

3M Science.
Applied to Life.™

Personal safety solutions for hearing conservation in construction.

Find useful information to help improve construction worker health and safety in environments with excessive noise.

Explore how 3M can help you protect the hearing of workers with protective communication and hearing loss prevention solutions.



Every day, nearly one million workers globally suffer a workplace accident, and close to 6,300 people will die due to an occupational accident or disease – including many in the construction industry.¹ Through collaboration and science, we believe that together we can help change that.

Construction safety. Backed by science.

Head impact and eye injuries. Hearing and respiratory hazards. Falls from height and dropped objects. Construction workers face all of these and more day in and day out, so they rely on safety and health solutions from 3M to help keep them protected and comfortable.

Our approach goes well beyond providing quality personal protective equipment. With knowledgeable industry specialists committed to developing worker-inspired innovations, our team delivers new technology and in-depth training that can make a measurable impact on worker health and safety.



Technical service/application engineers and regulatory specialists worldwide



Countries with local standards professionals



Active patents on safety technologies



Training professionals and 15 training centers globally²



Introduction

Construction sites are loud. And yet often, they can be relatively quiet. Sounds and situations can change very quickly, and rarely are construction workers exposed to the same noise levels for the same amount of time from one day to the next.

Furthermore, construction sites tend to be very busy places with large vehicles and equipment moving around the work site. Workers are challenged to remain alert to their surroundings while maintaining the ability to communicate with their co-workers.

In Europe, millions of workers are exposed to noise every day and one in five have to raise their voice to be heard at least half of the time they are at work. In construction, 35% of workers experience significant noise levels for half of their working time³. Reading the studies linked in this e-book will help you appreciate these statistics in their full context.

In certain situations, it can be challenging to find a hearing protection device (HPD) that will both help protect workers from hazardous noise while still allowing them to hear the critical sounds needed to perform their job safely and productively. In this eBook, we help you explore the auditory hazards, hearing protection and some innovative solutions that are available.

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Use the following pages to explore construction hazards related to noise, best practices for these applications and suggested PPE for each of your employees. It's important to remember that PPE should be considered the last line of defense in construction safety and health, as engineering controls (physical workplace changes) and administrative work practice controls should be established first to protect workers. When the safety and health of employees who work in loud environments is a priority, everyone on your team stands to benefit.

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Working in hazardous noise on construction sites

When noise becomes a problem

A report by the Health and Safety Executive (HSE) in the UK suggests that many workers are exposed to daily average noise levels above the Upper Exposure Action Value of 85dB(A) Lep,d⁴

One in five of Europe's workers has to raise their voices to be heard for at least half of the time that they are at work and 7% suffer from work-related hearing difficulties. Noise-induced hearing loss is the most common reported occupational disease in the EU.⁵ In Belgium, half of the construction workers report being exposed to noise at least 25 % of the time in their workplace. In Germany 50% of construction workers are exposed to noise.⁶

With repeated exposure to hazardous noise, workers are at an increased risk of noise-induced hearing loss (NIHL). Remember, hearing loss can be permanent and can have a significant impact on a worker's quality of life, both on and off the job.⁷

How does this happen? As the Health and Safety Executive (HSE) in the UK points out, most construction activities involving

powered tools, equipment and machinery creates noise levels above the Upper Exposure Action Value of 85dB(A) Lep,d. Typical examples include carpentry, form work, piling, general installation, driving a dumper or roller truck, welding, cutting pavement slabs. For example, angle grinding and cutting can generate noise levels between 90 and 110 dB while piling can reach in excess of 110dB.

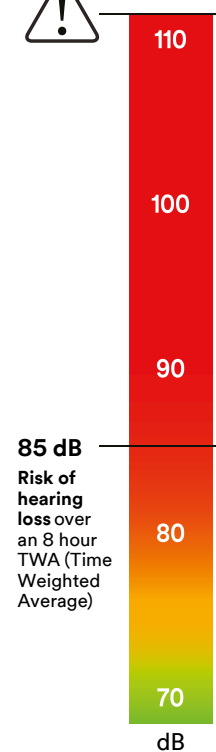
Even though the risk of exposure is well understood, noise hazards tend to be overlooked as they are sometimes viewed as annoyance or an obstacle in maintaining communication.

Noise-induced hearing loss is among the most common work-related illnesses in developed countries in Europe. In the construction sector, 40% of employees experience significant noise levels for more than half of their working time.⁸



In construction, many tasks result in average noise levels above the Upper Exposure Action Value 85dB(A) Lep,d.¹⁰

Sound levels in construction operations, dB(A)



Carpentry	92
Concrete:	
▶ Chipping/drilling	85+
▶ Floor finishing	85
▶ Grinding	85+
▶ Concrete worker	89
Driving a dumper or roller	85+
Formwork	92
Labouring:	
▶ Concrete pour	97
▶ Digging/scabbling	100
▶ Shovelling hardcore	94
▶ Shuttering	91
▶ Angle grinding/cutting	90–110
Mechanical and electrical general installation	89
Piling:	
▶ Operator	85+
▶ Worker	100+
Reinforcement work	86

For more information visit the 3M Center for Hearing Conservation:
www.3M.co.uk/3M/en_GB/hearing-protection-uk/support/hearing-conservation

Minutes of carelessness per day significantly reduces the effect of hearing protection.

Hearing protectors need to be worn for the full duration of noise exposure. Removing them for even a short time in a hazardous noise environment significantly increases the noise exposure. For example, not wearing a hearing protector with an SNR of 30dB for half an hour of an 8 hour work shift will still only achieve about 12 dB of the anticipated attenuation.

How much noise is too much?

There are many factors that impact how hazardous noise can have an adverse effect on your hearing. These include the noise level (or noise intensity), duration and exposure frequency. It is well understood that continued exposure to sound level above 85dB(A) can lead to irreversible hearing damage.

The European Physical Agents (Noise) Directive 2003/10/EC explains the three action values to help minimise the risk of hearing damage.¹¹

Limit Value 87dB(A) Leq,d or 140dB(C)peak: This Limit Value must not be exceeded under any circumstances and exposure assessment can take into account suitable hearing protection.

