1.3 Earplugs

5.1.3.1 General

Earplugs are hearing protectors that are designed to be inserted into the ear canal or to cover the ear canal entrance. They are sometimes provided with an interconnecting cord, rigid band or finger grips. Earplugs can be either disposable (intended for single use) or reusable (intended for repeated use). All types of earplugs except custom moulded earplugs can be available in range of sizes.

Requirements for earplugs are specified in EN 352-2.

5.1.3.2 Pre-shaped earplugs

Pre-shaped earplugs can readily be inserted into the ear canal without prior shaping. Pre-shaped earplugs are available in a variety of materials.

5.1.3.3 User-formable earplugs

User-formable earplugs are made from compressible materials that the user forms before inserting them into the ear canal. After insertion, these earplugs are designed to expand and form a seal within the ear canal.

5.1.3.4 Banded earplugs

These are pre-shaped earplugs attached to a band which presses them into the ear canal or against the entrance of the ear canal. Some are intended to be used in more than one position, e.g. with the band under-the-chin.

5.1.3.5 Custom moulded earplugs

Custom moulded earplugs are individually moulded to fit the shape of the user's ear canals typically using an impression or a scan of the individual concha and the outer ear canal of the user. They can be manufactured in a range of materials and with different acoustic filters to offer a range of attenuation.

5.2 Function mode

5.2.1 Basic function mode

All hearing protectors have the characteristics of reducing noise by their design and type of material used, to absorb and/or reflect sound. Devices that have only this function are called passive devices. They constitute the basis for all other additional function modes as described in 5.2.2 to 5.2.4.

5.2.2 Level-dependent hearing protectors

5.2.2.1 General

Level-dependent hearing protectors are designed to provide different attenuation as the external sound level changes. Their main purpose is to protect against impulsive or intermittent hazardous noise while allowing situational awareness.

5.2.2.2 Passive level-dependent hearing protectors

Passive level-dependent hearing protectors use the acoustic properties of carefully designed air ducts to give different protection at different noise levels. These types of hearing protectors are designed to be effective against very high level single-impulse noises, such as firearms, rather than the continuous noise or repetitive impulses found in most industrial situations.

5.2.2.3 Sound-restoration level-dependent hearing protectors

Sound-restoration level-dependent hearing protectors incorporate an electronic sound reproduction system. At low sound pressure levels, the sound detected by an external microphone is amplified and relayed to a loudspeaker inside the earmuff or earplug. As the external sound pressure level increases, the electronics reduce the gain and control the level of reproduced sound inside the hearing protector.

Requirements for level-dependent hearing protectors are specified in EN 352-4 (for earmuffs) and EN 352-7 (for earplugs), e.g. minimum criterion levels.

There are two types of sound-restoration level-dependent hearing protectors: products only intended for use in impulsive type noise situations and products for all types of noise environment (continuous, fluctuating and intermittent noise including impulsive noise, see Annex G).

5.2.3 Active noise reduction (ANR) protectors

These are hearing protectors which incorporate an electronic sound cancelling system to achieve additional noise attenuation where passive hearing protectors can be less effective. ANR is particularly effective at low frequencies (50 Hz to 500 Hz).

Requirements for active noise reduction earmuffs are specified in EN 352-5.

5.2.4 Hearing protectors with external audio input

5.2.4.1 General

These devices use a wired or wireless system through which communication signals, alarms, messages or audio entertainment can be relayed. Some products incorporate a system to limit the sound pressure level.

5.2.4.2 Hearing protector with entertainment audio input

These devices can incorporate a radio receiver set or music player for entertainment or allow audio input from external devices. Such devices incorporate functions for limiting sound exposure.

Requirements for entertainment audio hearing protectors are specified in EN 352-8 (for earmuffs) and EN 352-10 (for earplugs).

5.2.4.3 Hearing protector with safety-related audio input

These devices include wired or wireless input and/or built-in two-way radio and can be used for work-related or safety-related communication. As the information to be received might be crucial for safety, the product standards impose no limitation on the reproduced sound pressure level at the ear.

