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

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PH/7, Hearing protectors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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

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European foreword

This document (EN 458:2016) 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of an identical text or by endorsement, at the latest by September 2016, and conflicting national standards shall be withdrawn at the latest by September 2016.

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This document supersedes EN 458:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

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Introduction

This European Standard is intended to guide employers, supervisors and safety advisors. Additionally, the standard gives information to all who need to use hearing protectors.

Hearing protectors are items of personal protective equipment (PPE) intended to reduce the harmful effects that sound and noise may have on the hearing.

Guidance is provided on how to best select, use and take care of such devices. Tools to estimate the noise exposure level, when a certain hearing protector is used, are also provided.

National bodies may develop national application documents based on this standard.

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 concern is for the protector to provide sufficient attenuation.

It is often desirable to retain the ability to hear speech and warning signals. To achieve this, the hearing protector should not overprotect. 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 may be lower than that generated by the laboratory testing.

The performance of hearing protectors is subject to natural variability 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, some form of individual attenuation check can be made. 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, may 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.

1 Scope

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 352-1, *Hearing protectors — General requirements — Part 1: Ear-Muffs*

EN 352-2, *Hearing protectors — General requirements — Part 2: Ear-plugs*

EN 352-3, *Hearing protectors — General requirements — Part 3: Ear-muffs attached to an industrial safety helmet*

EN 352-4, *Hearing protectors — Safety requirements and testing — Part 4: Level-dependent ear-muffs*

EN 352-5, *Hearing protectors — Safety requirements and testing — Part 5: Active noise reduction ear-muffs*

EN 352-6, *Hearing protectors — Safety requirements and testing — Part 6: Ear-muffs with electrical audio input*

EN 352-7, *Hearing protectors — Safety requirements and testing — Part 7: Level-dependent ear-plugs*

EN 352-8, *Hearing protectors — Safety requirements and testing — Part 8: Entertainment audio ear-muffs*

EN 24869-1, *Acoustics — Hearing protectors — Subjective method for the measurement of sound attenuation (ISO 4869-1)*

EN 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications (IEC 61672-1)*

EN ISO 4869-2, *Acoustics — Hearing protectors — Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn (ISO 4869-2)*

EN ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals (ISO 7731)*

EN ISO 9612, *Acoustics — Determination of occupational noise exposure — Engineering method (ISO 9612)*

EN ISO 9921, *Ergonomics — Assessment of speech communication (ISO 9921)*

3 Terms and definitions

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

3.1
daily noise exposure level ($L_{EX,8h}$)
A-weighted noise exposure level normalized to a nominal 8 h working day

3.2
peak sound pressure level ($L_{p,\mathrm{Cpeak}}$)
C-weighted instantaneous peak sound pressure level according to EN ISO 9612

3.3
national regulation level (L'_{NR})
daily noise exposure level ($L_{\mathrm{EX,8h}}$) effective to the ear according to national regulations

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

3.4
national peak regulation level ($L'_{\mathrm{NR,peak}}$)
peak pressure level $L_{p,\mathrm{Cpeak}}$ effective to the ear according to national regulations

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

3.5
effective attenuation
measure of protection afforded by the hearing protector for the user

3.6
over-protection
selection and use of a hearing protector with too high attenuation which may lead to a sense of isolation and difficulties with perception of sounds

3.7
A-weighted sound pressure level ($L_{p,\mathrm{A}}$)
sound pressure level with frequency weighting A according to EN 61672-1

3.8
A-weighted sound pressure level effective to the ear ($L'_{p,\mathrm{A}}$)
A-weighted diffuse field equivalent sound pressure level under the hearing protector for the external sound pressure level $L_{p,\mathrm{A}}$

3.9
C-weighted sound pressure level ($L_{p,\mathrm{C}}$)
sound pressure level with frequency weighting C according to EN 61672-1

3.10
A-weighted equivalent sound pressure level effective to the ear ($L'_{p,\mathrm{A,eq}T}$)
A-weighted diffuse field equivalent sound pressure level under the hearing protector for the external sound pressure level for time period T $L_{p,\mathrm{A,eq}T}$

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

3.11
effective daily noise exposure level ($L'_{\mathrm{EX,8h}}$)
A-weighted diffuse field equivalent sound pressure level under the hearing protector for the external noise exposure level $L_{\mathrm{EX,8h}}$

3.12
peak sound pressure level effective to the ear ($L'_{p,\mathrm{Cpeak}}$)
C-weighted peak sound pressure level under the hearing protector for the external sound pressure level $L_{\mathrm{p,Cpeak}}$

3.13
flat frequency response
attenuation which is constant (or nearly constant) over the frequencies (H – L ≤ 9 dB)

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

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
$L_{p,\mathrm{eq}}$	equivalent sound pressure level
$L_{p,\mathrm{oct}}$	sound pressure level for a single octave band
$L_{p,\mathrm{oct,eq}}$	equivalent sound pressure level for a single octave band
PNR	predicted noise level reduction according to EN ISO 4869-2
$\mathrm{APV_f}$	assumed protection value $\mathrm{APV_{f84}}$ according to EN ISO 4869-2
rms	root mean square
$L_{\mathrm{EX,8h}}$	daily noise exposure level
$L_{p,\mathrm{Cpeak}}$	C-weighted peak sound pressure level
L'_{NR}	national regulation level
$L'_{\mathrm{NR,peak}}$	national peak regulation level
$L_{p,\mathrm{A}}$	A-weighted sound pressure level
$L'_{p,\mathrm{A}}$	A-weighted sound pressure level effective to the ear
$L_{p,\mathrm{C}}$	C-weighted sound pressure level
$L_{p,\mathrm{A,eq}T}$	A-weighted equivalent sound pressure level
$L_{p,\mathrm{C,eq}T}$	C-weighted equivalent sound pressure level
$L'_{p,\mathrm{A,eq}T}$	A-weighted equivalent sound pressure level effective to the ear
$L'_{\mathrm{EX,8h}}$	effective daily noise exposure level
$L'_{p,\mathrm{Cpeak}}$	peak sound pressure level effective to the ear

NOTE For simplification of notation, the subscript T is omitted throughout the following text.

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, a flexible head strap is sometimes 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 may 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. Universal bands, neck bands and chin bands may be complemented by head straps to ensure a reliable fit of the earmuff.

Requirements for earmuffs are specified in EN 352-1.

5.1.2 Helmet mounted earmuffs

Helmet mounted earmuffs consist of individual cups attached to arms that are mounted to an industrial safety helmet or other equipment serving as carrier for the hearing protector. The arms are adjustable so that the cups can be positioned over the ears.

Requirements for earmuffs attached to a helmet 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, head band or finger grips. Earplugs can be either disposable (intended for single use) or reusable (intended for repeated use).

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. They may be available in a range of sizes.

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. They can be provided with different 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.

Requirements for level-dependent hearing protectors are specified in EN 352-4 (for earmuffs) and EN 352-7 (for earplugs).

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 protector 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.

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 may 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 working 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 may incorporate a radio receiver set or music player for entertainment or allow audio input from external devices. It also offers the possibility to communicate warning signals or messages.

Requirements for entertainment audio earmuffs are specified in EN 352-8.

5.2.4.3 Hearing protector with work or safety-related audio input

These devices include wired input or wireless radio receiver and/or two-way radio for work 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 earmuffs with electrical audio input (for work or safety-related communication) are specified in EN 352-6.

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 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) how the hearing protector will be used, see 6.6;

f) special user groups and medical factors, see 6.7;

g) user comfort; and ergonomic requirements, see 6.8;

h) conformity with relevant requirements for incorporated electronics, see 6.9.

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

National regulations or other guidelines may stipulate selection criteria for personal hearing protection and place limits on sound exposure. Such relevant criteria and limits should be 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 ($L'_{p,\text{A,eq}}$) 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 may also feel isolated from their working environment. The perception of isolation increases as the sound level effective to the ear decreases.

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

EXAMPLE 1 A worker's only significant noise exposure is to an $L_{p,\mathrm{A,eq}}$ of 98 dB, for a total of 30 min per day. His $L_{\mathrm{EX,8h}}$ 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. The employer selects a protector that provides a sound attenuation of 26 dB.

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

6.2.2 Sound attenuation in practice (Real-world attenuation)

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

These differences may be overcome by appropriate information, instruction and on-going training in the use of the product. There are tools available to make individual tests to check the correct fitting.

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.

6.2.3 Acoustical selection methods

6.2.3.1 Methods for assessing the sound attenuation of a passive hearing protector for continuous noise exposure

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 1 shows the type of information on workplace noise needed for each estimation method.

Table 1 — Information on workplace noise required for assessing sound attenuation

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

For changing noise environments and/or exposure times it may 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).

6.2.3.2 Method for assessing the sound attenuation of a hearing protector for impulsive sounds

The method described in Annex B is applicable to passive, sound-restoration level-dependent, and ANR hearing protectors as described in EN 352. At high sound pressure levels non-passive devices operate in the passive mode. Accordingly the sound attenuation HML data used for the selection is for the passive mode.

6.2.3.3 Selection method for sound-restoration level-dependent hearing protectors using HML data

Annex C describes a method to aid the correct selection of a non-passive sound-restoration level-dependent hearing protector when it is used in a given 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 may be suitable for other similar non-passive devices.

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 and accordingly cannot be used for comparison with the national regulation level L'_{NR}.

6.2.3.4 Selection method for active noise reduction hearing protectors

Annex D describes a method to aid the correct selection of an active noise reduction hearing protector when it is used in a given noise environment. The method is applicable to both earmuffs and earplugs using the total (active plus passive) attenuation data obtained in accordance with EN 352-5. The method may be suitable for other similar devices.

6.2.3.5 Selection method for hearing protectors 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. Such devices allow the user to hear without removing the protector.

The user will be exposed to both the attenuated ambient noise and the audio input signal. Earmuffs with entertainment audio input conform to EN 352-8. For FM radio products the audio sound pressure level is limited to 82 dB(A) effective to the ear. For products with entertainment audio input the sound pressure level is limited to 82 dB(A) for all input signal levels up to the maximum specified by the manufacturer.

