14 HEARING PROTECTION

Many construction tasks produce noise. Typical construction work may involve equipment driven by large and small engines, metal fabrication, power drilling and sawing, air hammering, and blasting—all of which can produce noise at harmful levels.

Depending on the noise level, duration of exposure, and other factors, a temporary or permanent hearing loss may result. Temporary hearing loss will usually be restored by the body within a few hours after the exposure has stopped. Hearing loss that cannot be restored by the body over any length of time is termed permanent.

Noise Exposure Hazards

Over time, exposure to noise can cause the following problems:

- Noise-induced hearing loss (NIHL)
- Tinnitus (ringing in the ears)
- High blood pressure
- Fatigue.

Noise-induced hearing loss is the most common occupational disease suffered by construction workers in Ontario. It often happens gradually, so workers may not realize that loud noise from their job is damaging their hearing. By the time they do realize it, it's too late—the damage is permanent and can't be reversed. That's why protecting the hearing of workers must be part of a company's health and safety program.

New Noise Regulation

A new regulation on Noise (O. Reg. 381) came into effect in 2016. It requires employers to protect workers from overexposure to noise. It sets out a time-weighted average limit of 85 dBA of noise exposure over an 8-hour shift (dBA stands for decibels, which is a unit that measures the intensity of sound).

If workers are exposed to levels above 85 dBA, the employer must consider using engineering and administrative controls to reduce noise at the source or along the path to the worker.

If it is not possible to control noise at the source or along the path, the employer can consider using personal protective equipment (PPE) such as hearing protection devices (HPDs) to control noise at the worker. However, as specified in the Noise regulation, the employer must select the proper HPDs based on the jobsite conditions and must provide adequate training and instruction on the HPDs workers will be using.

Noise Measurement

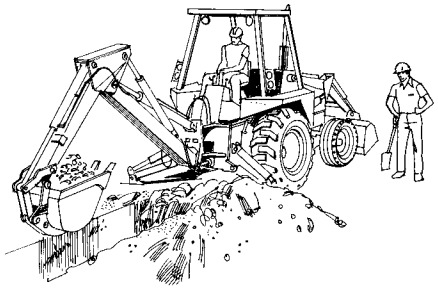
Measuring sound levels can determine the following:

- Whether or not the noise is a risk to workers' hearing
- The amount of noise workers are exposed to
- Where to focus controls to minimize the level of noise exposure.

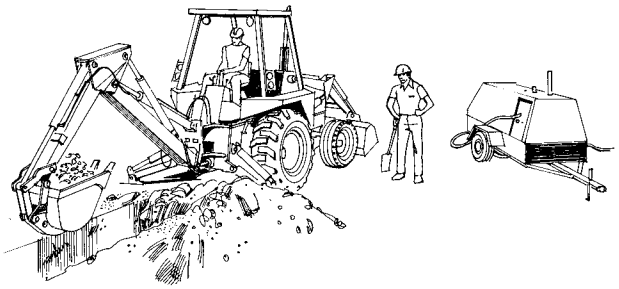
Measurements are performed with a sound level meter (SLM). The unit used to measure the intensity of sound is the decibel (dB). Intensity is perceived as loudness.

Noise levels can't be added directly like other numbers. For example, two noise sources producing 90 dB each would have a combined output of 93 dB, not 180 dB. The combined output of 93 dB is actually a *doubling* of intensity.

In many construction situations, several different sources each contribute to the overall noise. This means that a worker's exposure may be much higher than it would be if only one of the sources were present (Figure 14-1).



If a backhoe produces 90 dB of noise, the worker standing nearby is exposed to 90 dB.



If a backhoe and a compressor each produce 90 dB of noise, the worker standing between them is exposed to 93 dB, which is double the amount of noise intensity.

Figure 14-1: Noise Levels from Multiple Sources

In addition to intensity, the SLM can detect a wide range of frequencies. Since the human ear tends to filter out the lower frequencies and slightly accentuate the higher ones, SLMs are engineered to do the same. They feature an internal mechanism called "A-weighting." The resulting noise level is expressed as decibels (dB) on the "A" scale or dBA.

