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Leading edge developments in hearing protection

Summary overview of the European Guidance document EN 458:2016

Introduction

The European guidance document EN458 was first published in 1993 and since then it has undergone periodic reviews. The last revision of the guidance document began in 2008 to reflect emergence of new products/technologies e.g. Bluetooth communication headsets, best practice (i.e. fit testing) and the implementation of the European Physical Agents (Noise) Directive 2003/10/EC.

The guidance document EN 458:2016 is intended to help employers, supervisors, safety officers, industrial hygienists, or any other person responsible for managing safety and health of the employee in the workplace, select the appropriate hearing protector for the individual wearer and the work environment to ensure it is fit for purpose.

The guidance document has been compiled under a mandate given to CEN by the European Commission and European Free Trade Association. Although referred to as a European Norm, the guidance document EN 458:2016 is not a harmonised standard and therefore cannot be strictly enforced in the same way as other European Harmonised Standards, for example EN352. However, it does provide comprehensive information on the process of correct selection and usage of a wide range of hearing protectors including communication headsets and products fitted with other electronic functionalities.

The document provides an overview of different types of hearing protection products on the market and the correct process of selection with due consideration for isolation (from over-protection), risk of developing noise-induced hearing loss (from insufficient protection) and importance of essential communication.

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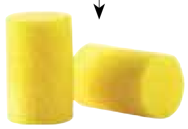
Types of hearing protector

Hearing protectors in general may be broken down into two main types - passive and electronic. Within each type, products may range from earplugs (including banded and custom moulded) to earmuffs (including neckband and helmet mounted version).

Hearing Protectors

Passive

Electronic



Earplugs

e.g disposable, re-usable, custom moulded, banded

Earmuffs

e.g. headband, neckband or helmet mounted version

In-ear solution

e.g. level dependent earplugs

Over-the-ears

e.g. two-way communication headset

In addition, hearing protectors may also be differentiated in terms of their functionality including the following examples:

Passive level dependent

These products are effective against very high single impulse noises e.g. firearms.

Sound-restoration level-dependent hearing protectors

These products include an electronic sound reproduction system where low sound pressure levels are amplified. As the external sound pressure level increases, it reduces the gain and controls the level of reproduced sound inside the hearing protector. Such devices need to meet the criterion levels (combined passive and reproduced sound) of 85dB(A) for High (H), Medium (M) and Low (L) frequency oriented noise, as defined in the European standard EN 352-4 (for earmuffs) or EN 352-7 (for earplugs).

Hearing protectors with work or safety-related audio input

These devices include wired or wireless radio receiver and/or two-way radio for work or safety -related communication. For these products, there are no limitations imposed on the reproduced sound pressure level at the ear, as the information to be received may be safety critical. However, as with any hearing protector selection process appropriate risk assessment is important to ensure suitability for the work environment and the individual wearer.

Hearing protectors with entertainment audio input

Typically, these devices incorporate a radio receiver or music player for entertainment purposes, or allow audio input from external devices.

Active Noise Reduction (ANR) hearing protectors

These types of hearing protector devices incorporate an electronic sound cancelling system. Such devices are particularly effective at low frequency noise (<500 Hz).

Process of Selection

Selection of hearing protectors should be based on the following criteria:

- Sound attenuation
- Work environment – including requirement for intrinsically safe work conditions
- Situational Awareness
- Communication
- Compatibility with other personal protective equipment
- Workplace and individual needs
- Comfort and ergonomics
- Fit checking

Sound attenuation:

Risk of developing hearing damage from occupational noise exposure is low where the daily A-weighted noise exposure level over an 8 hour period (L_{EX}, 8h) is below 80 dB, and insignificant below 75 dB. In general, not withstanding other factors influencing selection, the desirable range of effective A-weighted sound pressure level under the protected ear is between 70 to 75 dB to help ensure good situational awareness.

Given that EU Member Countries may have different definition of national regulation level when estimating sound level under the hearing protector, consider the following as an example on protection rating where the national regulation requires mandatory use of hearing protectors at 80 dB(A).

There are essentially three different ways of estimating effective sound level under the hearing protector:

- Octave band – requires sound pressure level at each octave band centre frequency
- HML (High, Medium, Low) – requires A-weighted and C-weighted sound pressure level measurements
- SNR (Single Number Rating) – requires C-weighted sound pressure level measurements

Within the three different methods, octave band and HML provide a greater degree of accuracy and are probably used by many health and safety professionals.

Continuous equivalent A-weighted sound level effective to the ear (L_{Aeq}) in dB	Protection rating
>80	✗ INSUFFICIENT
80 to 75	● ACCEPTABLE
75 to 70	✓ GOOD
70 to 65	● ACCEPTABLE
<65	✗ RISK OF OVER-PROTECTION*

* Speech intelligibility could be affected leading to acoustic isolation and communication difficulty

Selection criteria for impulse noise

Impulse noises have very short duration, lasting less than a second. Examples of impulse noise include weapon fire, nail gun, piling operation on a construction site, fireworks etc.