Requirements for hearing protectors with electrical audio input (for work or safety-related communication) are specified in EN 352-6 (for earmuffs) and EN 352-9 (for earplugs).

6 Selection

6.1 Principles

Personal hearing protection should be selected so that, when used correctly and for the entire duration of exposure, it will eliminate or minimize the risk to hearing.

As there are many different hearing protectors intended for use in a wide range of noise environments it is important to choose a suitable type. The product shall be checked for regulatory conformance. Consideration should be given to the factors listed in a) to h). The list is neither exclusive nor exhaustive:

- a) sound attenuation, see 6.2;
- b) work environment, see 6.3;
- c) essential work or safety-related communication, especially speech intelligibility, see 6.4;
- d) compatibility with other personal protective equipment (PPE), such as helmets, spectacles, etc., see 6.5;
- e) the interaction between the user and the situation of use, see 6.6;
- f) medical factors, see 6.7;
- g) user comfort and ergonomic requirements, see 6.8;
- h) sustainability aspects of the products, see Clause 9.

The selection procedure should be reviewed at regular intervals to ensure that an effective attenuation is maintained. When considering all factors in the selection process the most important outcome is that the hearing protector will be used during the whole time of noise exposure.

6.2 Selection according to sound attenuation

6.2.1 Guide to protection rating

Hearing protectors should be chosen according to the sound attenuation they will provide. Methods to predict the sound attenuation of hearing protectors are given in 6.2.3.

NOTE 1 It is generally accepted that the risk of hearing damage associated with occupational noise exposure is low where the daily noise exposure level ($L_{EX,8h}$) is below 80 dB, and insignificant where $L_{EX,8h}$ is below 75 dB.

NOTE 2 National regulations or other guidelines can stipulate selection criteria for personal hearing protection and place limits on sound exposure. Such relevant criteria and limits are often taken into account in deciding what level of sound attenuation is required.

In general, a hearing protector which provides an effective sound level at the ear ($L'_{p,A,eq}$) of between 70 dB and 80 dB is considered suitable. If the chosen hearing protector provides excessive attenuation, users are at risk of failing to recognize warning signals and understand essential communications. Users can also feel isolated from their working environment. The perception of isolation increases as the sound level effective to the ear decreases.

Workers can be exposed to different noise environments during the working day. It can be possible to select a single hearing protector which is adequate for all situations likely to be encountered, or in some situations, to select more than one type of hearing protector.

EXAMPLE 1 A worker's only significant noise exposure is to an $L_{p,A,eq}$ of 98 dB, for a total of 30 min per day. His $L_{EX,8h}$ is 86 dB. His employer wishes to minimize the risk to the worker's hearing, and so aims to provide a hearing protector that provides an effective sound pressure level at the ear of below 80 dB, ideally between 75 dB and 70 dB during the noise exposure. The employer selects a protector that provides a sound attenuation of $M = 26$ dB.

EXAMPLE 2 A worker spends the majority of her working day (a total of 6 h) in an environment with an $L_{p,A,eq}$ of 94 dB. Her $L_{EX,8h}$ is around 93 dB. Her employer wishes to reduce the effective $L'_{EX,8h}$ to at least below 80 dB, and to minimize the risk to the worker's hearing. The employer rejects a protector that provides a sound attenuation of $M = 32$ dB, as this would reduce the effective sound pressure level at the ear to 62 dB and so risk excessive attenuation. The employer selects a protector that provides a sound attenuation of $M = 22$ dB.

6.2.2 Sound attenuation in practice

The attenuation afforded by a hearing protector when used under normal working conditions can differ from that indicated on the device packaging or in the user information. This can be due to factors including incorrect selection of type and/or size, use (see Clause 7), misuse and poor maintenance. For remarks on improving field performance see Annex E.