Two types of noise measurements can be performed:

1. Area noise measurements

2. Personal noise measurements.

Area noise measurement is taken in a specific work area. It's generally a preliminary step to determine whether more detailed evaluation involving personal noise measurement is necessary. Area noise readings should not be used to determine what hearing protection is required or who needs a hearing test. Use personal noise measurement for that purpose.

Personal noise measurement involves a small device called a noise dosimeter. Workers can wear the device to determine their average noise exposure over a whole shift. The dosimeter has a microphone that is placed as close to the worker's ear as possible.

Noise measurements should be carried out in accordance with acceptable standards. Canadian Standards Association (CSA) Standard Z107.56: *Measurement of Noise Exposure* provides guidance on the type of equipment to use, which workers to test, and how to test.

Noise evaluation must be done by a knowledgeable person trained and experienced in conducting noise surveys.

Hearing Process

The hearing process begins when the outer ear directs sound waves into the ear canal (Figure 14-2). The eardrum vibrates as sound waves strike it. This vibration is then transmitted through the middle ear where it is amplified on a membrane called the oval window.

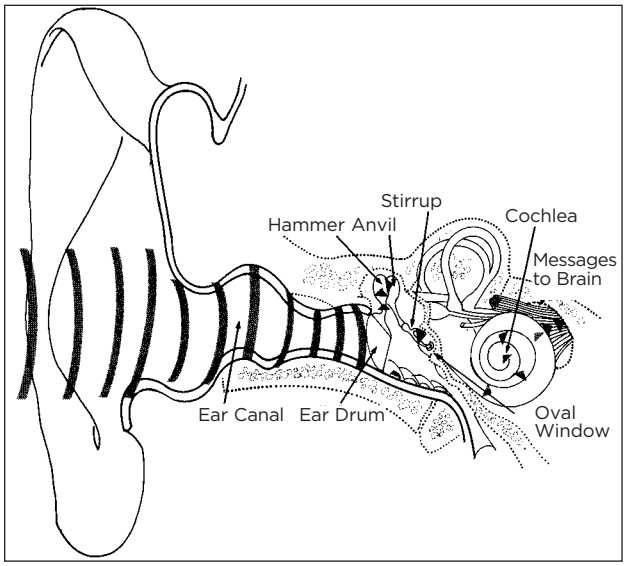


Figure 14-2: Sound Travelling Through the Ear Canal

The oval window separates the middle ear from the inner ear where the sensitive hearing organs are located. Attached to the other side of the oval window is a tiny, snail-shaped structure called the cochlea. The cochlea contains fluid and hair cells. These thousands of small but highly sensitive hair cells feel the vibration. Responding to the cells are microscopic nerve endings that send messages to the brain, where the signals are interpreted as varieties of sound.

Hearing Loss

Any reduction in the normal ability to hear is referred to as a loss of hearing. A hearing loss can be either temporary or permanent.

Temporary Threshold Shift

With a temporary hearing loss, normal hearing will usually return after a rest period away from all sources of intense or loud noise. The recovery period may be minutes, hours, a day, or perhaps even longer. It is believed that a temporary hearing loss occurs when hair cells in the inner ear have been bent by vibrations and need time to bounce back.

Most of the temporary hearing loss occurs during the first two hours of exposure. Recovery usually takes place within the first two hours after exposure stops. However, the length of time needed for recovery depends primarily on how great the initial loss was. The greater the initial loss, the longer the time needed to recuperate. This temporary decrease in hearing ability is called a temporary threshold shift (TTS) because the threshold or level at which sound can be heard has been raised.

For instance, to listen to your favourite music at the volume you like, you would have to turn it up a few more notches than usual. This phenomenon explains why some people, particularly those who suffer from some form of hearing loss, claim that they "get used to the noise."

If these previous exposures are allowed to continue under the same conditions and without the proper interval of rest, then a certain degree of permanent hearing loss is possible.

Permanent Threshold Shift

Permanent hearing loss is the result of hair cell or nerve destruction within the cochlea. Once these important parts of the hearing process are destroyed, they can never be restored or regenerated. The resulting permanent hearing loss, also referred to as permanent threshold shift (PTS), can range from slight impairment to nearly total deafness.