Upper Exposure Action Value 85dB(A) Leq,d or 137dB(C) peak: Action plan to eliminate or reduce exposure must be instigated and the use of suitable hearing protection must be made mandatory to immediately protect the worker from risk of hearing damage. Health surveillance initiated.

Lower Exposure Action Value 80dB(A) Leq,d or 135dB(C) peak: Risk assessment carried out and suitable hearing protection made available on request. Health surveillance initiated for the vulnerable individuals.

EU law also sets working methods or equipment that require less exposure to noise, instructions on the correct use of equipment, technical measures (shield, noise absorbing coverings) or organisational measures in order to reduce duration and intensity of exposure.¹²

Many construction workers assume that noise is something they can simply get used to. Even when noise seems to be at a reasonable level, it can still lead to long-term damage. What some mistake as a higher tolerance to noise may actually be temporarily dulled hearing, or even permanent hearing loss. If you need to shout to communicate with a person who is three feet away, it's likely that noise levels have surpassed 85 dB(A).

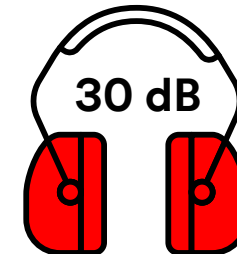


Your ears may also provide signs of noise risks in your environment. Hearing a buzzing, ringing or whistling sound after being in noisy environment may be a warning signal. This sensation is called tinnitus, and it indicates that the nerve cells of your inner ear may be irritated and overworked. Not only can tinnitus be annoying, it can become permanent.

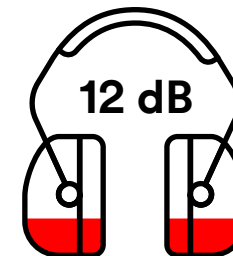
Another warning sign is the muffling or softening of sounds after noise exposure. This may signal a temporary threshold shift. Going into loud environments without hearing protection repeatedly can turn this temporary health problem into a permanent one.

Effective protection drops when hearing protectors are not worn.

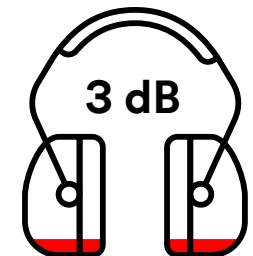
Worn 8 hours

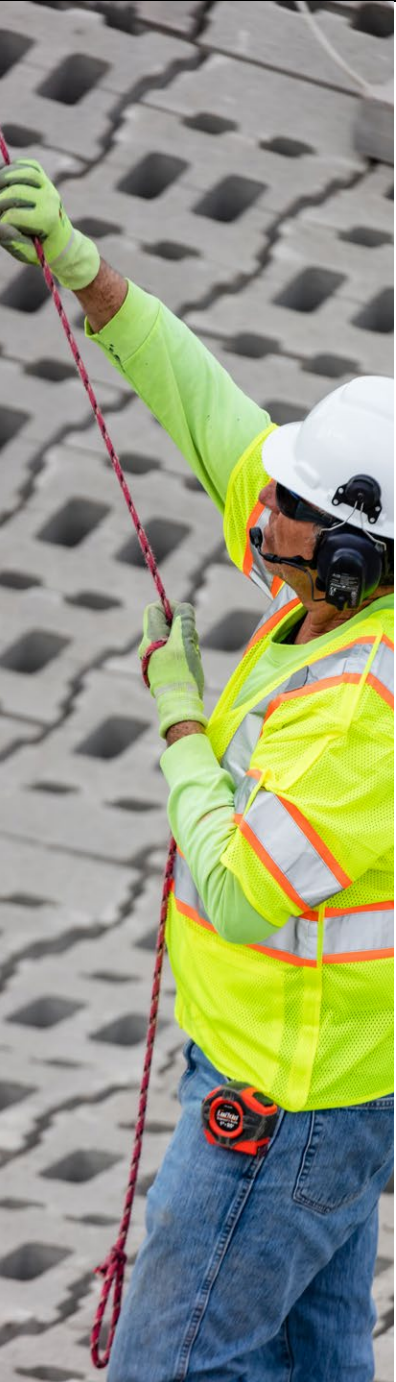


30 minutes not worn



4 hours not worn





How quickly is the damage done?

Our hearing is vulnerable to hazardous noise. Hearing loss occurs when tiny hair cells in the inner ear are damaged.¹³ Hearing loss can be caused by a one-time exposure to an intense noise. Repeated exposure to sound greater than 85 dB(A) can cause permanent hearing loss and tinnitus – constant ‘ringing’ in the ears. Not only does it impair the ability to hear other sounds, but noise exposure is also associated with headache, increased stress and fatigue.

It’s worth knowing that typically, hearing is damaged gradually. The accumulated damage may become perceptible after several years of working in noise. By then, the changes are likely to be irreversible. Fortunately, hearing damage due to noise is preventable.

Hearing loss affects more than hearing

We all love different sounds: the sound of a child’s laughter, a cat’s purring, a flowing river, a bird singing, music or a car’s finely tuned engine. All of us have just one sense of hearing, so we should protect it because hearing loss causes many additional consequences.

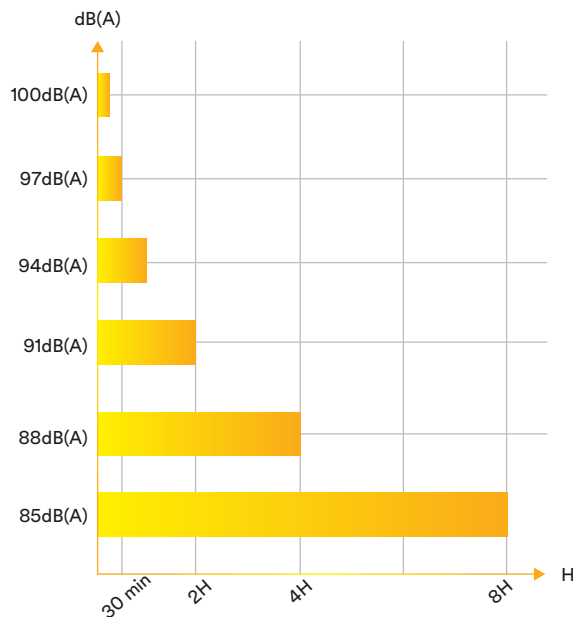
Hearing loss makes communication much harder. People with significant hearing damage often withdraw from the society, as they cannot participate fully, even in a simple conversation.