NOTE The sound pressure level can exceed 82 dB(A) for input signal levels 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, earmuffs should conform to EN 352-6. The audio input is not limited but the input signal level corresponding to 82 dB(A) effective to the ear should be provided by the device manufacturer (criterion voltage).

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 may be necessary to reduce the contribution of the external source.

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 may 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) especially if there is substantial noise at frequencies below 500 Hz. 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, user skills and what combination of protectors is used. In general, the total attenuation that can be expected is no more than about 6 dB above the higher of the two attenuation values. If both the earplug and earmuff are well fitted, the increase in attenuation is mainly at frequencies below 1000 Hz. Bone conduction may limit the total sound attenuation, particularly around 2000 Hz. Which combinations of earplug and earmuff (dual hearing protection) are most suitable, depends on both the noise as well as any needs for communication, situational awareness and issues related to use of personal protective equipment. Where dual protection is required it is important to obtain test data for the particular combination of earplug and earmuff (and helmet, if used).

Guidance for optimum use are given in Annex F.

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 may 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 using 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 ($L_{\mathrm{EX,8h}}$). For impulsive noise the selection is determined by the daily noise exposure level ($L_{\mathrm{EX,8h}}$) and by the peak sound pressure level ($L_{p,\mathrm{Cpeak}}$).

See Annex H 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 temperature of the workplace, may 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 may be most suitable. Passive or other hearing protectors may also be suitable subject to an appropriate risk assessment. In fluctuating noise there is a risk that the user will remove their hearing protector when a lower noise level is experienced for a prolonged period of time. This is even more likely if the selected device overprotects. When the high noise level events resume, the user is not protected. The exposure assessment, and training on the use of the device, shall take these factors into account.

6.3.2.4 Exposure to intermittent or repeated short-term noise

For intermittent or repeated short-term noise exposure, earmuffs and pre-shaped banded earplugs may be preferred because they are quick and easy to fit and remove. Level-dependent hearing protectors may 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 may be particularly preferred in environments where sudden loud noise may occur and where the user may not be prepared for the exposure.

6.3.2.5 Exposure to impulsive noise

For impulsive noise the selection is determined by the daily noise exposure level ($L_{\mathrm{EX,8h}}$) and by the highest peak sound pressure level ($L_{p,\mathrm{Cpeak}}$). Level-dependent hearing protectors may offer the optimum solution. For high peak levels, the passive attenuation is still very important when assessing the actual level of protection.

6.3.2.6 Dominant low frequency noise

In environments that are dominated by high-level low frequency noise, active noise reduction devices may be most suitable. The incorporated electronic sound cancelling system is designed to achieve additional attenuation beyond that of a passive device.

6.3.2.7 High frequency pure tone noise

High frequency pure tone noise may constitute a higher risk of hearing damage at the same level of exposure compared to a broad band noise.

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 may be speech, warning signals, machinery sound or music. Note that the use of dual hearing protection may impair recognition of informative sound 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.

6.3.2.8.2 Warning signals

Where the recognition of sounds such as warning signals is critical, passive hearing protectors with a flat frequency response may be preferred. In case of non-continuous noise, level-dependent hearing protectors should be considered. The use of hearing protectors provided with entertainment audio may not be suitable where there are risks associated with inaudibility of sounds that need to be heard, in order to reduce the risks of accidents, for example from moving vehicles.

Depending on the frequency content of the warning signal, hearing protectors with a suitable frequency response are to be considered. In any case, warning signals need to be clearly recognizable. In case of doubt, a listening check according to EN ISO 7731 should be carried out.

6.3.2.8.3 Localization of noise sources

Identification of the direction of a sound source is sometimes necessary. This may be impaired when hearing protectors are used. Earplugs may be preferred.

6.3.2.8.4 Speech communication

Generally speech intelligibility through passive hearing protectors is improved with flat frequency response. Speech intelligibility may also be improved with level-dependent hearing protectors (e.g. for intermittent noise) or hearing protectors with communication facilities.

6.3.2.8.5 Machinery sound

Machinery sounds may contain work related information. Depending on the frequency content of the machinery sound, hearing protectors with a suitable frequency response or level-dependent hearing protectors may be considered.

6.3.2.8.6 Live Music

For music performers and listeners, an attenuation as flat as possible (H, M and L values being nearly the same) is desirable. This will give the least distortion of the original sound. The attenuation should also be carefully selected. Over-protection should be avoided to encourage uninterrupted use of hearing protectors, see 6.4.2.

6.3.3 Environmental factors (non-acoustic)

6.3.3.1 General

In addition to acoustical factors affecting selection, other environmental factors should also be considered. Table 2 gives general guidance for selecting the appropriate hearing protector when considering environmental factors. Risk assessment and working environment influences may override the effect of the environmental factors on hearing protection selection described in this subclause.

6.3.3.2 Temperature (high and low temperatures and/or humidity)

Physical work, especially at high ambient temperatures and/or humidity, may cause perspiration under earmuff cushions. In such conditions earplugs may be preferred. If earmuffs are used, thin, absorbent hygiene cushion covers may be used. However, it should be noted that these covers may reduce the attenuation of the hearing protector. Products with published attenuation data for a combination of earmuff and hygiene cover should be preferred. Extreme low temperatures may affect the attenuation of hearing protectors because the pliability of the materials may be reduced.

6.3.3.3 Contamination and unclean working conditions

In unclean working conditions, care should be taken to ensure that the selected hearing protector can be fitted and used without risk of irritation to the user. Contaminants such as dirt, dust, germs or metal filings can lead to skin irritation or infection, for example dust on the surface of an earmuff cushion or dirt on an earplug which is then inserted into the ear canal. Before fitting the hearing protector the user should ensure that their fitting environment and hands are clean.

All earplugs should be inserted before entering a dusty environment.

6.3.3.4 Moving machinery parts

If working in an environment where machinery has moving parts, corded earplugs, where the cord could be caught by the machine, may not be suitable.

6.3.3.5 Personal incompatibility of the user

If a user has small ear canals or sensitive ear canal tissue, the use of earplugs may not be appropriate. In such cases earmuffs may be more appropriate.

6.3.3.6 Type of work being undertaken

Earmuffs with entertainment audio input may be suitable for users with monotonous or repetitive tasks or when the risk assessment allows it. When selecting such a device the additional noise source represented by the audio input should be taken into account (see 6.2.3.5 and Annex E). Warning signals need to be clearly recognizable. In case of doubt, carry out a listening check in accordance with EN ISO 7731.

Table 2 — General guidance for selection of hearing protectors in relation to environmental factors

Working environment and activity	Type of hearing protector					
	Earmuffs	Reusable earplugs	Disposable earplugs	Banded earplugs	Custom moulded earplugs	Corded earplugs
a) Very high temperature	- [a]	+	+	+	+	+
b) High airborne particle exposure		-	+	-		
c) Repeated short-term noise exposure	+	-	-	+	-	-
d) Localization of the noise source	-	+	+	+	+	+
e) Contaminants on the hands such as dirt, dust, germs or filings	+		+ [b]			
f) Moving machinery part	+	+	+		+	-

Key

- generally not preferable

+ generally preferable

Blank cells: case specific and subject to risk assessment

[a] Appropriate with absorbent hygiene cushion covers.

[b] Earplugs without grip should be inserted only with clean hands.

6.4 Communication

6.4.1 Essential work related speech communication, especially speech intelligibility

Where the recognition of sounds such as speech is critical, careful selection of attenuation is necessary to ensure a good balance between speech intelligibility and protection (with due consideration to the risk of overprotection). Hearing protectors with a flat frequency response may be preferred. In some cases, the use of devices with additional (electronic) sound-restoration or active noise reduction may be considered.

Where radio communication is required, hearing protectors are available with one-way or two-way radio communication.

For essential safety-related communication, the sound pressure level effective to the ear may occasionally be of a potentially damaging level in order to achieve a good signal-to-noise ratio. Methods for assessing the speech intelligibility can be found in EN ISO 9921.

6.4.2 Effects of over-protection

Caution should be exercised to ensure that the user is not provided with a hearing protector that gives unnecessarily high attenuation. Such hearing protectors may cause difficulties with communication and their hearing of warning signals. Users may feel uncomfortable or isolated from the environment. As a result, hearing protectors may not be used for the entire exposure time.

6.5 Compatibility with other PPE

In the selection of hearing protectors it is important to ensure that the hearing protector's performance is not impaired by the use of other PPE. For more information see 7.4.

6.6 Selection according to hearing protector types

6.6.1 Earmuffs – General

Earmuffs may be preferred:

a) in cases where the hearing protector shall be used and taken off frequently due to repeated short term noise exposure (banded earplugs are also suitable);

b) in cases where earplugs result in discomfort;

c) whenever earplugs cause inflammation of the ear canal or other local reactions.

Earmuffs of low weight are to be preferred.

6.6.2 Helmet-mounted earmuffs

Helmet-mounted earmuffs are intended for use with an industrial safety helmet when a user requires simultaneous head and hearing protection. Use only tested and certified combinations of helmet and earmuff. Information about permissible combinations is contained in the user information from earmuff manufacturers.

6.6.3 Earplugs – General

Earplugs may be preferred:

a) where sweating under earmuffs may occur;

b) if other conflicting personal protective equipment is used, e.g. safety helmets, respirators, goggles and face shields.

Hearing protectors tend to impair the localization of noise sources. Preference may be given to earplugs if it is required to identify the sound direction.

Banded or corded earplugs may be preferred in cases where they are frequently used and removed. Such devices also lower the risk of loss of one earplug. If working in an environment where machinery has moving parts, corded earplugs may not be suitable.

Custom moulded earplugs, properly fitted to the ear canal, may be preferred for long duration use because they are unlikely to work loose during the period of use, are easy to insert and can provide a repeatable fit.