A symptom of PTS is the inability to pick up sounds with higher frequencies. As damage increases, the reception of speech becomes more difficult.

Unfortunately, the damage builds up gradually. Workers may not notice changes from one day to another. But once the damage is done there is no cure.

Look for the following signs that hearing loss may be occurring:

- Having difficulty telling similar-sounding words apart or picking out a voice in a crowd (Sounds and speech have become muffled.)
- Asking people to speak up, then complaining that they are shouting
- Experiencing a permanent ringing in the ears (tinnitus)
- Turning the volume on the radio or television up very high
- Difficulty hearing a person on the telephone.

Determining Factors

The following factors determine the degree and extent of hearing loss:

- **Type of Noise**
  (i.e., continuous, intermittent, impact, high or low frequency)
- **Intensity of Noise**
  (i.e., level of loudness)
- **Duration of Exposure**
  (length of time worker subjected to noise—during the day, on specific shifts, etc.)
- **Employment Duration**
  (i.e., years worker subjected to noise)
- **Type of Noise Environment**
  (character of surroundings—enclosed, open, reflective surfaces, etc.)
- **Source Distance(s)**
  (i.e., distance of worker from noise source)
- **Worker's Position**
  (i.e., position of worker relative to noise source)
- **Worker's Age**
  (e.g., a 20-year-old apprentice versus a 50-year-old journeyperson)
- **Individual Susceptibility**
  (e.g., degree of sensitivity, physical impairments)
- **Worker's Present Health**
  (i.e., whether a worker has any detectable hearing loss or ear diseases)
- **Worker's Home and Leisure Activities**
  (exposures to noise outside the workplace, such as hunting, skeet shooting, earphone music, snowmobiling, wearing earphones, listening to loud music, etc.)

Other prime causes of permanent hearing loss are age, traumatic injuries (such as from explosions or gunfire), and infection. Noise, however, is the major identifiable cause of hearing loss.

Hearing Protection Devices

Hearing protection devices (HPDs) should only be provided when engineering and administrative controls to reduce noise at the source or along the path cannot be implemented or while such controls are being put in place.

HPDs are barriers that reduce the amount of noise reaching the sensitive inner ear. Fit, comfort, and sound reduction or "attenuation" are important considerations in choosing HPDs.

The types of HPDs used most commonly are earplugs or earmuffs. Earplugs attenuate noise by plugging the ear canal. Earmuffs cover the external part of the ear, providing an "acoustical seal" (Figure 14-3). Table 14-1 describes some of the characteristics of these different types of hearing protectors.

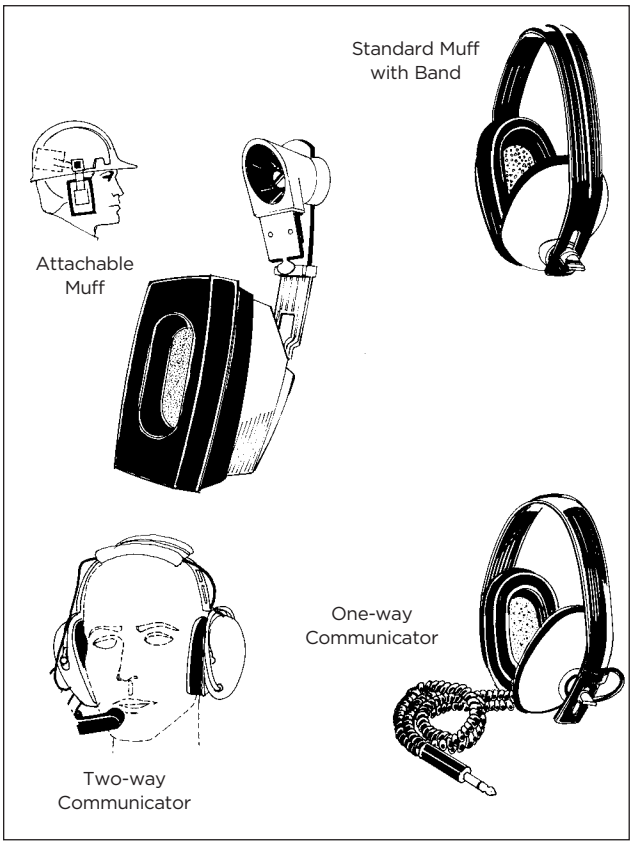
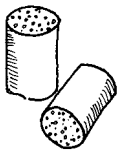
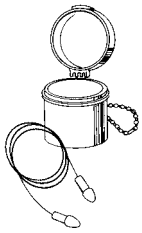