Selection criteria for impulse noise is based on the frequency range of the acoustic energy.

Impulse noise is categorised into three types:

Type 1: Where most of the acoustic energy is distributed in the lower frequency range (< 500 Hz). Examples of such impulse noises include explosives and punch press.

Type 2: Where most of the acoustic energy is distributed between the medium and higher frequencies (between 500Hz to 8000kHz). Examples of such impulse noises include nail gun, hammer on plate, rifle.

Type 3: Where most of the acoustic energy is distributed in the higher frequencies, for example a pistol (2000 Hz to 8000 Hz).

The modified sound attenuation values for the three types of impulse noise are as follows.

Noise type	Modified attenuation value [d_m (dB)]
Type 1	L -5
Type 2	M -5
Type 3	H

In the table above, the HML values have been obtained from passive attenuation data in accordance with EN ISO 4869-2.

For example, to calculate the effective peak sound pressure level at the ear for Type 1 impulse noise when wearing a hearing protector with HML values of 30, 24 and 22 respectively and when the measured peak sound pressure level is 145 (C)dB, the following equation applies:

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

$$L'_{p,Cpeak} = 145 - 17$$

= 128 dB

(below the equivalent Lower Exposure Action Value of 135 dB(C) peak)

Selection criteria for extreme-noise environment

Where operator noise exposure exceeds 105 dB(A), especially if there is a substantial amount of low frequency content e.g. compressor, generator room etc., dual protection may be required. Where dual protection is needed it is not necessary to select the highest attenuating earmuff and highest attenuating earplug. Preference should be given to a combination that best suits the individual wearer.

The effective attenuation of earmuff and earplug combination is ideally determined by subjective attenuation measurements. In the absence of such data you could reasonably estimate the combined attenuation by adding 6 dB to the higher of the two hearing protectors. For example, if a worker is wearing the 3M Peltor X4A (SNR 33 dB) and 3M E-A-R Classic (SNR 28 dB) the estimated combined attenuation will be:

33 dB + 6 dB = 39 dB

Process of Selection

Work environment

Consider the overall work environment including:

- Physical working environment – e.g. hot, humid etc
- Type of noise – continuous, fluctuating, intermittent, impulsive, dominant low frequency content
- Situational awareness – audibility of warning signals
- Localisation of noise source
- Speech communication
- Machinery sound – level dependent hearing products may be deemed suitable
- Working condition e.g. clean, contaminated, sterile etc.
- Type of work undertaken – i.e. repetitive and individual motivation

Situational awareness

The workplace is a dynamic environment with lots of activities ranging from moving vehicles, machinery noise, important information received and conveyed. It is vitally important that the worker remains adequately protected from exposure to hazardous noise whilst ensuring he/she maintains audibility of important signals such as moving vehicles or fire alarm. Some conventional passive hearing protectors may adversely affect audibility of important signals. To help maintain situational awareness whilst ensuring worker protection from developing noise-induced hearing loss (NIHL), use of sound restoration hearing protectors (e.g. level dependent) may be beneficial.

Communication

For essential work related communication it is important to maintain a good balance between speech intelligibility and protection. In some situations, to achieve a good signal-to-noise ratio for essential safety related communication, the sound pressure level to the ear may temporarily reach a level above the permitted safe limit. Careful risk assessment is needed to prevent development of noise-induced hearing loss. Some factors for consideration include:

Essential work related speech communication requiring hearing protection devices fitted with one-way- or two-way radio communication. Particularly beneficial are those hearing protectors that feature wireless Bluetooth technology that enables the wearer to allow mobile phone communication without having to remove the hearing protectors.

Effects of over-protection: high attenuating devices may cause difficulties with communication and warning signals. User may feel uncomfortable or isolated and consequently hearing protective device may not be worn for entire duration of exposure period.

Process of Selection

Compatibility
It is common for hearing protection devices to be used in conjunction with other personal protective equipment in a workplace environment to protect against a wide range of occupational hazards e.g. respiratory, head protection, eye protection etc. Steps should be taken to ensure that when used collectively, the protection afforded by each device is not compromised.

Factors that can affect acoustic seal may include:

- Protective clothing – these should be worn over the hearing protection device
- Safety spectacles – to minimise any acoustic leakage, avoid using safety spectacles with broad side arms. Internal tests demonstrate good compatibility between certain models of 3M eyewear and the PELTOR X Series range of earmuffs
- Goggles / face shield – ensure that head strap (goggles) or head cradle (face shield) do not interfere with acoustic seal
- Safety helmets – apart from helmet mounted earmuffs, consideration should be given to other types of hearing protectors e.g. neck-band earmuffs or earplugs
- Respiratory protective equipment – ensure that the head strap or harness does not interfere with acoustic seal between earmuffs and side of head

Consider, for example, the use of an earmuff with safety spectacles. In general, if the measured base line difference in overall subjective attenuation between a given hearing protector worn on its own or as a combination with safety spectacles is within +/- 3dB, the difference is well within the permitted limits for human subject variability of measurements.