It’s a life without bird songs that leads to loneliness and depression. Let’s protect our hearing to be able to listen to the sounds we love to hear.



Noise-induced hearing loss is the most common reported occupational disease in the EU.¹⁴

Daily noise exposure – understanding the 3dB exchange rule



There is a way you can estimate noise dose by applying a 3dB exchange rule. For example, let’s take the Upper Exposure Action Value of 85dB(A) Leq,8h and consider the relationship of noise level vs exposure time.

- 85dB(A) => 8hour
- 88dB(A) => 4 hour
- 91dB(A) => 2 hour
- 94dB(A) => 1 hour
- 97dB(A) => 30 minutes
- 100dB(A) => 15 minutes
- 103dB(A) => 7.5 minutes
- 107dB(A) => 3.75 minutes

From this example, you can see that each time you increase the sound level by 3dB you reduce exposure by a half.

A person exposed to 107dB(A) for 3.75 minutes unprotected has the same risk of hearing damage as a person exposed to 85dB(A) for 8 hours unprotected.

Controlling noise in construction

Compared to general industry, controlling noise on construction sites may be more challenging for construction contractors. The work often occurs outdoors and may be impacted by weather. Loud moving equipment means that the location of a noise source moves around the site. Noisy tools result in significant sound levels and intensity fluctuations throughout the workday. Construction workers frequently receive hearing protection devices to help control exposures to loud equipment in a work area. However, personal protective equipment (PPE) should be used after engineering and administrative controls have been exhausted and proved infeasible. For further information refer to the EU-OSHA guidelines and EU Physical Agents (Noise) Directive 2003/10/EC.¹⁶

Refer to the HSE document L108: The Control of Noise at Work Regulations 2005 for controlling noise exposure.

Practical and effective noise control methods on construction sites

Even though every project varies, and each day brings different tasks, reducing noise on construction sites remains a real possibility.

Noise control solutions must be tailored for the situations often found in construction. Fortunately, there are a variety of ways by which construction equipment and work site noise can be controlled.

Engineering controls are considered the most effective way to modify a work area or equipment to reduce the noise levels. For example, consider using quieter equipment, retrofitting existing equipment with mufflers, damping materials or enclosing loud devices, installing barriers and maintaining noisy equipment. Administrative controls or work practice controls to help minimise exposures could include restricting access to noisy areas, shutting down loud equipment when it is not being used, moving workers farther away from the source of noise and job rotation.



Six tips for controlling noise on construction sites

The following is a list of ways to control noise levels in your worksites (not an exhaustive list).

1 Purchase quieter equipment

Machinery supplied within the European Economic Area must comply with the noise requirement of the Machinery Directive 2006/42/EC. Manufacturers of machinery must reduce noise to lowest level achievable and provide noise emission data to the buyer so that it can be used without risk from noise. Many manufacturers are making quieter tools. When purchasing new equipment, ask for quieter compressors, better made gears and other features that may reduce noise. To learn more, contact your national regulatory authority or refer to the European Machinery Directive 2006/42/EC.

2 Modifying existing older equipment

Older equipment can be modified with damping materials, sound panels or mufflers to help reduce sound levels. Sometimes it may not be feasible or cost effective to modify old equipment and if the need arises to replace it, refer to your local 'Buy Quiet' programme.



3 Maintenance

Keeping construction equipment in good working order not only makes it last longer, but also may help to make the work site quieter. Lack of maintenance can create or make noise hazards worse. For example, loose parts can create more noise because of scraping against other parts. Inadequate lubrication may cause grinding noises. It is especially important to properly maintain any noise control devices designed or added to machinery. Key areas that get noisier with use include: worn or chipped gear teeth, worn bearings, loose parts, poorly lubricated parts, imbalanced rotating parts, whistling noises from obstructed airways, blunt cutting blades, removal of mufflers, silencers, covers and isolators.¹⁷

4 Installing sound barriers

Placing barriers around noisy equipment on a construction site doesn't have to be complicated. Construction contractors can utilise commonly found materials such as plywood, stacks, block or spoils. It's also possible to build barriers with commercial panels. For further sound reduction, line the panels with sound-absorbing materials. Select appropriate barrier length to maximise effectiveness and position it as close to the noise source as possible.

5 Noise area demarcation

Establish an appropriate noise demarcation zone to alert people entering noise hazardous areas. This is another example of an administrative control to help limit exposure to as few workers as possible. Determine which areas of the construction site have noise levels that are above the Upper Exposure Action Value of 85dB(A) Leq,8h requiring mandatory use of suitable hearing protection while investigating other ways to reduce exposure risk. The area can be cordoned off and marked '**Noise Hazard - hearing protection required**' in the same way that a 'hard hat area' is marked off. All workers who need to work within the zone must wear hearing protection, and the demarcation area will help limit access to only those who are authorised to work in the noise hazard area and have the correct hearing protection.

6 Work activity scheduling

Jobs can be rotated to help limit exposure time. Consider transferring construction workers from high noise exposure tasks to lower exposure tasks to help make the employee's daily noise exposure acceptable. If job rotation is not possible, it can be beneficial to adjust work scheduling to reduce the number of exposed employees in areas surrounding loud tasks, like pavement breaking operations. Another option is switching off noisy equipment when not in use and only run when necessary.¹⁷



Personal protective equipment considerations

Is dual protection required?

Many construction tasks such as jack hammering, scraping or piling can exceed 100 dB(A). In accordance with the Physical Agents (Noise) Directive 2003/10/EC, if the daily noise exposure (normalised over 8 hours) exceeds the lower exposure action value, the employer is required to make hearing protectors available for workers. If the daily noise exposure (normalised over 8 hours) reaches or exceeds the upper exposure action values, the use of hearing protectors must be made mandatory and strictly enforced. Dual hearing protection is wearing both earmuffs and well-fitted earplugs simultaneously.¹⁸

When a combination of two forms of hearing protectors (earplugs and earmuffs) are worn together the combined attenuation should ideally be assessed in an acoustic laboratory. In the absence of any laboratory data, a general rule of thumb can be applied where 6dB is added to the highest of the two attenuation values. For example, if an earplug has SNR of 30dB and earmuffs 35dB and the two products are worn together, the resultant attenuation would be 41dB. Dual protection can help extend the time that a worker can work in high noise, however it may also reduce the worker's ability to hear warning sounds or communicate.