6.6.4 Hearing protectors with additional function modes

6.6.4.1 Earmuffs and earplugs with level-dependent attenuation may be preferred if the working noise environment contains intermittent or impulsive noise or if speech intelligibility is required.

6.6.4.2 Communication earmuffs and earplugs may be preferred if work activities require the ability to communicate through for example a two-way radio or a mobile phone. Other situations could be one-way communication during training or touring through noise areas.

6.6.4.3 Active noise reduction earmuffs are suitable for low-frequency noise with a high sound pressure level.

6.6.4.4 Earmuffs with entertainment audio input may be suitable for users with monotonous or repetitive tasks, where situational awareness or perception of informative sounds of the working process is not required. Warning signals need to be clearly recognizable at all times.

6.7 Medical disorders

Before any type of hearing protector is selected, the user should be asked if he has had or has any ear trouble, such as irritation of the ear canal, earache, discharge or hearing loss, or is having treatment for any ear disease or skin disorder.

Individuals with any such medical problems should be referred for specialist advice as to the most suitable type of hearing protector. Individuals with an existing hearing loss may find that the use of hearing protectors leads to additional hearing difficulties. In general a hearing protector with a flat-frequency response could improve the situation. Sound restoration protectors can also provide assistance with hearing if a person prefers to remove their hearing aid.

6.8 Ergonomics and fitting

Ergonomics to be considered include, but are not limited to, size and shape of the head, ear canal and pinna.

Perceived comfort is an important element in the selection process of a hearing protector. If the chosen product is not comfortable, it is unlikely to be used. Wherever possible, the user should be allowed to make a personal choice of hearing protector from among adequate and effective types.

For earmuffs, the perceived comfort of a hearing protector may be affected by the size, mass, cushion pressure, headband force, adjustability, type of material used and the design and construction of the device.

For earplugs, the perceived comfort may be affected by the size, ease of fit and removal and the material, design and construction of the device.

At low ambient temperature, foam-made plugs may become too hard, meaning that they have to be warmed-up prior to insertion.

6.9 Conformity with relevant requirements for incorporated electronics

6.9.1 Intrinsic safety

Where hearing protectors incorporating electronics are selected for use in potentially explosive atmospheres, care should be taken to ensure that they are properly certified as intrinsically safe for the particular environment.

6.9.2 Electromagnetic compatibility (EMC)

Where necessary, devices that incorporate electronic circuitry shall meet the requirements of the appropriate European Standards.

7 Use

7.1 General

Effective explanation of the need to use hearing protection may help to overcome initial resistance. A sense of isolation may be experienced when hearing protectors are used for the first time.

When a hearing protector is used the low frequency energy transmitted by the ear canal wall (bone conduction path) will be more effectively radiated and coupled to the eardrum. This phenomenon is known as the occlusion effect. The user may experience their own voice differently and a sense of pressure or blockage in the ear.

Further guidance on use is available in Annex F.

7.2 Availability of hearing protectors

Personnel should not enter noise hazard areas without using hearing protectors. Where disposable protectors are used, a supply should be available at all points of entry to a noise hazard area. Where appropriate, provision should be made to ensure that hearing protection is available for visitors, and that it is used.

7.3 Correct fitting

7.3.1 General

Head and ear canal shapes vary considerably from one person to another. To achieve a good fit it is therefore essential that any hearing protector is correctly sized for each individual.

In order to achieve the desired attenuation, hearing protectors should be fitted in accordance with the manufacturer's instructions and fit tested where applicable.

Earmuffs are generally easy to fit, but large or small head sizes may require specific selection or adjustments. This particularly applies to helmet-mounted muffs.

Fitting of earplugs may be more difficult initially. A combination of training and a variety of products and/or sizes should be offered.

In cases where hearing protectors have one cup or plug intended only for the left ear and another for the right ear, care should be taken to ensure that the hearing protectors are used in the correct orientation.

7.3.2 Earmuffs

Earmuffs should be used with the head band or neck band correctly positioned and adjusted on the head.

For helmet-mounted earmuffs, a suitable helmet/earmuff combination is important to ensure appropriate head band force, cushion pressure and attenuation when the earmuff is in the working position. Only tested and certified combinations should be used, information on which is available from the device manufacturers.

7.3.3 Earplugs

Earplugs should be correctly inserted into the ear canal, providing a good seal. Failure to do so leads to poor sound attenuation, particularly at low frequencies.

When earplugs are used in high-noise environments, individual fit testing may be beneficial.

When in use, earplugs (except custom moulded) may slowly become loose due to jaw movement etc. Check and refit as appropriate.

Those parts of the earplug that come into contact with the ear canal should be clean and earplugs should always be inserted with clean fingers.

Earplugs available in a range of sizes should be fitted for each ear individually.

7.3.4 Fit check for hearing protectors

Fit checks are beneficial for all types of hearing protectors due to the differences between the laboratory sound attenuation and the attenuation in practice. For earplugs this difference might be higher than for earmuffs. For custom moulded earplugs it might be due to errors in imprint taking or manufacturing. Different testing methods exist. Further guidance on fit checks and tests may be found in Annex G.

7.4 Simultaneous use of hearing protector with other PPE

7.4.1 General

It is not uncommon for personnel working in a noisy environment to be required to use other PPE. This may lead to a reduction in hearing protector attenuation. Manufacturers' data may be available for multiple PPE combinations.

When a hearing protector is used in combination with other PPE equipped with acoustic warning signals, care should be taken to ensure the user's recognition of these warning signals is not impaired.

7.4.2 Protective clothing

Protective clothing should be used over any hearing protector. Using hearing protectors over clothing is likely to greatly reduce their attenuation.

7.4.3 Spectacles

The side arms of spectacles should be of a low profile type so as not to disturb the seal of the earmuff against the head. In order to minimize the acoustic leakage, avoid using spectacles with broad arms. Earplugs or earmuffs with wide and pliable cushions may be preferred.

7.4.4 Goggles

Care should be taken to ensure that the head straps do not interfere with the earmuff cushions and seals.

7.4.5 Face shields

The design of the face shield should be such as to prevent it interfering with the hearing protector when in use.

7.4.6 Hoods

Hearing protectors are usually used under a hood. Some hoods have been designed to be used under specific hearing protectors. Further advice should be available from manufacturers of such devices.

7.4.7 Safety helmets

Some earmuffs are designed to be used with safety helmets (not helmet-mounted earmuffs) and may be held in place with a head strap and/or neck band. Care should be taken to ensure that the helmet does not interfere with the fitting of the earmuff.

7.4.8 Respiratory protection devices

Care should be taken to ensure that the retaining harness or head strap of the respirator does not interfere with the seal between the earmuff and the side of the head.

7.5 Speech intelligibility and signal audibility

It is a natural reaction to drop the voice level when hearing protectors are used. However, it is important that users maintain or even increase their voice level to improve communication. Alarm, warning or call signals in the noisy area should be selected so that they are audible to those who have to use hearing protection. The audibility of any desired signal should be ensured by testing it under actual working conditions, allowing for variations in sound pressure levels (e.g. time of day/work process).

If the sound pressure levels are loud enough to interfere with the audibility of such signals it may be necessary to adopt an additional backup visual alarm system. Hearing protectors with communication facilities may be preferable if speech intelligibility or signal audibility is critical.

Poor speech intelligibility may prompt the user to temporarily remove the hearing protector for the purposes of communication. This is likely to lead to dramatically reduced effective attenuation.

7.6 Instruction and training

7.6.1 General

All personnel who need to use hearing protectors should be provided with sufficient information and adequate training in their correct use.

7.6.2 Information

In particular, information should be provided to the user on the following points:

a) risk of hearing damage if hearing protectors are not used;

b) damaging sound pressure levels;

c) influence of the period of use on the protection achieved;

d) availability of hearing protectors;

e) importance of the fit of the hearing protector on performance and the protection achieved;

f) audibility of speech and/or warning and alerting sounds;

g) manufacturer's instructions for use.

First time use requires a period of time for the user to adapt and familiarize to the new acoustical situation. This applies in particular to musicians.

Where required, additional information should be provided for the following:

h) use of hearing protectors in particular orientations;

i) compatibility of other PPE with earmuffs and banded earplugs;

j) ageing of protectors (maintenance) – For how long can a product be used for before it significantly loses its performance?

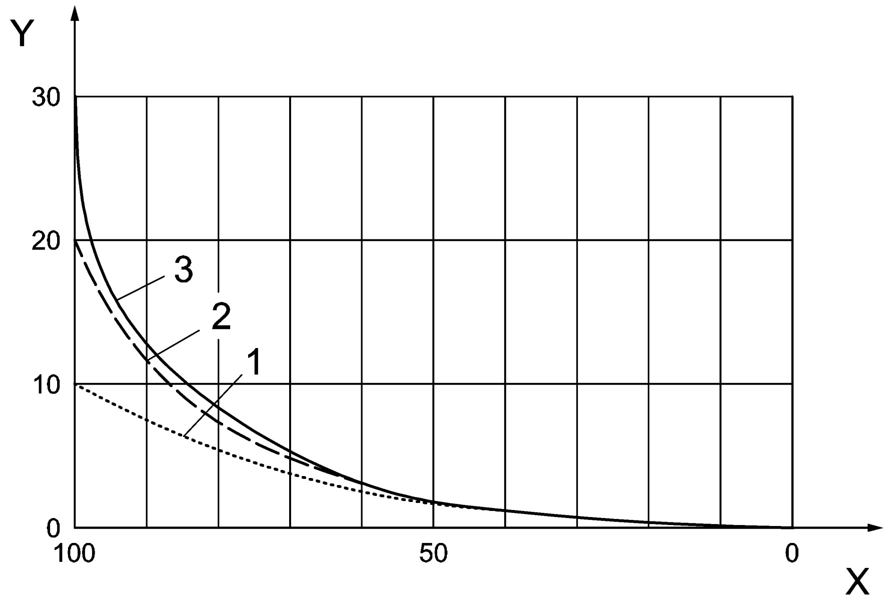
7.6.3 Special instructions for use including training

This guidance can be used to minimize the difference between the sound attenuation according to the EC type examination and the sound attenuation in practise.