These differences can be overcome by appropriate information, instruction and on-going training in the use of the product. There are tools, referred to as “fit testing systems” that allow individual tests to be carried out to verify the correct fit. Further information and guidance on these systems can be found in 7.3 and more extensively in EN 17479.

In the absence of fit testing, some countries have published specific guidance on de-rating the published data in an attempt to address the issue of attenuation in practice. Refer to your national guidance for further information.

NOTE Sound attenuation in practice can be referred to as real-world attenuation or field attenuation.

6.2.3 Acoustical selection methods

6.2.3.1 Overview of applicable methods

The applicability of methods for estimating the sound pressure level effective to the ear for different types of hearing protector is summarized in Table 1. If the risk assessment indicates that the national peak regulation level is likely to be exceeded, refer also to the last column of Table 1.

Table 1 — Applicability of acoustical selection methods to different types of hearing protector

Type of hearing protector	Selection based only on L'_{NR}	Selection also based on $L'_{NR,peak}$
Passive	Annex A	Annex B
Passive level dependent	Annex A	Annex B
Sound restoration level dependent	Annex C	Annex B ^a
ANR	Annex A ^b	Annex B ^a
Audio input	Annex A and Annex D	Annex B ^a
Dual hearing protection	Annex A ^c	Annex B ^c
^a using the passive attenuation data ^b using the total (passive and active) attenuation data ^c using the passive attenuation data for the combination		

6.2.3.2 Methods for estimating the level effective to the ear when selecting a hearing protector based on the national regulation level L'_{NR}

This approach is suitable for continuous, fluctuating and intermittent noise.

When selecting a suitable hearing protector, consideration should be given to the characteristics of the noise and the attenuation data of potentially suitable hearing protectors. The attenuation of most hearing protectors varies with frequency. To determine if a hearing protector is (acoustically) suitable, it is necessary to estimate the sound pressure level effective to the ear when the hearing protector is used. There are four methods of estimating the sound pressure level effective to the ear. These are:

- Octave band method;
- *HML* method;
- *HML* check method;
- *SNR* method.

All four methods are explained in detail in Annex A including worked examples. Table 2 shows the type of information on workplace noise needed for each estimation method.

Table 2 — Information on workplace noise required for assessing sound attenuation

Estimation method	Information required
Octave band method (see A.2)	octave band sound pressure level; $L_{p,oct} / L_{p,oct,eq}$
<i>HML</i> method (see A.3)	A and C-weighted sound pressure level; $L_{p,A}$ and $L_{p,C} / L_{p,A,eq}$ and $L_{p,C,eq}$
<i>HML</i> check method (see A.4)	A-weighted sound pressure level, $L_{p,A} / L_{p,A,eq}$ subjective decision between two noise classes (using lists of examples of noise sources, see A.4)
<i>SNR</i> method (see A.5)	C-weighted sound pressure level, $L_{p,C} / L_{p,C,eq}$

For changing noise environments and/or exposure times it can be appropriate to use more than one type of hearing protector in a working day. If the noise is not continuous but fluctuating or impulsive, the equivalent level should be calculated or measured. The four estimation methods do not take account of any de-rating values. Refer to your national guidance for further information on this issue (see 6.2.2).

6.2.3.3 Method for estimating the level effective to the ear when selecting a hearing protector based on the national peak regulation level $L'_{NR, peak}$

The method described in Annex B is applicable to all hearing protectors. At high peak sound pressure levels non-passive devices operate in the passive mode and therefore passive *HML* attenuation data are used.

6.2.3.4 Selection method for sound-restoration level-dependent hearing protectors intended for all types of noise environment, using *HML* criterion values

Annex C describes a method to aid the correct selection of a non-passive sound-restoration level-dependent hearing protector for use in all types of noise environment. The method is applicable to both earmuffs and earplugs using *HML* criterion level data obtained in accordance with EN 352-4 and EN 352-7 respectively. The method can be suitable for other similar non-passive devices. The criterion levels describe the maximum external noise level for which this product does not lead to more than 85 dB(A) effective to the ear. The criterion levels are determined with volume control set to maximum.