*3M makes no warranties as to the suitability of the SNR for this purpose. 3M strongly recommends personal fit testing of hearing protectors. Research suggests that users may receive less noise reduction than indicated by the attenuation label value(s) on the packaging due to variation in fit, fitting skill, and motivation of the user. Refer to your national regulations and guidance on how to adjust attenuation label value(s).

Fit Testing

Hearing protector fit testing is the measurement of the amount of noise reduction, or attenuation, a hearing protector provides while it is being worn by a specific individual. This real-world measurement is referred to as a 'Personal Attenuation Rating' or PAR. The purpose of hearing protector fit testing using a Field Attenuation Estimation System (FAES), is to verify that the attenuation is adequate for the individual and to help validate hearing protectors that can be used successfully in his or her work environments. A laboratory-derived SNR rating is calculated from attenuation data from a panel of sixteen test subjects, whose hearing protector was fitted by the lab technician. Comparatively, PARs tell us how much attenuation a particular hearing protector model is providing when fitted in the actual user's ear, by the actual user.

In line with the European guidance document EN 458:2016 'Hearing protectors – Recommendations for selection, use, care and maintenance – guidance document', fit testing plays an important role in helping improve field performance of hearing protectors. Fit testing is seen as a useful training and motivation tool in helping select the right product for the individual wearer and the workplace requirement. Evidence shows that use of fit testing can help identify workers who may be at risk of developing noise-induced hearing loss.¹⁹ With each new hearing protection recommendation, standard, regulation and eye-opening statistic, it's clear that fit testing is an excellent solution to help protect your workers. Learn more about the importance of this process in the Fit Testing eBook.



Dual hearing protection is wearing both earmuffs and well-fitted plugs simultaneously.

Personal protective equipment considerations

Why is fit testing needed?

It comes down to the fact that no one shares the same set of ears. Everyone has their own unique ear canals – that’s why there can be a large range in attenuation achieved by individuals in the workplace using the same model of hearing protector. Even if you give everyone a high SNR earplug, you should expect they won’t all receive the same attenuation. Plus, there’s the issue of inserting hearing protectors properly.

A study in the UK in construction involving 117 test subjects revealed that 40% of them were unable to achieve 10dB noise reduction from a selection of hearing protectors putting them at risk of developing noise induced hearing loss. After training, additional 23% were able to achieve the desired attenuation while 17% had to switch to a different type of hearing protector.²⁰

The positives are clear – fit testing can help enhance your hearing conservation program. Are there negatives? Not really, even if there’s concern about the initial cost of implementation. Reducing incidents of noise-induced hearing loss not only saves money in the long run – it saves people’s hearing – and that’s priceless.

How does fit testing work?

There are different types of fit test systems, but in general, the worker selects the hearing protector normally used, and then it is tested on the worker to learn how much noise reduction it provides. Some of the systems are subjective, meaning that the worker must respond to a test signal. Other systems are objective and don’t depend on the worker’s hearing or ability to take a test. The point is the attenuation or protection provided is determined for the individual worker the way the worker typically uses the tested hearing protector.

Research supports hearing protector fit testing

Recent research shows many advantages to hearing protector fit testing, including:

1. Reduced likelihood of hearing loss²¹
2. Improved use of hearing protectors²²
3. Ability to evaluate attenuation when combined with other Personal Protective Equipment (PPE)²³

See **Why Hearing Protection Fit Protection Matters** video for more information.



Identify workers at risk

Even though turnover is traditionally high in the construction industry, it is still critical to identify workers who may be at risk for noise induced hearing loss.

Fit testing can help you quickly identify workers at risk of appropriate protection. With fit testing and training, they can improve their PAR and maintain it over time. In one study, the 3M™ E-A-Rfit™ Dual-Ear Validation System was used to conduct fit tests on workers.²⁰

See the **Fit Testing eBook** for more information.

Passive earplugs and earmuffs

Conventional passive earplugs and earmuffs

The noise reduction provided by conventional passive hearing protectors is not affected by noise exposure levels. These products are designed to provide consistent attenuation throughout the workday as long as the product is fitted correctly and worn for the entire duration when exposed to the noise hazard.

Disposable foam earplugs

The most widely used type of HPD. The soft foam is rolled into a compressed cylinder then inserted into the ear.

- ▶ Comfortable: conforms to the unique shape of ear canal
- ▶ Affordable: low price per pair
- ▶ Effective: high noise reduction when worn correctly



3M™ E-A-R™ Classic™ Earplugs

3M™ E-A-R™ Classic™ Earplugs meet wearer needs with soft, proprietary, energy-absorbing slow recovery foam and a cylindrical shape to help with in-ear comfort. Corded for easy short-term storage around the neck when not in use.



3M™ E-A-Rsoft™ Yellow Neons™ Earplugs

3M™ E-A-Rsoft™ Yellow Neons™ Earplugs feature a natural tapered shape and smooth texture for a more comfortable fit. Bright yellow colour is designed to help make them easier to spot for compliance verification. Soft, slow-recovery foam helps make insertion easier. Available corded and uncorded.

Push-to-fit earplugs

Soft foam tips with a flexible stem. No need to roll the foam tips before inserting into ears.

- ▶ Easy to use: works well for employees who have difficulty rolling and inserting disposable foam earplugs
- ▶ Convenient: can be used when hands are dirty or when wearing gloves
- ▶ Comfortable: soft foam conforms to the unique shape of ear canal
- ▶ Cost effective: replace when signs of wear and tear
- ▶ Effective: some models offer high noise reduction when inserted correctly



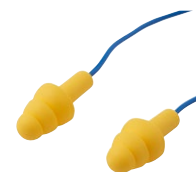
3M™ E-A-R™ Push-Ins™ Earplugs

3M™ E-A-R™ Push-Ins™ Earplugs feature a soft foam eartip made from 3M™ E-A-Rfoam™ with a smooth skin surface for improved comfort and a semi-flexible stem that helps easy insertion and removal in the ear canal. This product can be fitted using one hand fitting method with an SNR of 31dB or two hand fitting method with an SNR of 35dB.