The table below shows results of a half-panel subjective measurement involving 3M™ PELTOR™ X Series Earmuffs and 3M™ SecureFit™ Safety Spectacles.

Testing in accordance with EN24869-1

SecureFit SF600 and 3M X2A	**SNR**
X2A (without eyewear)	31.6
X2A with Eyewear SecureFit SF600	30.0
Difference	**1.6**
Results – very good compatibility with minimal loss of attenuation	

Comfort
The importance of comfort within the context of wearability is well known. If a given hearing protector is not comfortable, it is unlikely to be worn and as such the user will be at risk from development of NIHL, even though the device meets all the relevant harmonised European standards and is fully CE approved. Perceived comfort means different things to different people. For example, an earmuff may be perceived uncomfortable if it has excessive headband force, cushion pressure, does not exceed the maximum limit of 14 N as required in the European Standard EN 352-1 or does not sit well on the ears. For earplugs, perceived comfort may be dictated by the ease of fitting or removal, softness of the material, overall design of the product or pressure inside the ear canal immediately after fitting or following extended wear time.

Ergonomics
Factors that can influence ergonomic and fitting may include size and shape of head, ear canal and pinna. Ergonomics is particularly important in the case of earmuffs attached to safety helmets or rigid head tops incorporated into a powered and supplied air respirator system (PAPR).

When attached to a safety helmet, the earmuffs must not have any adverse effect on fit and adjustability or overall balance of the earmuffs, safety helmet or the combined equipment. Due to variation in individual ear canal shape, fitting of earplugs may require additional training and support.

Effects of non-wear time
For a hearing protector to provide adequate protection, you need to ensure the device is:

- Fit for purpose i.e. suitable for the individual wearer and the work environment
- Worn at all time when exposed to the noise hazard

Non-wear time can have a dramatic effect on the overall attenuation provided by the hearing protector. Consider the effect of non-wear of a hearing protector with a labeled SNR value of 30dB during an 8-hour work shift.

Time NOT worn	Attenuation achieved (dB)
Not worn at all	0
4 hours	3
2 hours	6
1 hour	9
30 minutes	12
15 minutes	15
7.5 minutes	18

Fit testing

“Fit testing can play a valuable role in training and in achieving and documenting an effective hearing conservation programme in the workplace.”

To help achieve the desired level of attenuation, hearing protectors should be correctly fitted in accordance with the manufacturer's instructions and fit tested as best practice. The actual attenuation achieved by a pair of hearing protector in the ‘real world’ is often lower compared with laboratory-generated data under controlled conditions. The difference can be significant, particularly for earplugs. The main cause of the difference is attributed to incorrect size selection and/or poor fitting.

Fit testing is a key element of training and motivation that helps the wearer understand the pitfalls of poor fitting. Individual fit testing can play a valuable role in training and achieving and documenting an effective hearing conservation programme in the workplace. There are different commercially available fit testing systems on the market which can be divided into two broad categories:

Objective – involving the use of Field Microphone-In-Real-Ear (FMIRE)
Subjective – involving Field-REAT (Real-Ear Attenuation at Threshold) or loudness balance

The objective method, such as the 3M™ E-A-Rfit™ Dual-Ear System, involves a sound source and simultaneously measures the sound outside the hearing protector and inside the hearing protector. Tests are carried out at multiple test frequencies and do not rely on test subject's response which can be influenced by other factors.

The subjective method is similar to the gold standard REAT measurements but carried out in field under audiometer earphones rather than in an anechoic chamber. Measurements are carried out with ears unoccluded and ears occluded with hearing protector.

With the loudness balance method, the wearer is presented with a test signal and is asked to balance loudness between left and right ears. This is usually performed without earplugs, with one ear occluded and finally with both ears occluded.

Summary

There are many important factors involved in the selection of hearing protectors that need to be carefully balanced against individual needs vs. workplace environment and any form of essential communication. Remember, the workplace is a dynamic environment with the added potential safety risk, for example, from moving vehicles. It is vitally important that the worker remains connected with the immediate work environment without adversely affecting audibility of important signals. It is also important to recognise the need for essential work related or safety related communication requirement.

Selection of appropriate hearing protector that helps facilitate situational awareness and essential communication whilst protecting the worker from developing NIHL is a key consideration. Comfort, fit and compatibility are some of the important factors for consideration when selecting hearing protectors. Fit is particularly important in the case of earplugs due to significant differences in the size and orientation of individual ear canal. Offering a range of earplug sizes to the worker may help improve not only fit but also comfort and protection.

Individual fit testing plays a vital role in improving field performance of hearing protectors as an integral part of hearing conservation programme, thus helping increase regulatory compliance. Fit testing is particularly important when wearing earplugs as incorrect fitting often leads to significant reduction in the overall attenuation.

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