The annex determines only whether the hearing protector will reduce the A-weighted sound pressure level effective to the ear to below the defined limit of 85 dB(A). This annex cannot give the specific level at the ear.

6.2.3.5 Method for estimating the level effective to the ear when an active noise reduction hearing protector based on the national regulation level L'_{NR}

The selection can be made following the methods of Annex A according to the octave band method in A.2, the *HML* method in A.3 or the *HML* check method in A.4, using the total attenuation values according to EN 352-5. In addition, it should be checked that the external sound pressure level for which the sound pressure level effective to the ear remains linear is not exceeded (these data are obtained from the instructions for use). The outcome of the assessment is compared to the national regulation level L'_{NR} . The product should be assessed based on the passive attenuation values in the event that the active noise reduction is not operational.

6.2.3.6 Method for estimating the level effective to the ear for a hearing protector with audio input

When there is a need or demand for radio for essential communication or entertainment, hearing protectors with an audio input are available. These are divided in two types: for entertainment (listening to a music source) or for safety or work-related speech communication.

The user will be exposed to both the attenuated ambient noise and the audio input signal. Hearing protectors with entertainment audio input shall conform to EN 352-8 (for earmuffs) or EN 352-10 (for earplugs). For products with wireless or wired entertainment audio input the sound pressure level is limited to 82 dB ($L'_{p,A,eq}$).

For hearing protectors with electrical audio input the sound pressure level can exceed 82 dB(A) for input voltages higher than those specified by the manufacturer. To minimize the risk of hazardous exposure it is therefore recommended to select products with built-in limiter functions.

Where communication is essential, hearing protectors shall conform to EN 352-6 (for earmuffs) or EN 352-9 (for earplugs). The following information is provided by the manufacturer:

- the input signal level corresponding to 82 dB(A) effective to the ear (criterion input signal);
- the relationship between sound output level and input signal in 5 dB steps from a sound output level of 70 dB(A) up to the maximum input signal;
- the sound output level for maximum input signal;
- the usage time for the maximum input signal that corresponds to an equivalent sound output level of 82 dB(A) over 8 h.

NOTE The usage time can be increased, if the input signal level is lowered.

If the contribution of the audio input signal to the sound level effective to the ear is substantial the combined exposure should be considered. It can be necessary to reduce the contribution of the external source. Annex D describes a calculation method for combining these sources.

When selecting this type of product, it is important to realize that the additional sound input will negatively affect the awareness of the sound from the environment and warning signals. Systems providing the input signal to only one ear might be a safer solution. The audibility of warning signals shall be checked.

6.2.4 Selection of combination of earmuffs and earplugs

Personnel working in extremely noisy environments can require higher attenuation than a single hearing protector can provide. In such cases, increased protection can be obtained by using a combination of earmuffs and earplugs. Dual protection should be considered when the daily noise exposure exceeds 105 dB(A) if there is substantial noise at frequencies below 500 Hz. For higher

frequency dominant noise dual protection should be considered from 110 dB(A). The attenuation of a combination of earmuffs and earplugs is not the sum of the attenuation of the individual protectors. The typical increase in attenuation will depend on the noise, fit and what combination of protectors is used.

NOTE Results from 46 combination measurements show a range of 1 dB to 12 dB increase above the higher SNR. For seven combinations of earmuffs with high attenuating earplugs an increase in M -value between 5 dB and 9 dB was observed. The L -value can vary in a wider range and is dependent strongly on the attenuation of the earplug.

Where dual protection is required, it is important to obtain attenuation data for the chosen combination of earplug and earmuff (and helmet, if used), e.g. by contacting the manufacturer. If both the earplug and earmuff are well fitted, the increase in attenuation is mainly at frequencies below 1 000 Hz. Bone conduction can limit the total sound attenuation, particularly around 2 000 Hz. The most suitable combinations of earplug and earmuff (dual hearing protection) are dependent on both the noise as well as any need for communication, situational awareness and issues related to use of personal protective equipment.