Reusable earplugs

Washable earplugs with flexible, elastic flanges attached to a stem.

- ▶ Less waste: can be reused many times
- ▶ Cost effective: replaced less often for lower cost long term
- ▶ Convenient: can be used when hands are dirty or when wearing gloves
- ▶ Versatile: moisture resistant. Works well in hot and humid conditions or when employees perspire heavily
- ▶ Good attenuation: provides reliable protection against most hazardous noise levels



3M™ E-A-R™ UltraFit™ Earplugs

The 3M™ E-A-R™ UltraFit™ Earplugs are made with a triple-flange design to help contour to the different shapes and sizes of ear canals. This helps create an acoustic seal. Durable material, can be washed and reused, cutting down costs and extending the hearing protector's life.

Passive earplugs and earmuffs

Earmuffs

Earmuffs have rigid cups with soft plastic cushions that seal around the wearer's ears to reduce noise.

- ▶ Easy to use: most people learn to properly use them with little difficulty
- ▶ Convenient: quickly put on and take off hearing protection as needed
- ▶ Alternative to earplugs: some people prefer not to, or are unable to, wear earplugs



3M™ PELTOR™ X4 Earmuffs

For high performance hearing protection against moderate to high noise levels, use 3M™ PELTOR™ X4 Earmuffs. 3M™ PELTOR™ X4 Earmuffs are colour-coded bright green, making it simple to select the correct level of protection from the X series range. Combining 3M's legendary hearing protection knowledge with advanced technology, our earmuffs include a specially designed spacer and new ear cushion technology which improves noise reduction without the excess bulk and weight. The X4 is lightweight and even more streamlined compared to other high attenuating earmuffs whilst reducing noise up to 33 dB.

Banded hearing protector:

Soft foam or elastic tips held in place by a flexible band.

- ▶ Convenient: quickly put on and take off hearing protection as needed. Good choice for people who move frequently in and out of noisy environment
- ▶ Versatile: wide variety of headband styles and types of ear tips
- ▶ Moderate attenuation: provides moderate attenuation thus helping avoid isolation due to over-protection



3M™ E-A-Rcaps™ banded earplugs

The 3M™ E-A-Rcaps™ banded earplugs are one of the lightest products on the market featuring comfortable foam ear tips on a flexible band. The ear tips are made from soft polyurethane foam which provide effective seal of the entrance part of the ear canal.

This product is intended to be worn in under-the-chin wearing mode thus improving compatibility with other PPE such as safety helmets, and is ideal for workers with intermittent hearing protection needs.

Fit testing equipment:



3M™ E-A-Rfit™ Dual-Ear Validation System

The 3M™ E-A-Rfit™ Dual-Ear Validation System helps determine whether workers are receiving adequate protection from their hearing protector by measuring across 7 standard frequencies in under five seconds, providing a detailed report on the noise attenuation performance of earplugs or earmuffs and a pass or fail rating for each individual person based on the employee's personal attenuation rating and noise exposure.

See demonstration.



Communicating and auditory situational awareness in hazardous noise on construction sites

Noise levels on a construction site can vary widely from moderate to extremely high depending on the application. Due to the extreme noise levels, safety managers sometimes provide conventional passive earplugs and earmuffs with a high single number rating (SNR) for their workers. While these hearing protectors can be an effective way to reduce exposure to hazardous noise, they provide the same amount of noise reduction regardless of the environmental sound level. So, when the noise quiets down, workers may have more noise reduction than necessary, which may lead to overprotection isolation.

Overprotection occurs when HPDs reduce sounds well below what is considered to be hazardous and may limit the wearer's ability to detect important and/or emergency sounds or understand speech critical to performing the job safely. This may create additional safety risk which can lead to potentially serious consequences. To compensate for inaudibility of important sounds, workers often fit hearing protectors poorly so that they are able to maintain situational awareness.

This practice can lead to insufficient protection thus resulting in hearing loss. Wearing HPDs improperly or inconsistently, even for a short period of time, can reduce the effectiveness and lead to a higher risk of permanent noise-induced hearing loss.

Hearing-impaired workers may be at a particular disadvantage when using high SNR, passive hearing protection because the added attenuation may further reduce their ability to detect important signals and emergency sounds such as fire alarm. It is critical for people with hearing loss to protect their remaining hearing while also balancing their need to be connected to their environment. Workers with impaired hearing can face many challenges including communication, being able to perform their normal work duties safely and effectively. Workers with hearing impairment normally wear hearing aids and when working in a noisy hazard it may be necessary to use sound restoration level dependent hearing protectors. There is divided opinion whether they are used in conjunction with the hearing aid or as a substitute. Always check with your national regulation for further guidance.



Industrial hearing conservation programs may not fully address the specific needs of hearing-impaired workers.

Why is auditory situational awareness important?

Many types of heavy equipment use auditory cues to communicate warnings to nearby workers. On construction sites, a warning sound such as a truck's reversal beeping noise can help workers become more aware of their surroundings.

The Health and Safety Executive (UK Government Agency) investigated 11 incidents between 1998 and 2015 which involved fatalities. One of the key areas of focus in any investigation is the potential of ineffective audibility of warning signals which can lead to serious accidents. In addition to focussing on use and limitation of any items of PPE, the accident investigation team also examined whether the PPE issued was worn correctly.

In some instances, conventional hearing protectors with rising attenuation from lower to higher frequencies can degrade speech signal. There are sophisticated electronic hearing protectors that can vastly improve signal recognition and communication in noisy environments.

The construction industry is a dynamic work environment with lots of activities generating noise i.e. moving vehicles, use of powered tools etc., and the need to maintain auditory awareness of moving vehicles and essential communication are key to an effective hearing conservation programme that can help improve safety and welfare of the worker.

For these reasons, it is important to consider advanced hearing protection and communication solutions to help assist workers with audibility and communication. When workers are able to hear the signals that help enhance safety, they are more likely to maintain proper physical distances.



Crane operator and signal person communications

For those operating cranes or directing vehicle traffic in a work zone, miscommunication between the equipment operator and the signal person can be deadly.

Consider providing the signal person with hearing protection devices that help provide protection from noise, enhance communication with the crane operator and helps enhance awareness of the crane's moving parts.