For details see Annex F.

7.7 Period of use

To be effective, hearing protectors need to be used all the time in environments where harmful sound pressure levels exist. If hearing protectors are removed, even for short periods of time, the effective attenuation and protection is greatly reduced. Figure 1 illustrates the effect of removing the hearing protector for a period of time during an 8 h exposure. When people don't use hearing protectors for the complete noise exposure time, the limiting factor, in terms of attenuation, will become the time spent without the hearing protector rather than the performance of the protector. The loss in attenuation is more significant for higher attenuating devices, even when they are removed for a relatively short period of time during the exposure.



Key

x-axis: Exposure time with hearing protector in %

y-axis: Effective attenuation in dB

1 Hearing protector with an attenuation of 10 dB

2 Hearing protector with an attenuation of 20 dB

3 Hearing protector with an attenuation of 30 dB

Figure 1 — Effective protection provided by hearing protectors with decreased usage time over an 8 h shift

Example: If used for 4 h of an 8 h exposure period (i.e. 50 % of the time), the effective protection provided by any hearing protector is not more than 3 dB.

7.8 Leisure activities

The use of hearing protectors should be encouraged when exposure to noise outside the work situation may be hazardous.

8 Care and maintenance

8.1 General

Hearing protectors should be regularly maintained and cleaned in order to avoid loss of attenuation. The same earplugs should never be used by more than one person. In circumstances where the same earmuffs may need to be used by more than one person (e.g. earmuffs supplied for use by visitors) they should be hygienically cleaned between uses. The use of disposable earmuff cushion covers may be appropriate, however, it should be noted that this may result in a loss of attenuation. Information on the care and maintenance of hearing protectors should be given to all persons who may need to use hearing protectors, and should be repeated at regular intervals.

8.2 Hygiene and cleaning

Contamination of hearing protectors by foreign materials, solutions, liquid residues, dusts, particulate matter, etc. could cause skin irritation or abrasions. The user should ensure that their hands are clean when handling hearing protectors, especially earplugs. Medical assistance should be sought if skin irritation occurs during or following the use of hearing protectors. The use of disposable earmuff cushion covers may be appropriate, however, it should be noted that this may result in a loss of attenuation.

Earmuffs (especially the cushions) and reusable earplugs should be cleaned and stored following the manufacturer's instructions. Care should be exercised when cleaning hearing protectors that incorporate electronic or other specialized components and they should not be immersed in fluid.

8.3 Inspection and replacement

Hearing protectors should be inspected at frequent intervals for damage due to mechanical or electrical failure, ageing, accident or abuse. Signs may include evidence of hardness, brittleness or cracking. Head bands should not be subject to intentional deformation.

Earmuff cushions and inserts, and banded earplug ear tips, should be replaced in accordance with the manufacturer’s instructions.

8.4 Storage

Hearing protectors should be stored in a clean, dry and uncontaminated environment, in accordance with the manufacturer’s instructions.

8.5 Disposal

Disposal arrangements for used hearing protectors should follow manufacturer’s instructions or national regulations as applicable. Such disposal arrangements should ensure that the hearing protectors cannot be inadvertently reused and that they do not cause environmental damage.

Annex A
(normative)

Methods for assessing the sound attenuation of a passive hearing protector

A.1 General

This annex is applicable to passive hearing protectors, as described in EN 352 parts 1, 2, 3, and explains the principles, including examples. The attenuation of most hearing protectors varies with frequency. Therefore, to correctly estimate the sound pressure level effective to the ear when a hearing protector is used, the frequency characteristics of both the noise environment and the protector should be taken into account. This annex describes four different estimation methods to do this.

When the sound pressure level effective to the ear has been estimated, the daily noise exposure level shall be calculated, allowing for the combination of the noise environment and taking into account the duration of exposure. The method for predicting the hearing protector attenuation should be chosen according to the information available for the workplace noise as shown in Table 1.

All the methods are based on assumed protection values (APV_f) as measured according to EN 24869-1 (APV_f is mean attenuation minus one standard deviation for octave band centre frequency f). In addition, possible compensation for expected effects in practice may be made (see 6.2.2 and national guidelines). Used in this manner, the main purpose of the selection methods is to identify whether a protector is likely to be suitable for the user(s), subject to a given noise exposure.

The octave band method (A.2) is the most accurate method. It involves both the octave band sound pressure levels at the workplace and the octave band attenuation data of the hearing protector being assessed. Without the use of a computer or calculator program this method is complex and time consuming.

The HML method (A.3) specifies three attenuation values, H, M and L, calculated from the APV_f values of the hearing protector for high (H), middle (M) and for low (L) frequency noise details given in A.1. These values, together with the measured A-weighted and C-weighted sound pressure levels, are used to calculate the predicted noise level reduction (PNR). The PNR is then subtracted from the observed A-weighted sound pressure level to calculate the A-weighted sound pressure level effective to the ear when the hearing protection is used.

The HML check method (A.4) is an abbreviation of the HML method, that uses examples of noise sources which typically have a certain frequency content.

The SNR method (A.5) uses a single attenuation value, the Single Number Rating (SNR). The SNR-value is subtracted from a measured overall C-weighted sound pressure level, to calculate the A-weighted sound pressure level effective to the ear when the hearing protector is used.

The choice of method depends on the data available. In general, octave band sound pressure levels are often not available. This together with the added calculation complexity, means that the octave band method is not often used. It is therefore suggested to consider the HML method.

However, the octave band method is clearly recommended if:

— the noise is dominated by a significant high or low frequency content;

— the noise has a pure tone character and/or

— the attenuation of the protector is notably frequency dependent (which is often the case with low attenuation devices).

All four methods (A.2 to A.5) predict the overall A-weighted sound pressure level effective to the ear when the hearing protector is used ($L'_{p,\mathrm{A}}$). For changing noise environments and/or exposure times, the daily noise exposure level should be calculated and used. In some of these cases it may be appropriate, for reasons of comfort, to use more than one hearing protector, each one selected according to the $L_{p,\mathrm{A,eq}}$ for the different noise environments.

A full data label describing the attenuation of a hearing protector is shown in Table A.1. It contains three sets of data:

a) Octave band

b) HML

c) SNR

Table A.1 — Complete set of attenuation data for a hearing protector

Octave band centre frequency in Hz:	63	125	250	500	1k	2k	4k	8k
Mean value in dB (Row 1):	7,4	9,5	14,2	18,8	21,7	29,6	34,9	32,4
Standard Deviation in dB (Row 2)	2,4	2,5	2,8	3,1	2,3	5,2	2,3	2,7
Assumed Protection Value (APV_f) in dB (Row 3)	5,0	7,0	11,4	15,7	19,4	24,4	32,6	29,7
H = 25 dB		M = 19 dB		L = 13 dB		SNR = 22 dB		

Octave band data

Rows 1 to 3 show the octave band data. The data for each frequency band are:

— the mean attenuation in decibels;

— the standard deviation in decibels;

— the “Assumed Protection Value” (APV_f). This is the difference between row 1 and row 2.

It is recommended to use the Assumed Protection Value with a protection performance of 84 % (APV_f equals mean value minus standard deviation). This value is also applied in EN 352-1 to EN 352-3.

The reason for calculating mean values is that the attenuation of any hearing protector will show variation between users due to person-related physical factors as well as variation in fitting. This variation is expressed by the standard deviation value. The mean and standard deviation values are derived from the data obtained during the laboratory test for the type approval. For each APV_f, there is statistically an 84 % chance that the value is exceeded, or a 16 % chance that the value is below the presented value.

From the APV_f octave band data (row 3), two simplified data sets are calculated (for detailed information see ISO 4869-2).

HML data

The attenuation of most protectors is frequency dependent. H-M-L is a three number data set specifying the typical attenuation that may be achieved by a protector for noises that are respectively predominantly “High”, “Medium” or “Low” in frequency content. The H, M and L values correspond to $L_{p,\mathrm{C}}$-$L_{p,\mathrm{A}}$ differences of −2 dB, +2 dB and +10 dB respectively.

The difference between C-weighted and A-weighted sound pressure levels is used to determine which formulae and value to use. The higher the difference, the more low-frequency the noise is.

SNR data

The *Single Number Rating* value is based on the C-weighted sound pressure level outside the protector to predict the effective A-weighted sound pressure level to the ear The higher the frequency content, the more accurate the result. The lower the frequency content the more chance for incorrect estimation.

Calculation examples are provided in the following subclauses A.2 to A.5.

For the examples given in A.2 to A.5, the data from Table A.2 and Table A.3 have been applied:

Table A.2 — Continuous noise environment throughout the day

Frequency in Hz:	63	125	250	500	1k	2k	4k	8k
Octave band level ($L_{p,\mathrm{oct}}$) in dB:	80	84	86	88	97	99	97	96

$L_{p,\mathrm{A}}$ = 104 dB

$L_{p,\mathrm{C}}$ = 103 dB

$L_{p,\mathrm{C}} - L_{p,\mathrm{A}}$ = − 1 dB

Noise Class HM

Table A.3 — Hearing protector to be assessed

Frequency in Hz:	63	125	250	500	1k	2k	4k	8k
Attenuation (APV_f) in dB	5,0	7,0	11,4	15,7	19,4	24,4	32,6	29,7

$$\left.\begin{array}{l}\mathrm{H} = 25\ \mathrm{dB}\\ \mathrm{M} = 19\ \mathrm{dB}\\ \mathrm{L} = 13\ \mathrm{dB}\\ \mathrm{SNR} = 22\ \mathrm{dB}\end{array}\right\}\ \text{Derived in accordance with EN ISO 4869-2}$$

As a basis for assessment the following Table A.4, referring to a national regulation level, can be used:

Table A.4 — Example of assessment on the basis of a national regulation system

Level effective to the ear ($L'_{p,\mathrm{A,eq}}$ in dB)	Protecting rating
Greater than L'_{NR}	Insufficient
Between L'_{NR} and L'_{NR} - 5	Acceptable
Between L'_{NR} – 5 and L'_{NR} – 10	Good
Between L'_{NR} – 10 and L'_{NR} – 15	Acceptable
Less than L'_{NR} – 15	Risk of over-protection[a]

[a] Sound attenuation may be too high, speech intelligibility could be hindered, check for communication and acoustical isolation.