Figure 14-3: Types of Earmuffs

Table 14-1: Types of Hearing Protection Devices

	FOAM EARPLUGS	PREMOULDED EARPLUGS	EARMUFFS	FORMABLE EARPLUGS	CUSTOM-MOULDED EARPLUGS	SEMI-INSERT EARPLUGS
						
STYLE and COMFORT	Made of compressible plastic foam. Comes in many shapes. Often described as "disposable plugs." Elasticity lets them adapt easily to changes in ear canal.	Usually made of plastic or silicone rubber attached to a flexible stem for handling and insertion. Comes in many shapes and sizes to suit different ear canals.	Consists of two insulated plastic cups attached to metal or plastic band. Cups are equipped with soft cushions for seal and comfort. Headband tension ensures good seal.	Made from pliable material such as cotton/wax mixture, silicone putty, and mineral wool.	Custom made to fit a particular ear by taking an impression of the ear, making a mould, and casting a plug.	Commonly known as banded earplugs or canal caps. They consist of small caps or pods that are held in place over the ear canal by spring-loaded bands.
INTENDED USE	Most brands can be reused a few times before being discarded.	To be used more than once.	To be used regularly. Can be worn with or without plugs. Easily attached to hard hats.	• Single-use for mineral wool products. • Multi-use for cotton/wax products. • Semi-permanent for silicone putty products.	Permanent use	To be used more than once.
HYGIENE PRACTICES	Clean hands required each time fresh plugs are inserted.	Plugs should be cleaned regularly with warm soapy water, preferably after each removal from ear.	General maintenance required. Headband must be maintained. Cushions must be replaced when soiled or brittle.	Clean hands required for shaping and insertion.	Wash with hot water and soap, preferably after removal.	Wash with hot water and soap, preferably after removal.
ADVANTAGES	Low risk of irritation. One size fits most workers.	Reusable.	Less likely to cause irritation. Always available for use when attached to hard hat.	Relatively cheap	Good fit only if a proper impression of the ear is taken.	Good for when frequent removal is required.
DISADVANTAGES	Use requires clean hands. Large supply required for frequent removals and usage.	Plugs must be kept clean to prevent irritation. May produce some discomfort with pressure. Reusable, but may degrade over time. Inspect and replace as necessary.	Bands may wear out and tension decrease. Eyewear and hair may interfere with fit and reduce protection.	Not recommended for the noise levels found on construction projects.	If the wearer's weight changes drastically, new plugs should be made. Plugs can be lost, shrink, harden, or crack over time, and must be replaced.	Proper seal is necessary for good attenuation.

Effectiveness

The effectiveness of HPDs depend on the amount of time they are worn. What is not obvious to most wearers is that the effectiveness of HPDs can be reduced by as much as 95% or more if the protectors are not worn for as little as three or four minutes in noisy environments. It is therefore important to wear HPDs during the entire period of exposure in order to achieve the maximum protection available.

The effectiveness of HPDs also depends on the manner in which noise is transmitted through or around the protector. The following points should be noted.

- Even relatively small openings or air leaks in the seal between the hearing protector and the skin can typically reduce attenuation by 5 to 15 dB or more.
- Constant movement of the head or body vibration can lead to air leaks, so make regular adjustments when necessary to ensure a proper seal.
- Proper fitting is crucial to obtaining a reasonable degree of protection from an HPD.
- Hair, especially long hair and facial hair, can cause a poor fit.
- The effectiveness of earmuffs is greatly reduced if the tension of the headband decreases, whether due to normal use or alteration by the user.
- Modifying the earmuff by drilling holes in the earcups renders the protection useless.
- Anatomical differences such as ear canal size, jaw size, and head shape and size may affect the fit of earmuffs and earplugs. To accommodate these differences, HPDs should be made available to users in various shapes and sizes.
- Recreational headphones used to listen to music are **not** to be used as hearing protection.