Communication challenges during the COVID-19 pandemic

Workers may need to work while physically distancing or while wearing face coverings. You are probably already aware that face coverings may pose communication challenges. But there are some recent studies worth noting.

Face coverings or masks make communication challenging in at least three ways:

- 1** A 2020 study conducted for healthcare environments highlights the first challenge. Masks can attenuate or reduce high frequencies. The amount of degradation depends on the mask, but there can be as much as a 12 dB(A) drop. This is especially significant because it is affecting the frequencies that most contribute to our ability to distinguish between consonant sounds, thus affecting our ability to understand speech.²⁴
- 2** Secondly, when we cover our faces, we lose our ability to see facial expressions and see each other's lips.²⁵
- 3** And then lastly, it also turns out that wearing a mask can affect how you produce speech. Wearers continually raise their voices to be heard.²⁶



Consider audibility when selecting hearing protectors

To go beyond the basics requires us to think a little differently about selecting hearing protection. In construction, acoustical environments are often dynamic and task based. The noise may be intermittent, fluctuate during the day or the source of noise may shift location. There may be periods of relative quiet, or a need to be aware of moving equipment, warning signals and alarms.

As a result, selecting hearing protection is more complicated than simply knowing the time weighted average or how loud the noise is. Besides the required regulatory elements based on assessment of the noise exposure and the attenuation capabilities or the SNR of the hearing protector, there are many other factors to consider. Focusing on only the required elements limits the opportunity to go beyond regulatory compliance and implement best practices.

In addition to the regulatory requirements, consider the following additional criteria for a more holistic approach to selecting hearing protection:

- ▶ **Fit and comfort:** each worker is a unique individual with unique ear anatomy, has differing ideas of comfort and may possess a different skill level for inserting earplugs
- ▶ **Application:** construction tasks may vary each day, and the working conditions and environment may be different (such as temperature, humidity, elements, etc.)
- ▶ **Compatibility with other PPE:** construction tasks may often require the use of additional PPE such as hard hats, safety glasses, and respirators. Consider the compatibility with other PPE the workers are required to wear
- ▶ **Hearing ability:** some construction workers may have pre-existing hearing impairment
- ▶ **Audibility:** and finally, what about the worker's need for audibility and communication while they do their job duties?

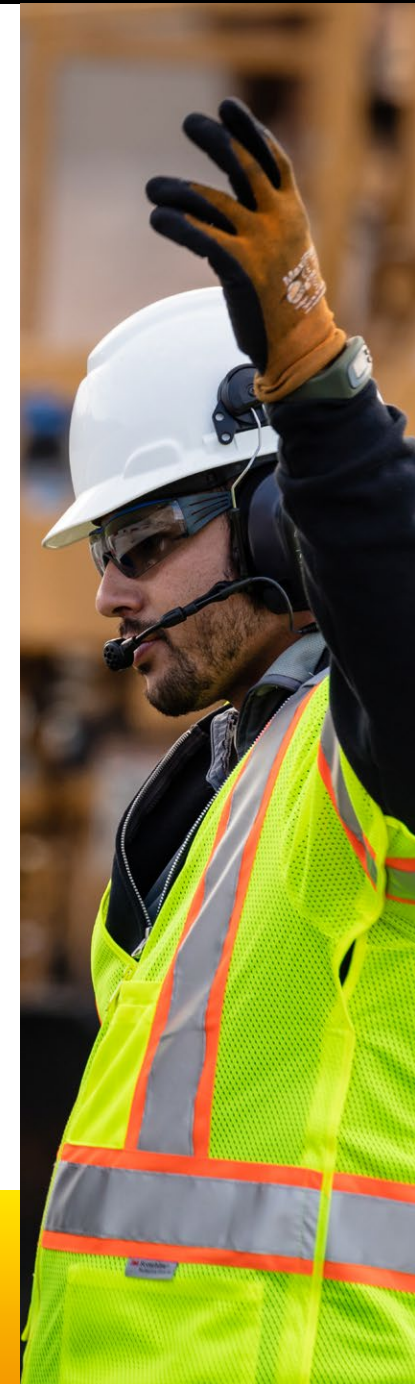
Audibility in construction

In construction work, our auditory demands are significant. The ability to have auditory situational awareness may impact safety. The ability to communicate face-to-face and over radio may impact productivity and work efficiency. It may impact the quality of a person's work life. Auditory situational awareness describes how people use auditory information and their other senses to develop an understanding of their environment. Components of situational awareness include sound detection, distance estimation, sound localisation, and ability to understand speech communication.

On a busy construction site, estimating the distance to moving equipment is crucial. For example, you can't determine the location of a sound before you detect it. Sound detection is critical. The other components of awareness may rely on additional systems or senses. When we hear a sound or noise, we naturally turn our head to look for the source of the noise.

The level of importance with each criterion varies with task, dynamic listening situation and industry. Not all factors are equivalent in all situations. As a hearing conservation program manager, are you evaluating the audibility and communication needs of your workers? Have you ever wondered if a worker's hearing protection device compliance is related to their audibility and communication needs? Consider an audibility risk assessment to help incorporate these additional criteria in your programme.

The ability to have auditory situational awareness may impact safety.





Audibility risk assessment

You may be inclined to review your hearing conservation or hearing loss prevention program from a risk assessment point of view. Consider these questions when you are reviewing your overall hearing conservation program:

- ▶ What is a 'typical' hazardous noise exposure?
- ▶ What do workers need and want to hear while working?
- ▶ Are workers OK with reduced hearing due to hearing protection use?
- ▶ What is the impact of hearing protection on a hearing-impaired worker?
- ▶ What effects are your hearing protector selections having on safety? Productivity? Efficiency?

Observe worker communication

Look for people wearing hearing protection and using two-way radios:

- ▶ What happens if they can't hear each other?
- ▶ Could improved communication help enhance productivity?

Look for the physical hazards; fork lift trucks, moving equipment, etc.

- ▶ What degree of auditory awareness is necessary to maintain safety?
- ▶ Could improved communication help reduce the potential for injuries?

After you identify the high-risk tasks, evaluate your noise, your worker's hearing abilities and hearing protector attenuation by conducting hearing protector fit testing. Evaluate whether the HPD solution 'works' for the worker!