A.2 Octave band method

The octave band method is a noise reduction calculation involving the workplace octave band sound pressure levels and the octave band attenuation data for the hearing protector being assessed.

Step 1: Calculate the A-weighted sound pressure level ($L'_{p,\mathrm{A}}$) under the hearing protector using the following formula:

$$L'_{p,A} = 10 \log \sum_{f=125}^{8000} 10^{0,1(L_{p,f} + A_f - APV_f)}$$

where:

- f represents the centre frequency of the octave band in Hz;
- $L_{p,\mathrm{f}}$ is the octave band sound pressure level ($L_{p,\mathrm{oct}}$) of the noise in dB in octave band f;
- A_f is the frequency weighting A in dB for octave band centre frequency f;
- $\mathrm{APV_f}$ is the assumed protection value of the hearing protector in dB for octave band centre frequency f.

If the attenuation data of 63 Hz are available the calculation may commence at this frequency.

Step 2: Round to the nearest integer.

Table A.5 contains a calculation example.

Table A.5 — Example of calculation of $L'_{p,\mathrm{A}}$ using the octave band method (using data given in A.1):

Octave band centre frequency in Hz	63	125	250	500	1k	2k	4k	8k
Measured octave band sound pressure levels of the noise in dB (Row 1)	80	84	86	88	97	99	97	96
A-weighting in dB (Row 2)	−26,2	−16,1	−8,6	−3,2	0	+1,2	+1,0	−1,1
Add Row 2 to Row 1 (Row 3)	53,8	67,9	77,4	84,8	97,0	100,2	98,0	94,9
Assumed protection values of the hearing protector (Row 4)	5,0	7,0	11,4	15,7	19,4	24,4	32,6	29,7
Subtract Row 4 from Row 3 and multiply by 0,1 (Row 5)	4,88	6,09	6,60	6,91	7,76	7,58	6,54	6,52
NOTE Modern instrumentation may combine rows 1 to 3 and directly display the A-weighted spectrum.								

Step 1: Calculate $L'_{p,\mathrm{A}}$ as follows:

$$\mathrm{L'}_{\mathrm{p,A}} = 10\log(10^{4,88} + 10^{6,09} + 10^{6,60} + 10^{6,91} + 10^{7,76} + 10^{7,58} + 10^{6,54} + 10^{6,52})$$

$$\mathrm{L'}_{\mathrm{p,A}} = 80{,}6\ \ \mathrm{dB(A)}$$

Step 2: Round this figure to the nearest integer; the A-weighted sound pressure level under the hearing protector is 81 dB(A).

Assessment: For a value of L'_{NR} = 85 dB(A), the $L'_{p,\mathrm{A}}$ of 81 dB(A) lies between 0 and – 5 dB of the L'_{NR}. The choice of hearing protector is therefore considered “acceptable” for the given noise (see Table A.4).

A.3 HML method

The HML method is based on three attenuation values, H, M and L, derived from the octave band attenuation data of a hearing protector. These values, when combined with a measurement of the A-weighted and C-weighted sound pressure levels of the noise, are used to calculate the predicted noise level reduction (PNR). The PNR is then subtracted from the observed A-weighted sound pressure level to calculate the A-weighted sound pressure level effective to the ear when the hearing protector is used ($L'_{p,\mathrm{A}}$).

Step 1: Calculate the difference between the C-weighted and the A-weighted sound pressure levels of the noise ($L_{p,\mathrm{C}} - L_{p,\mathrm{A}}$).

Step 2: Calculate the predicted noise level reduction (PNR) according to one of the following formulae:

Either:

$$PNR = M - \frac{H - M}{4}(L_{p,C} - L_{p,A} - 2)\,dB;\ for\ (L_{p,C} - L_{p,A}) \leq 2\ \ dB$$

Or:

$$PNR = M - \frac{M-L}{8}(L_{p,C} - L_{p,A} - 2)\ \ dB;\ for\ (L_{p,C} - L_{p,A}) > 2\ \ dB$$

Step 3: Round to the nearest integer.

Step 4: Calculate the A-weighted sound pressure level effective to the ear according to the following formula:

$$L'_{p,A} = L_{p,A} - \ PNR$$

As an example for assessment compare $L'_{p,A}$ to Table A.4.

Example of calculation of $L'_{p,A}$ using the HML method (using data given in A.1)

Step 1: The difference between the C-weighted and the A-weighted sound pressure levels of the noise is −1 dB.

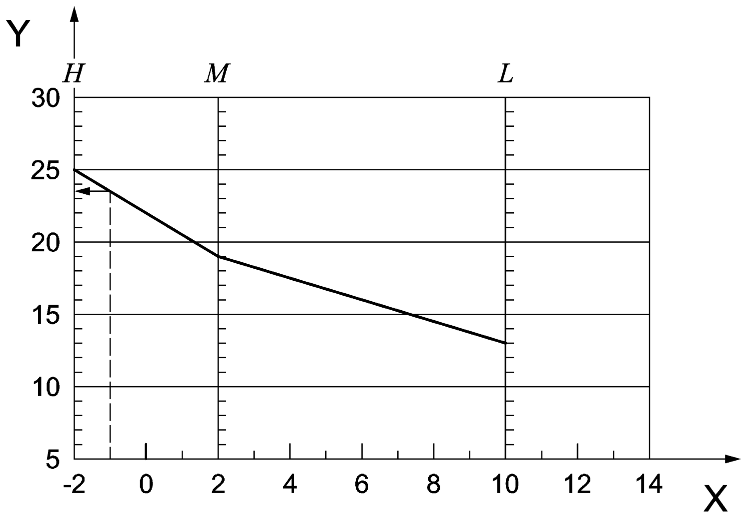
Step 2: Instead of calculating the PNR value, Figure A.1, in which the values of H, M and L for this hearing protector have been marked, may be used. Starting, as indicated, from ($L_{p,C}$ – $L_{p,A}$) = – 1 dB, the PNR can be read as 23,5 dB.

Step 3: Round to the nearest integer (PNR = 24 dB).

Step 4:

$$L'_{p,A} = 104\,dB - 24\ dB = 80\,dB(A)$$

Assessment: For a value of L'_{NR} = 85 dB(A), the $L'_{p,A}$ of 80 dB(A) lies between 0 and – 5 dB of the L'_{NR}. The choice of hearing protector is therefore considered "acceptable" for the given noise (see Table A.4).



Key

x-axis: $L_{p,C}$ – $L_{p,A}$ [dB]

y-axis: PNR [dB]

Figure A.1 — Graph enabling the PNR value to be read without calculation

A.4 HML check method

The HML check method is an abbreviation of the HML method. In general, it needs no knowledge of the C-weighted sound pressure level or the level difference ($L_{p,C} - L_{p,A}$).

Step 1: Decide, by a listening check of the noise at the workplace and consultation of the list of examples in Tables A.6 and A.7, if the noise is:

categorized as being the class for which $L_{p,C} - L_{p,A} < 5$ dB (middle to high frequency noises) (see List 1: Examples of noise sources - Noise Class HM) - Go to Step 3

or

categorized as being the class for which $L_{p,C} - L_{p,A} \geq 5$ dB (dominant low frequency noises) (see List 2: Examples of noise sources - Noise Class L) - Go to Step 2

Table A.6 — List 1: Examples of noise sources — Noise Class HM (middle to high frequency noises) ($L_{p,C} - L_{p,A} < 5$ dB)

Flame cutting	High speed web-fed rotary presses
Sugar-coating machines	Jolt-squeeze moulding machines
Compressed air nozzles	Impact tools
Power nail drivers	Grinding machines
Folding/beading machines	Forging hammers
Bottle filling machines	Spinning frames
Trimming of castings	Hosiery/knitting machines
Wood working machines	Abrasive cutting machines
Hydraulic pumps	Power weaving looms
Honing machines	Centrifuges

Table A.7 — List 2: Examples of noise sources – Noise Class L (dominant low frequency noises) ($L_{p,C} - L_{p,A} \geq 5$ dB)

Excavators	Compressor units (piston)
Motor-generator sets	Converter units
Electric melting furnaces	Cupola furnaces
Combustion furnaces	Die-casting machines
Annealing furnaces	Earth-moving equipment
Blast furnaces	Blast-cleaning machines
Crushing mills	Large diesel engines (locomotives, ships)

Step 2: Subtract the L-value from the A-weighted sound pressure level ($L'_{p,A} = L_{p,A} - L$):

if $L'_{p,A} > L'_{NR}$ the protection is insufficient; try another hearing protector with higher attenuation;

if $L'_{p,A} \leq L'_{NR}$ the sound attenuation of the hearing protector is sufficient;

if $L'_{p,A} > L'_{NR} - 15$ dB the sound attenuation is “acceptable” or “good”.

Step 3: Subtract the M-value from the A-weighted sound pressure level ($L'_{p,\mathrm{A}} = L_{p,\mathrm{A}} - \mathrm{M}$):

if $L'_{p,\mathrm{A}} > L'_{\mathrm{NR}}$ go to Step 4;

if $L'_{p,\mathrm{A}} \leq L'_{\mathrm{NR}}$ the sound attenuation of the hearing protector is sufficient;

if $L'_{p,\mathrm{A}} > L'_{\mathrm{NR}} - 15$ dB the sound attenuation is “acceptable” or “good”.