Selection Criteria

In addition to attenuation characteristics, the following factors should be considered when selecting hearing protectors:

1. Noise exposure levels
2. Comfort
3. Appearance
4. Work environment or work procedures
5. Overprotection.

Noise Exposure Levels

Before choosing a hearing protector, it's important to find out the level of noise exposure that a worker will face throughout an entire working day.

As an example, a quick-cut saw may produce a noise level of 110 dBA. But the mason who operates it may only be exposed to an average of 92 dBA over the full eight-hour shift. The reason is that the saw is not operated continuously during that period. There will be times when the worker is laying brick, taking a coffee break, etc.

Ontario's Ministry of Labour (MOL) has developed *A Guide to the Noise Regulation,* which is available on their website:
labour.gov.on.ca/english/hs/pubs/noise/

The information below is taken from Appendix C: Selection of Hearing Protection Devices and De-Rating Schemes.

According to CAN/CSA-Z1007: *Hearing Loss Prevention Program (HLPP) Management,* HPDs can be selected based on one of four methods:

1. Single Number Reporting Methods:
   a. Noise Reduction Rating or NRR Method
   b. Single Number Rating (subject fit 84th percentile) or SNR (SF84) Method
2. CSA Class Method
3. Octave-Band (OB) Computation Method
4. Field Attenuation Estimation System (FAES).

In Ontario, the NRR Method and CSA Class Method are the most common indicators used to estimate the level of protection afforded by a hearing protector. More details on these two methods are below. For full details on other methods for selecting HPDs, consult CSA-Z94.2-14: *Hearing Protection Devices – Performance, Selection, Care, and Use.*

Noise Reduction Rating (NRR) Method – a single number that describes the sound level reduction in decibels provided by the HPD. The NRR on the package often overestimates the reduction in noise provided by that HPD because the data is normally obtained in laboratory settings, which is not representative of real-world conditions.

Additionally the NRR is reported in C-weighted sound measurements, whereas measurements taken in the workplace typically use A-weighting. To account for these factors the NRR must be de-rated. CSA Z94.2-14 recommends the de-rating scheme in Table 14-2.

Table 14-2: Noise Reduction Rating (NRR) and De-Rating

Device Type	% of NRR Achieved	Predicted dBA Effective at the Ear
Earplugs	50%	L_{eq} – [NRR (0.5) – 3]
Earmuffs	70%	L_{eq} – [NRR (0.7) – 3]
Dual Protection	65%	L_{eq} – [NRR+5 (0.65) – 3]

NOTE: L_{eq} is the equivalent sound pressure level in dBA

Example: A restoration worker's exposure (L_{eq}) is 94 dBA. Earplugs used by the worker are assigned an NRR of 28. The predicted noise exposure (A-Weighted effective L_{eq}) is calculated as follows:

L_{eq} – [NRR (0.5) – 3] = XX dBA

94 dBA – [28 (0.5) – 3] = 94 – 11 = 83 dBA

CSA Class Method – HPDs may also be selected based on their CSA class. This method uses the letters A, B, or C to describe the range of reduction in sound level provided by an HPD.

Source: *A Guide to the Noise Regulation (O. Reg. 381/15) under the Occupational Health and Safety Act, Ontario Ministry of Labour, 2016.*

Table 14-3 provides guidelines for proper selection of HPDs based on class and noise exposure, presuming a desired effective exposure of L_{EX}, 8h = 85 dBA when HPDs are worn.

Table 14-3: Guidelines for Selecting HPDs

Level of Noise Exposure L_{EX} (dBA)	Class
≤ 90	C
91 to 95	B or BL*
96 to 105	A or AL*
> 105	Dual†

Source: *CSA Z94.2-14: Hearing Protection Devices - Performance, Selection, Care, and Use*

* AL or BL class HPDs meet the requirements for either Class A or Class B and have a minimum attenuation of 20 dB at 125 Hz.