Once this process is complete, incorporate audibility and communication in your Hearing Conservation Program. Apply the expanded HPD selection criteria.

Additional considerations for incorporating auditory situational awareness and communication in your hearing conservation programme



Identify higher risk tasks

- ▶ Warning signals/machinery need to be heard
- ▶ Collision with a moving vehicle is possible
- ▶ Communication is critical



Evaluate

- ▶ Ambient noise frequency spectrum
- ▶ Speech/warning signals frequency spectrum
- ▶ Hearing protection attenuation
- ▶ Workers' audiograms
- ▶ Electronic communications



Incorporate in hearing conservation program

- ▶ Hearing Ability
- ▶ Hearing Requirements
- ▶ Fit testing
- ▶ Engineering Controls

Take a proactive approach to hearing protection by considering every possible scenario related to noise and communication. When you ask important questions before construction work begins, you can better understand the possible hazards that may arise. As a result, it will be easier to choose the PPE that best suits your team's specific needs.

Productivity: case study Swedish excavation and pipe installation project

A 2015 study of a Swedish company completing excavation and pipe installation activities demonstrated significant downtime reductions. The study showed that workers continued face-to-face, radio and mobile phone communications without needing to leave noisy areas. Workers also reported that they could better hear warning sounds and equipment.²⁷



Personal protective equipment considerations

Advanced hearing protection and communication solutions, such as 3M™ PELTOR™ Protection and Communication Solutions, are among the most innovative ways to assist construction workers who work in very dynamic noise environments. The hearing protection attribute of these electronic or active devices is the same as their passive hearing protector counterparts, but this family of advanced products allows for additional capabilities to assist workers with audibility and communication on the job. Consider two categories of advanced HPDs: protective hearing solutions and protective communication solutions.

Protective hearing solutions

Protective hearing solution devices allow sounds to pass through when it is quiet, but also help provide hearing protection when it is loud with environmental listening technology – also called level-dependent technology. Environmental listening microphones can be found in both in-ear and over-the-ear products.

This category of products may help workers hear communications when they are exposed to intermittent, unpredictable or low to moderate levels of noise. Or when there are periods of quiet or periods of quiet interrupted by impulsive noise. Environmental listening technology can assist workers who move between loud and quiet areas and assists if the workers need a heightened awareness of their surrounding due to moving vehicles, equipment or alarms. It is important to note that when you turn the electronics off, the device functions as a passive hearing protector. When the electronics are turned on, the worker can adjust the level of sound and even amplify the sound coming in through the environmental microphones.

Just as amplification can help normal hearing workers with auditory needs, it may also benefit workers with pre-existing hearing impairments. However, these products are not considered hearing aids.

All environmental listening safety products should have circuitry, or an internal sound limiter built into the device. 3M™ PELTOR™ products use compression to limit the sound level through these environmental microphones down to around 82 dB(A) or lower in a continuous noise environment. Compression takes the auditory signal that the mic has picked up; keeps the signal but reproduces it and limits it lower than 82 dB(A). Other manufacturers may use peak clipping where any signal above 82 dB(A) is clipped, which may result in a distorted sound output compared to a compressed signal. In the case of protective hearing products, a worker's protected exposure depends on the combination of the environmental listening electronic circuit limiter and the amount of passive attenuation provided by the hearing protector.

Simply, how does environmental listening technology work? In quiet environments, sounds pass through. In loud environments, sounds coming in through the environmental microphones are compressed and reproduced down below 82 dB(A) or lower. Therefore, the protection becomes 'level-dependent.' The protection against the noise coming in through the environmental microphones automatically adjusts as the noise level changes.

Protective hearing solutions give workers the ability to have face-to-face communication in low noise. Consequently, workers may be less tempted to remove their hearing protectors to hear and this may encourage workers to wear their hearing protection correctly and consistently.



Personal protective equipment considerations

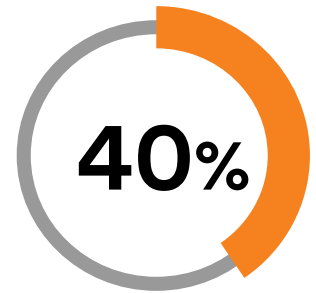
Protective communication solutions

Protective communication solutions are advanced HPDs that feature integrated two-way radios and/or wireless technology, along with noise-canceling speech microphones, and enable workers to communicate in high noise environments.

In conjunction with the voice-operated transmission, workers can communicate hands-free so they can remain productive while communicating.

These advanced HPDs are smart hearing protectors that can not only help protect workers' hearing but may also improve the workers' ability to communicate in noise and/or hear the important sounds needed to do their job safely and productively.

Ultimately, if workers are provided hearing protectors with an amount of noise reduction appropriate for their environment while also helping them communicate with their colleagues, they may be even more motivated to wear their HPDs continually and consistently. This factor may help to reduce the incidence of NIHL (Noise Induced Hearing Loss) in the construction industry.



40% of workers did not either select the correct hearing protectors or wore it when exposed to noise.²⁸



Protective hearing devices

Environmental listening (level-dependent) technology

The noise reduction provided by level-dependent hearing protectors varies with the level of the noise. This type of protector provides more noise reduction at high noise levels and is particularly effective for:

- ▶ Intermittent or variable noise conditions: helps make it easier for workers to maintain situational awareness without having to remove their hearing protectors
- ▶ Impulse noises: very short, loud sounds such as the blast of an arc flash or the bang of a pneumatic nail gun. To learn more about hearing protection for impulse noise, read 3M Technical Data Bulletin #234

Level-dependent HPDs may be non-electronic (passive) or electronic (active). Electronic level-dependent HPDs feature environmental microphones to pick up low-level sounds. The wearer can adjust the volume of the incoming sounds for their preferred listening level.



3M™ PELTOR™ Electronic Earplug, EEP-100

Helps protect workers' hearing and can help promote auditory situational awareness and communications in challenging environments. External microphones help you hear communication and environmental sounds. Intuitive one-button operation powers earpiece on/off and selects volume level. The small and lightweight design helps improve the overall comfort and user experience and makes it compatible with most head borne PPE, such as helmets and face shields.