Step 4: Subtract the H-value from the A-weighted sound pressure level ($L'_{p,\mathrm{A}} = L_{p,\mathrm{A}} - \mathrm{H}$):

if $L'_{p,\mathrm{A}} > L'_{\mathrm{NR}}$ the protection is insufficient; try another hearing protector with a higher attenuation;

if $L'_{p,\mathrm{A}} \leq L'_{\mathrm{NR}}$ the hearing protector may be suitable; obtain additional information for the noise and go to A.2, A.3 or A.5.

Example of calculation of $L'_{p,A}$ using the HML check method (using data given in A.1)

Step 1: Given a high frequency noise of Noise Class HM with $L_{p,\mathrm{A}} = 104$ dB, go to Step 3.

Step 3: $L'_{p,\mathrm{A}} = L_{p,\mathrm{A}} - 19$ dB = 85 dB(A)

Assessment: For a value of $L'_{\mathrm{NR}} = 85$ dB(A), the $L'_{\mathrm{p,A}}$ of 85 dB(A) is equal to the L'_{NR}. The choice of hearing protector is therefore considered just “acceptable” for the given noise (see Table A.4).

A.5 SNR method

The SNR method specifies a single attenuation value, the Single Number Rating (SNR). Like the PNR, the SNR is subtracted from an overall sound pressure level measurement, in this case the C-weighted sound pressure level, to calculate the A-weighted sound pressure level effective to the ear when the hearing protector is used.

The predicted A-weighted sound pressure level under the hearing protector ($L'_{p,\mathrm{A}}$) may be calculated:

on the basis of the C-weighted sound pressure level at the workplace ($L_{p,\mathrm{C}}$) according to $L'_{p,\mathrm{A}} = L_{p,\mathrm{C}} - \mathrm{SNR}$

or

on the basis of $L_{p,\mathrm{A}}$ and the difference between C-weighted and A-weighted sound pressure levels according to

$L'_{p,\mathrm{A}} = L_{p,\mathrm{A}} + (L_{p,\mathrm{C}} - L_{p,\mathrm{A}}) - \mathrm{SNR}$

where applicable, round $L'_{p,\mathrm{A}}$ to the nearest integer.

As an example for assessment compare $L'_{p,\mathrm{A}}$ to Table A.4.

Example of calculation of $L'_{p,A}$ using SNR method (using data given in A.1)

The C-weighted sound pressure level ($L_{p,\mathrm{C}}$) is 103 dB, therefore $L'_{p,\mathrm{A}}$ is calculated according to:

$L'_{p,\mathrm{A}} = 103$ dB – SNR (where SNR = 22 dB for the selected hearing protector)

$L'_{p,\mathrm{A}} = 81$ dB(A)

Assessment: For a value of $L'_{\mathrm{NR}} = 85$ dB(A), the $L'_{\mathrm{p,A}}$ of 81 dB(A) lies between 0 and – 5 dB of the L'_{NR}. The choice of hearing protector is therefore considered “acceptable” for the given noise (see Table A.4).

Annex B
(informative)

Method for assessing the sound attenuation of a hearing protector for impulsive noise

B.1 General

This annex is applicable to passive, sound-restoration, and ANR hearing protectors as described in EN 352. For the selection of level-dependent hearing protectors with respect to the peak sound pressure level, the sound attenuation value which is achieved in passive mode should be used (HML data).

A practical method for the estimation of $L'_{p,\mathrm{Cpeak}}$ is given below.

As an example the assessment can be done by using the national peak regulation level.

Level-dependent impulse/impact noises have been classified as Types 1, 2 or 3 with respect to the frequency content of the noise (see Table B.1).

The effective peak sound pressure at the ear ($L'_{p,\mathrm{Cpeak}}$) is determined using the modified sound attenuation value (d_m) of the hearing protector (see Table B.2). The equivalent A-weighted sound pressure level at the ear ($L'_{p,\mathrm{A,eq}}$) is determined according to Annexes A, C or D of this document.

B.2 Method

The following method for the estimation of a sufficient protection is based on a scientific laboratory evaluation.

Step 1: $L_{p,\mathrm{Cpeak}}$ of the noise is measured.

Step 2: Refer to Table B.1 to define the noise type (1, 2 or 3).

Table B.1 — Types of impulsive/impact noise

Noise type	Frequency range	Noise sources
Type 1	Where most of the acoustic energy is distributed in the lower frequency ranges	punch press
		jolt squeeze
		explosive (1 kg)
		explosive (8 kg)
Type 2	Where most of the acoustic energy is distributed between the medium and higher frequencies	nail pistol
		hammer on plate
		nailing gun
		hammer (steel)
		hammer (aluminium) rifle proof firing
Type 3	Where most of the acoustic energy is distributed in the higher frequencies	pistol
		pistol (light)
		Pistol (heavy)

Step 3: Refer to Table B.2 to determine the d_m (dB).

Table B.2 — Modified sound attenuation value

Noise type	**d_m (dB)** [a]
1	L – 5
2	M – 5
3	H

[a] Where H, M and L values are obtained in accordance with EN ISO 4869-2 from passive attenuation data.

Step 4: Calculate $L'_{p,\text{Cpeak}}$, the effective peak sound pressure level at the ear:

$$L'_{p,\text{Cpeak}} = L_{p,\text{Cpeak}} - d_m$$

Assessment: Compare $L'_{p,\text{Cpeak}}$ to the national peak regulation level ($L'_{\text{NR,peak}}$) to determine if the attenuation of the hearing protector is sufficient.

Step 5: Calculate the $L'_{p,\text{A}}$

$L'_{p,\text{A,eq}}$ is determined according to Annexes A, C or D of this document.

Assessment: The attenuation of the hearing protector is sufficient if the assessments of $L'_{p,\text{A,eq}}$ and $L'_{p,\text{Cpeak}}$ with regard to the national regulation levels both show positive results.

Annex C
(informative)

Selection method for sound-restoration level-dependent hearing protectors using HML-data

C.1 General

This annex describes a method to aid the correct selection of sound-restoration and level-dependent hearing protectors when used in a given noise environment. The method may be suitable for other similar devices.

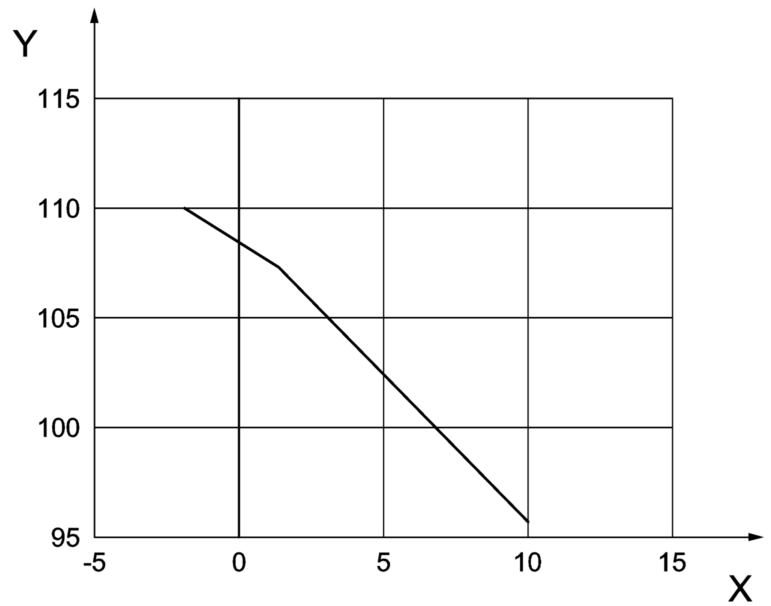
The following methods are used for predicting if the A-weighted sound pressure level $L'_{p,\mathrm{A,eq}}$ effective to the ear is less than 85 dB(A). These methods are based on three defined criterion levels determined as per EN 352-4 or EN 352-7 as appropriate for a particular hearing protector. Three methods are given. The first and second require determination of the difference between the C- and A-weighted levels (measured as the $L_{p,\mathrm{eq}}$ of the same or equivalent events). The third requires a measurement of the A-weighted sound pressure level $L_{p,\mathrm{A,eq}}$ and an estimate of whether the sound is middle to high frequency, or low frequency.

C.2 Method 1: HML Method

Step 1: Measure $L_{p,\mathrm{C,eq}}$ and $L_{p,\mathrm{A,eq}}$

Step 2: Calculate $L_{p,\mathrm{C,eq}} - L_{p,\mathrm{A,eq}}$

Step 3: Plot the H, M and L criterion levels given for the protector against corresponding $L_{p,\mathrm{C}} - L_{p,\mathrm{A}}$ values of –2 dB, 2 dB and 10 dB respectively as in the example shown in Figure C.1.



Key

x-axis: $L_{p,\mathrm{C}}$-$L_{p,\mathrm{A}}$ value [dB]

y-axis: Criterion level $L_{p,\mathrm{A,eq}}$ [dB]

Figure C.1 — Example plot of H, M, and L criterion levels against the $L_{p,\mathrm{C}} - L_{p,\mathrm{A}}$ value

Step 4: The level effective at the ear ($L'_{p,\text{A,eq}}$) is less than 85 dB(A) if $L_{p,\text{A,eq}}$ lies below the line connecting the H,M and L criterion levels at the calculated difference $L_{p,\text{C,eq}} - L_{p,\text{A,eq}}$ of the sound.

C.3 Method 2A: HML check method - Measurement check

Step 1: Measure $L_{p,\text{C,eq}}$ and $L_{p,\text{A,eq}}$.

Step 2: Calculate $L_{p,\text{C,eq}} - L_{p,\text{A,eq}}$

Step 3: If $L_{p,\text{C}} - L_{p,\text{A}} < 5$ dB then the noise is categorized as middle to high frequency. If the $L_{p,\text{A,eq}}$ is less than the M criterion level, then the effective level at the ear will be below 85 dB(A).

Step 4: If $L_{p,\text{C}} - L_{p,\text{A}} \geq 5$ dB then the noise is categorized as dominant low frequency. If the $L_{p,\text{A,eq}}$ is less than the L criterion level, then the effective level at the ear will be below 85 dB(A).