† Dual hearing protection is required (Class B ear muff and Class A ear plug). Limit exposure duration. Octave-band analyses required for attenuation predictions and more frequent audiometric testing required.

Table 14-4 lists typical noise levels for various kinds of construction equipment. The upper limits of the noise levels can be used as a guide in selecting appropriate hearing protectors.

14-4: Typical Noise Levels of Tools and Equipment

Equipment	Noise Level (dBA)
Cranes	78 – 103
Backhoes	85 – 104
Loaders	77 – 106
Dozers	86 – 106
Scrapers	97 – 112
Trenchers	95 – 99
Pile drivers	119 – 125
Compactors	90 – 112
Grinders	106 – 110
Chainsaws	100 – 115
Concrete saw	97 – 103
Sand blasting nozzle	111 – 117
Jackhammers	100 – 115
Compressors	85 – 104

NOTE: These noise levels are measured at the operator's position.

Comfort

Comfort is an important consideration in selection. An HPD that isn't comfortable will simply not be worn or will be worn improperly.

With earplugs, several factors affect comfort. Since some plugs are relatively non-porous, they can often create a pressure buildup within the ear and cause discomfort. Dirty plugs may irritate the ear canal. Because of the shape of an individual's ear canals, certain plugs may not fit properly.

Earmuffs should be made of materials that do not absorb sweat and that are easy to maintain and clean. The earmuff cup should be adjustable to conform to various head sizes and shapes. Headband tension and earcup pressure should be adjusted so that they are effective without being uncomfortable. Weight may also be a factor.

Workers should be allowed to try out various HPDs to determine which are most comfortable.

Appearance

HPD appearance may influence selection. Those that look bulky or uncomfortable may discourage potential users. Allowing workers to select from various HPDs, or various makes of the same HPD, can help overcome this problem.

Work Environment/Procedures

HPD selection is sometimes dictated by the constraints of the work area or work procedures. For example, large volume earmuffs may not be practical in confined work situations with little head room or clearance. In that case, flat-cup muffs or earplugs may be more practical.

Where work is necessary near electrical hazards, it may be desirable to use non-conductive suspension-type muffs. The choice of protector may also be affected by the nature of work, as in welding where certain types of earmuffs may interfere with the welder's helmet.

The attenuation of the muff-type hearing protector may be considerably reduced when worn with spectacle-type safety glasses. (The head configuration of the wearer and the type of glasses worn will determine the reduction in attenuation.) Where safety glasses must be worn, cable-type temples should be used in order to allow the smallest possible opening between the seal of the protector and the head. Otherwise earplugs should be worn, provided they are adequate.

Consideration should be given to hearing protectors that can be attached to hard hats where exposures to noise may be high but intermittent and where hard hats must be worn at all times. Periodic adjustments may be necessary because movement of the hard hat may break the seal of the HPD.

Consideration should also be given to work involving oils, grease, and other products that may soil hands. Ear infections may occur when earplugs are inserted by dirty hands.

Overprotection

Workers wearing HPDs that provide too much attenuation may feel isolated from their surroundings. Sounds may be heard as muffled. Speech or warning sounds may be unrecognizable.

Overprotection can lead workers to resist wearing HPDs. Protectors should be chosen to provide sufficient, but not excessive, attenuation. The objective should be to reduce noise levels to or below the recommended maximum eight-hour exposure of 85 dBA, but not below 70 dBA.

Where communication is critical and hearing protection is required, communication headsets can be considered. These devices provide protection against harmful levels of noise, yet allow for important communication to be heard.

Fit, Care, and Use

According to the new Noise regulation (O. Reg. 381, s. 3), an employer who provides a worker with an HPD must provide adequate training and instruction to the worker in the care and use of the device, including its limitations, proper fitting, inspection and maintenance and, if applicable, cleaning and disinfection.

Training

Training should include a hands-on demonstration. Workers should then practice using the HPDs under close supervision. Checks are needed to ensure the best possible protection. Many of these checks relate to fit.

Workers should understand the following.