Protective communication devices

Protective communication solutions are advanced HPDs that feature integrated two-way radios and/or wireless technology, along with noise-canceling speech microphones, and enable workers to communicate in high noise environments. Using the voice-operated transmission, workers can communicate hands-free so they can remain productive while communicating.



3M™ PELTOR™ LiteCom Plus Headset

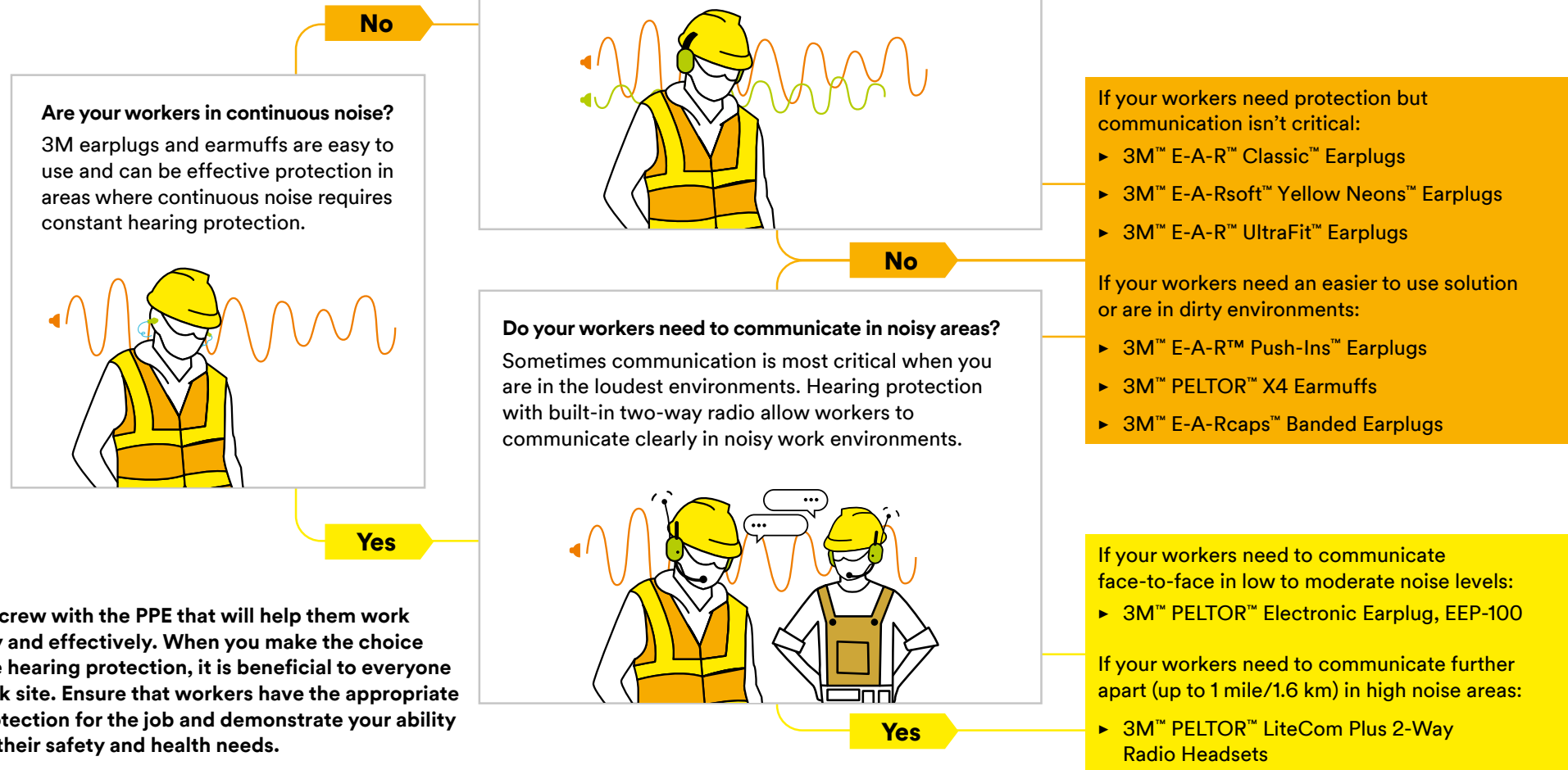
The 3M™ PELTOR™ LiteCom Plus Headset is a hearing protector with an integrated analog two-way radio and a noise-cancelling speech microphone to deliver a wireless, hands-free protective communication solution. The 3M™ PELTOR™ LiteCom Plus headset also includes the environmental listening technology that assists workers to hear environmental sounds in low noise and helps provide protection when it's loud.

Designed for use in equipment maintenance, crane operations, construction and many other applications in noisy environments, the 3M™ PELTOR™ LiteCom Plus headset helps your work group communicate while helping provide hearing protection when workers are exposed to hazardous noise. Three buttons on earcup designed for simple and intuitive operation. The noise-cancelling microphone can be activated by pressing the Push-to-Talk (PTT) button on the earcup or by using voice operated transmission (VOX). As you speak into the microphone, the channel is opened in milliseconds, allowing for near instantaneous, clear communication in noisy environments.

Choose the appropriate hearing protection solution

Selecting the appropriate hearing protection solutions depends entirely on your unique circumstances.

The work site environment and your team's operational needs should factor into the decision. Every situation is different, so consider the factors below to help in your decision.



Equip your crew with the PPE that will help them work more safely and effectively. When you make the choice to prioritise hearing protection, it is beneficial to everyone at your work site. Ensure that workers have the appropriate hearing protection for the job and demonstrate your ability to address their safety and health needs.

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Hearing and PELTOR

▲ WARNING

These hearing protectors help reduce exposure to hazardous noise and other loud sounds. Misuse or failure to wear hearing protectors at all times that you are exposed to noise may result in hearing loss or injury. For correct use, consult supervisor and User Instructions, or call your local 3M office for further information. 3M PSD products are for occupational use only.

▲ WARNING

3M strongly recommends personal fit testing of hearing protectors. Research suggests that users may receive less noise reduction than indicated by the attenuation label value(s) on the packaging due to variation in fit, fitting skill, and motivation of the user. Refer to applicable regulations or guidance on how to adjust attenuation label value(s). In the absence of applicable regulations, it is recommended that the attenuation label value(s) be reduced to better estimate typical protection.

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