C.4 Method 2B: HML check method - Listening method

Step 1: Measure the $L_{p,\text{A,eq}}$ of the noise.

Step 2: Decide by a listening check of the noise at the workplace and consultation of Table C.1 whether the noise is middle to high frequency, or dominant low frequency noise. Reference may also be made to the noises categorized in A.4.

Table C.1 — Examples of middle to high frequency and low frequency noise

Middle to high frequency noise	**Dominant low frequency noise**
Rifle	Explosion
Shot gun	Detonation
Pistol	Punch press
Proof firing	Large stamp press
Fireworks	Jolt squeeze
Gun nailer	Drop forge
Impact tools	Piling

NOTE For intermittent short-duration events it is important that the duration and the number of events included in the $L_{p,\text{eq}}$ measurement is typical of the normal working pattern.

Step 3: If the noise is middle to high frequency then the hearing protector is suitable if the $L_{p,\text{A,eq}}$ is less than the M criterion level.

Step 4: If the noise is low frequency then the hearing protector is suitable if the $L_{p,\text{A,eq}}$ is less than the L criterion level.

Annex D
(informative)

Selection method for active noise reduction hearing protectors

This annex describes a method to aid the correct selection of an active noise reduction hearing protector when it is used in a given noise environment. The method is applicable to both earmuffs and earplugs using the total (active plus passive) attenuation data obtained from EN 352-5. The method may be suitable for other similar devices.

The selection may be made following the method of Annex A according to the octave band method in A.2 by using the sum of passive and active sound attenuation values. If HML-values for active mode are available use A.3 or A.4. 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 (data are obtained from the instructions for use). The outcome of the assessment may be compared to the national regulation level.

This method is applicable to steady-state or fluctuating noise. It is not applicable to impulsive noises.

Annex E
(informative)

Calculation method for hearing protectors with audio input

E.1 General

When selecting a hearing protector with audio input, the additional noise source represented by the audio input should be taken into account (see 5.2.4). This annex describes a method to aid the selection of such a device. These protectors are available for entertainment or for essential communication. This method is not applicable to level-dependent earmuffs (EN 352-4) or earplugs (EN 352-7) fitted with external audio input.

The sound pressure level effective to the ear has two components; the attenuated ambient sound and the sound from the audio input. If the audio input is for entertainment then the earmuffs should conform to EN 352-8. For products with FM-radio these standards require the audio sound pressure level effective to the ear to be limited to 82 dB(A). For products with electrical audio input these standards require the audio sound pressure level effective to the ear to be limited to 82 dB(A) for all input signal levels up to the maximum specified by the manufacturer. If the input signal level specified by the manufacturer is exceeded, use the method described below as for communication products.

If the audio input is for essential communication, the earmuffs should conform to EN 352-6. Under these standards the audio sound pressure level may exceed 82 dB(A). A criterion voltage value, the voltage that will give an effective level of 82 dB(A) at the ear, should be provided for these unlimited protectors, according to the standard mentioned above.

E.2 Method

To ensure the daily personal exposure level effective to the ear does not exceed a national regulation level:

Estimate the level effective to the ear from the attenuated ambient noise according to Annex A or Annex D. Select a hearing protector that provides an attenuated level at least 3 dB below the national regulation level.

The number of hours the audio facility can be actively used before the national regulation level may be exceeded will depend on the maximum voltage input to the protector.

Maximum number of hours for use of audio input = $K * (V_{crit}/V_{max})^2$.

Where

V_{crit} = the criterion voltage

V_{max} = the maximum rms voltage input to the protector audio input

K = a constant as given in Table E.1 for the corresponding national regulation level.

Table E.1 — National regulation levels and corresponding K values

Regulation level [dB(A)]	K value
87	12
86	10
85	8
84	6
83	5
82	4
81	3
80	2,5

If the hearing protector has an audio system limited to 82 dB(A), as is the case for products with FM-radio, the value for $(V_{crit}/V_{max})^2$ equals 1, and the K value in Table E.1 corresponds to the number of hours the audio system can be used before the national regulation level is exceeded.

Annex F
(informative)

Improving field performance and special instructions for use

F.1Improving field performance

Experience shows that hearing protectors are often not used properly. As a consequence, they may provide less protection than anticipated.

To improve the situation it is first and foremost to be realized that good performance does not solely come from the product itself. Good performance is most critically dependent on the user. Optimum performance relies on both careful selection and user training and motivation. These aspects become more important at higher noise levels.

Guidance for improving field performance is provided in Table F.1. Some of these are generally valid, while some are more relevant for typical groups of industrial users (and those managing them).

Table F.1 — Tips for improving field performance of hearing protectors

Attenuation	• Choose hearing protectors with an attenuation suited for the noise and work situation. If the noise exposure is distinctly different for various groups of workers (or for the same worker at different locations), then different products should be considered. • Avoid choosing protectors with the highest possible label values for people working in moderate noise levels.
Fitting and compatibility	• In principle all protectors should be individually fitted. A “one-size fits all” approach is unlikely to work well. • Conformance of individual fit is recommended for muffs (particularly when mounted on helmets), but is usually most critical for generic plugs. • For earmuffs, avoid the use of spectacles with overlength and/or broad side arms as they will reduce the attenuation substantially (and often also be uncomfortable). Side arms should be thin and close to the head. Use spectacles designed for use with earmuffs.
Comfort and acceptance	• Choose a range of products that are as comfortable as possible. Discomfort is likely to discourage use of the product.
Information and training	• Awareness of the risks associated with hearing damage is essential. Information, instruction and training should be provided as appropriate (for example one-to-one or in small groups).
Individual fit testing	• Fit testing can play a valuable role in training and in achieving and documenting an effective hearing protection programme in the workplace.

User involvement and feedback	• Involve end users in purchasing decisions. Test different products in real life and be prepared to make changes based on user feedback.
Signposting	• Clear delineation of hearing protection zones is essential.
Maintenance	• Ensure hearing protectors are regularly checked and maintained.
Management support	• Any hearing conservation program should be actively and wholeheartedly backed by management and supervisors at all levels.
Enforcement	• Individuals demonstrating unwillingness to adhere to a hearing protection programme may require redeployment into a quieter job, disciplinary action or dismissal.

F.2 Special instructions for optimum use

To reach the sound attenuation approximately as measured at the type examination, a special instruction for use and - especially for earplugs - training is necessary. This instruction and the training are to be regularly repeated every few months.

Earmuffs

When using earmuffs, during the instructions information should be given to the reduction of the protection effect by:

a) obsolete or damaged cushions;

b) use of cushions, which are damaged from storage;

c) strongly developed hair of head that could reduce the sealing between the cushion and the head;

d) earrings;

e) simultaneous use of spectacles or goggles and hearing protectors;

f) simultaneous use of a respirator mask;

g) interchange of the earmuff cups, intended for use on the right or left side of the head or top/down, if the earmuffs have a specific construction;

h) using the head band of the earmuffs not over the head but behind the neck or under the chin;

i) use of a protective helmet unsuited to the helmet-mounted earmuff;

j) aging of the head band.

Earplugs

When using earplugs the most significant problems result from incorrect handling and inserting. They can be avoided by special training.

The incorrect use results from:

a) Insufficient rolling down or pressing of the user-formable earplugs;

b) insufficient deep insertion of the earplugs in the ear canal;

c) too short fixing of the inserted earplugs inside the ear canal;

d) Inappropriate size of the earplugs.

All handling errors should be demonstrated by examples arising from experience in the company.

In accordance with Figures F.1 to F.4 special user training for earplugs should include:

Figure F.1 — Rolling down of the earplug

The rolled or squeezed earplugs shall be inserted in the ear canal immediately. Only in this manner is an accurate positioning with small diameter possible.

Earplugs should be inserted in the ear canal by pulling the ear upwards, thus straightening the ear canal. The straightening of the ear canal is important for insertion of all types of earplugs.

Figure F.2 — Straightening of the ear canal

After insertion in the ear canal, the formable earplug shall be fixed by the finger for a few seconds.

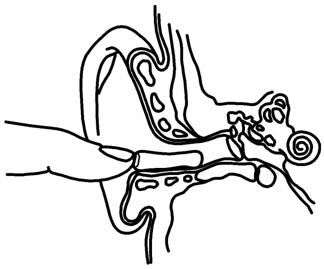


Figure F.3 — Insertion in the ear canal and fixation

The fixing is to continue until the earplug seals the ear canal (30 s or according to the manufacturer's information).

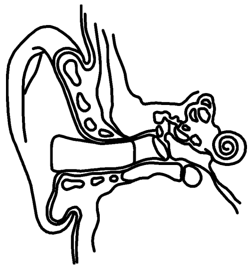


Figure F.4 — Correct fitting of the earplug

Annex G
(informative)

Further guidance on fit check methods for earplugs

G.1 General information

Fit checks are a useful way to determine if selected hearing protectors provide a sufficiently good fit to achieve the anticipated sound attenuation. Fit checks can also be a helpful training aid for the user. There are a number of fit check methods, most of which use a measured value of sound attenuation to indicate the quality of the fit. The measured value of sound attenuation can be obtained through mechanical, acoustic, subjective or objective methods. Alternatively, there may be a specific type of fit check for a particular product or product range.

G.2 Fit check methods suitable for all types of earplugs

There are three methods of fit checking that can be used for all types of earplugs.

a) MIRE (microphone in real ear) technique

  1) Using a sound field generated by an (audiometric) headphone:

    The headphone is used with the earplugs in place. A microphone outside the earplug (but under the headphone) and a microphone behind the earplug (in the ear canal) simultaneously measure a known sound field presented through the headphone. The sound pressure level difference between the two microphones indicates how well the earplug is fitted. This is an objective assessment.