6.3 Selection according to work environment

6.3.1 Factors of work environment – overview

Further to the acoustical selection guidance (see 6.2) consideration should also be given to influences present in the work environment. These can include, but are not limited to, temperature, dust, hazardous substances, moving machinery, vibration, localization of noise sources, feeling of isolation and the daily time of use of the hearing protector.

In addition, the importance of hearing warning signals and informative sounds should also be taken into consideration (see 6.3.2.8).

6.3.2 Acoustical factors

6.3.2.1 Influence of types of noise

The selection of hearing protectors should consider the type(s) of noise in the working environment:

- a) continuous noise;
- b) fluctuating noise;
- c) intermittent or repeated short-term noise;
- d) impulsive noise;
- e) dominant low frequency noise;
- f) high frequency pure tones in the noise (increased risk of hearing damage);
- g) presence of informative sounds.

For continuous, fluctuating or intermittent noise the selection is determined by the daily noise exposure level ($L_{EX,8h}$). For impulsive noise the selection is determined by the daily noise exposure level ($L_{EX,8h}$) and by the peak sound pressure level ($L_{p,Cpeak}$).

See Annex G for illustrations of the different noise types.

6.3.2.2 Exposure to continuous noise

In a continuous or steady-state noise environment, most types of hearing protectors can be used. Other influencing factors, such as communication requirements or environmental factors, can help determine which particular type of hearing protector is most suitable (see 6.3.3 and 6.4).

6.3.2.3 Exposure to fluctuating noise

In a fluctuating noise environment, a level-dependent or sound-restoration hearing protector can be more suitable. Passive or other hearing protectors can also be used subject to an appropriate risk assessment. In fluctuating noise, there is a risk of the user removing their hearing protector during prolonged periods of lower noise level. This is even more likely if the selected hearing protector is providing excessive attenuation. When the high noise level events re-occur, the user is not protected. The exposure assessment, and training on the use of the device, should take these factors into account.

6.3.2.4 Exposure to intermittent or repeated short-term noise

For intermittent or repeated short-term predictable noise exposure, earmuffs and pre-shaped banded earplugs can be an option because they are quick and easy to don and doff. Alternatively, earplugs with a switching function can be used. This allows the users to temporarily select a lower or higher attenuation without the need to don and doff the earplugs.

Level-dependent hearing protectors can also be preferred since they provide protection during the noise exposure, and also allow communication and situational awareness during the quieter periods. Level-dependent hearing protectors can be the preferred option in environments where the user is exposed to sudden and unexpected loud noise.

6.3.2.5 Exposure to impulsive noise

For impulsive noise, the selection is determined by the daily noise exposure level ($L_{EX,8h}$) and by the highest peak sound pressure level ($L_{p,Cpeak}$). Level-dependent hearing protectors can offer the optimum solution. For high peak levels, the passive attenuation should be considered when assessing the actual level of protection (see Annex B).

6.3.2.6 Dominant low frequency noise

In environments that are dominated by high-level low frequency noise, hearing protectors with high L -values are recommended. Active noise reduction devices can provide additional attenuation in the low frequency range compared to passive devices of the same type. The incorporated electronic sound cancelling system is designed to achieve additional attenuation beyond that of a passive device.

6.3.2.7 High frequency tonal noise

High frequency tonal noise can constitute a higher risk of hearing damage at the same level of exposure compared to a broad band noise. Hearing protectors with high H -values are recommended. Devices with a non-flat attenuation curve can be suitable, as long as communication situations are not affected.

6.3.2.8 Informative sounds

6.3.2.8.1 General

In many workplaces it is important that sounds are heard clearly and distinctly. Such sounds can be speech, warning signals, machinery sound or music. Note that the use of dual hearing protection can impair recognition of informative sounds more than single hearing protection. If informative sounds of the working process are important, the aspects in 6.3.2.8.2 to 6.3.2.8.6 should be considered.