  2) Using a sound field generated by a loudspeaker:

    This method uses the same simultaneous sound pressure level measurement method using two microphones. Instead of the sound field being presented through a headphone it is presented through a loudspeaker. This is an objective assessment.

b) Audiogram with and without the earplugs fitted

  The user's threshold of hearing is assessed with and without the earplugs in place. The difference between the two audiograms indicates how well the earplugs are fitted. This is a subjective assessment.

c) Loudness matching

  The user is presented with a test signal and is asked to balance the loudness between their ears. The loudness matching is repeated for the user without the earplugs, with one ear occluded only and then with both ears occluded. The results of the loudness matching indicate how well the earplugs are fitted. This is a subjective assessment.

NOTE The sound attenuation values determined by the methods described above are likely to differ from those obtained from laboratory testing for EC type examination. The differences occur because the described methods above are not the same as the method used to obtain the laboratory data.

G.3 Fit check method exclusive to custom moulded earplugs

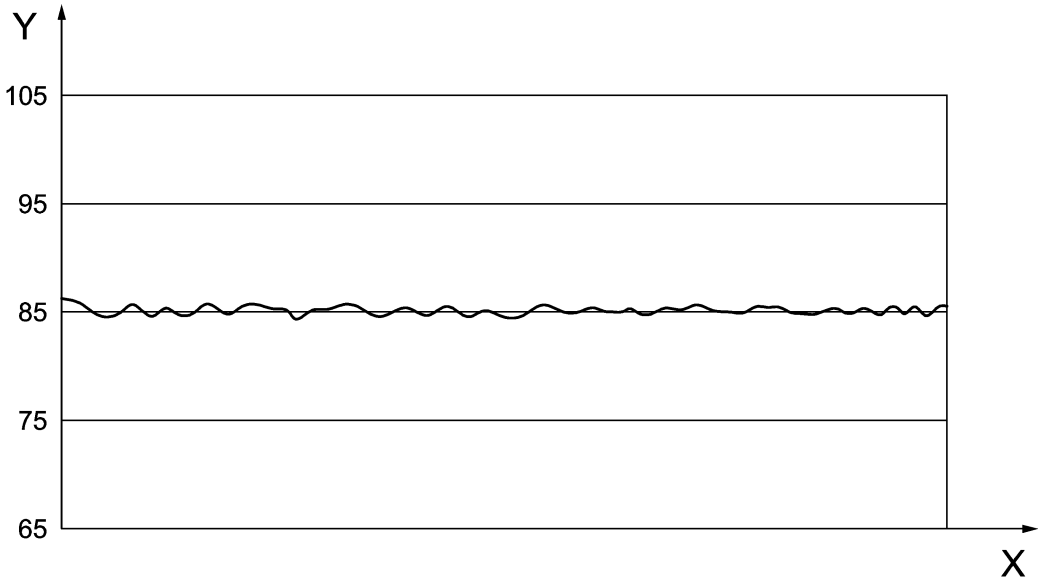
Custom moulded earplugs should be fit checked prior to first use. This is to ensure that an effective seal is achieved. Errors can sometimes occur in the imprint and manufacturing process of custom moulded earplugs. Thereafter the fit should be checked at regular intervals to ensure a continuing effective seal. Possible influences on the fit include a change in shape of the ear canal, due to changes in body mass, or other unknown causes.

A fit check method that can only be used for custom moulded earplugs is known as an air leakage test. The air leakage of the custom moulded earplug is determined by the decay of a small overpressure behind the earplug. This method does not give any information about sound attenuation.

Annex H
(informative)

Noise types

Figures H.1 to H.4 display the different types of noise exposure. The relation between sound pressure level and time is depicted.



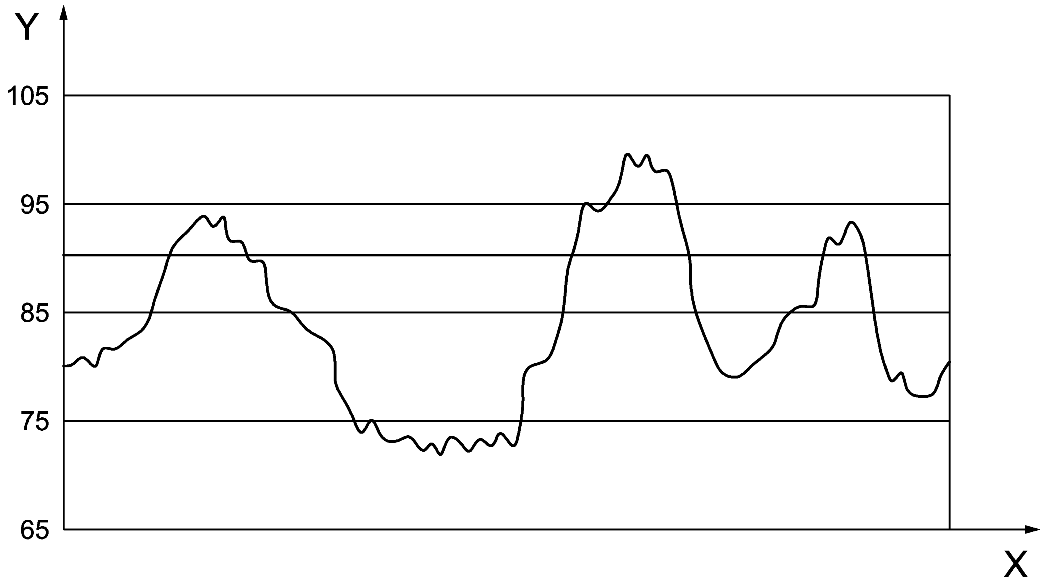
Key

x-axis: Time

y-axis: Sound pressure level [dB]

Figure H.1 — Continuous noise

Continuous noise has very little variation in level over time.



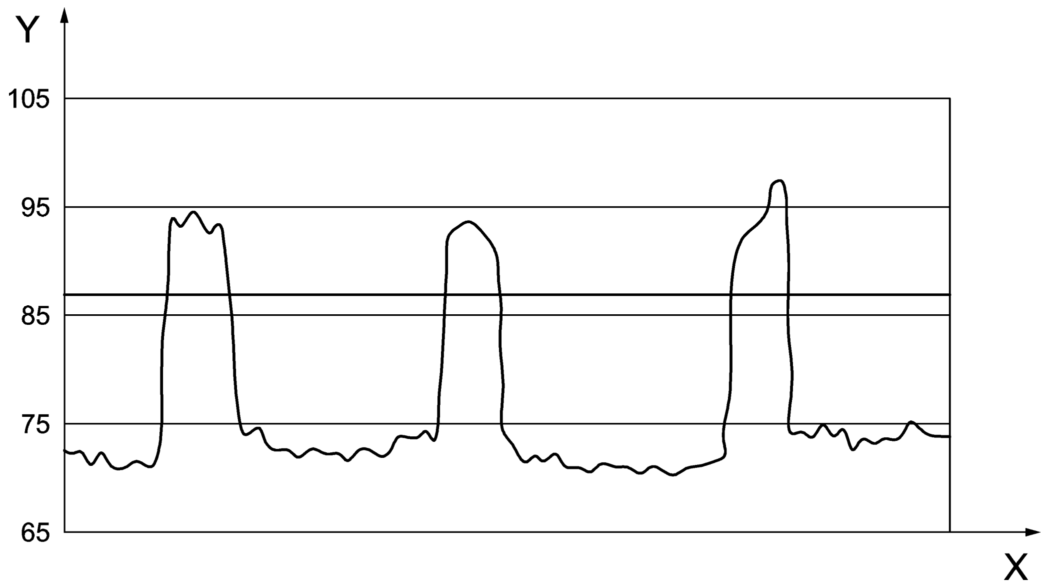
Key

x-axis: Time

y-axis: Sound pressure level [dB]

Figure H.2 — Fluctuating noise

Fluctuating noise varies irregularly in level over time.



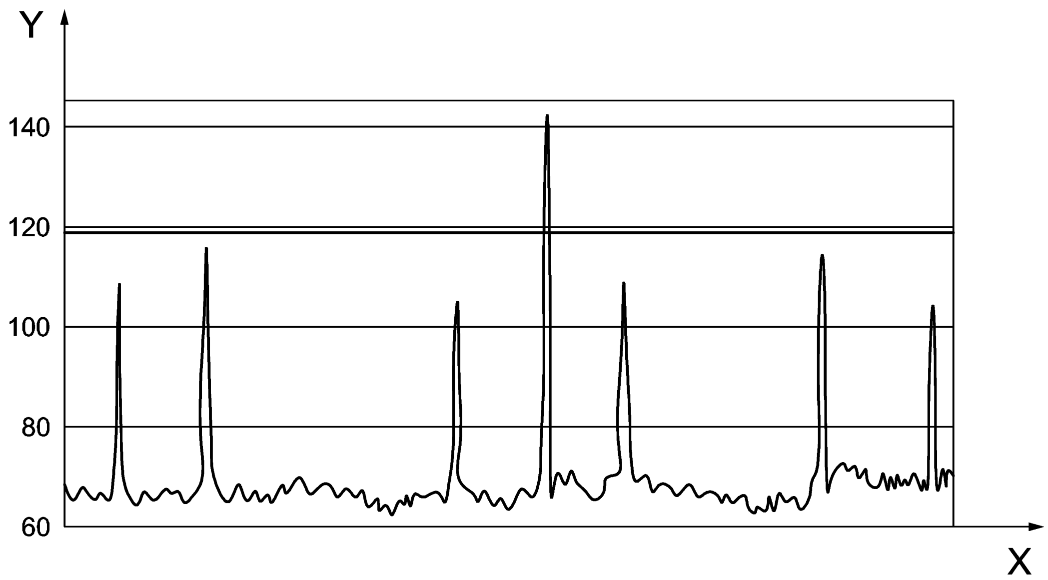
Key

x-axis: Time

y-axis: Sound pressure level [dB]

Figure H.3 — Intermittent or repeated short-term noise

Intermittent or repeated short-term noise is similar to fluctuating noise in terms of level variation but is more predictable over time.



Key

x-axis: Time

y-axis: Sound pressure level [dB]

Figure H.4 — Impulsive noise

Impulsive noise may be characterized by short duration high-level peaks.

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