- There is risk of hearing loss if HPDs are not worn in noisy environments.
- To be effective, an HPD must not be removed even for short periods.
- Various HPDs are available to accommodate differences in ear canal size and shape, comfort level, compatibility with other forms of PPE, etc.
- Proper fit is essential to achieve maximum protection.

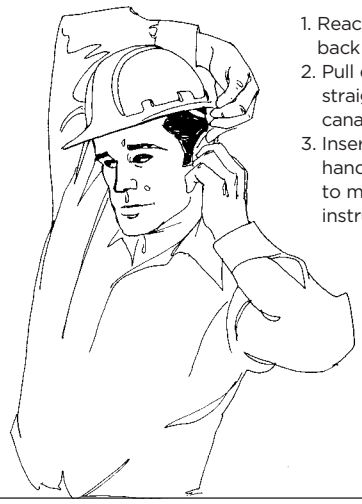
Earmuffs

1) Earmuffs should conform to the latest issue of CSA Standard Z94.2.
2) The cup part of the earmuff should fit snugly over the entire ear and be held firmly in place by a tension band.
3) The cup and band should not be so tight as to cause discomfort.
4) Cup, cushion, and band should be checked for possible defects such as cracks, holes, or leaking seals before each use of the HPD.
5) Because band tension can be reduced over a period of time, the band may require repair or replacement.
6) Defective or damaged parts should be repaired or replaced as needed. Tension band, cushions, and cups are readily replaceable. Consult the manufacturer's instructions for information related to the selection, care, and use of earmuffs.

Earplugs

1) Earplugs should conform to the latest issue of CSA Standard Z94.2.
2) As best practice, use the method of insertion illustrated in Figure 14-4. Because the ear canal is slightly S-shaped, the ear must be pulled back to straighten the canal for the plug to fit properly.
3) Earplugs must be fitted snugly in the ear canal. This will cause some discomfort initially. However, in time (usually a period of two weeks) the discomfort vanishes. Should there be severe discomfort initially or mild discomfort for more than a few weeks, seek professional advice. In most instances it will only be a matter of re-sizing, although some ear canals cannot be fitted with plugs because of obstructions, unique shapes, or deformities. In fact, the shape of one ear canal may be entirely different from the other.
4) Reusable earplugs should be washed daily with warm soapy water to prevent the remote possibility of infection or other discomfort. When not in use, they should be kept in a clean container.
5) Earplugs with torn or otherwise damaged flanges should be replaced.

Figure 14-4: Inserting Ear Plugs



1. Reach one hand around back of head.
2. Pull ear upwards to straighten S-shaped ear canal.
3. Insert plug with other hand according to manufacturer's instructions.

WARNING: Cotton batten does not provide adequate protection from construction noise.

Audiometric Testing

Workers who are exposed to noise levels that exceed 85 dBA, L_{EX}, 8hr should participate in audiometric testing. This testing is used to monitor an individual's hearing ability and determine the effectiveness of controls implemented in the workplace to minimize noise exposure for workers.

Two types of audiometric tests should be performed:

1. **Reference test –** a baseline test to which future audiometric tests are compared to.
2. **Monitoring test –** a periodic audiometric test compared to the reference test. This test is used to identify if hearing loss has occurred.

The results of audiometric tests can be used to do the following:

- Monitor patterns or trends in hearing loss if more than one worker has been impacted.
- Review work tasks to identify causal factors of hearing loss.
- Investigate engineering or administrative controls to reduce noise exposure.
- Verify proper use of hearing protective devices, ensure the correct type is used, that workers are able to fit them correctly, and that they are used consistently.
- Counsel and educate workers about noise in the workplace and as motivation to protect hearing.

Audiometric testing also provides an opportunity to examine HPDs used by workers. It is a good idea for workers to bring their hearing protectors to the test.

Summary

Control of noise in workplaces is of growing importance as a result of increasing hearing loss claims.

Most noise problems can be analyzed in terms of controlling the hazard at the source, along the path, and at the worker. This is a convenient way of understanding the overall problem and a useful approach for putting control measures in place. The three components can usually be treated in isolation, although sometimes all three must be considered together in order to control unacceptable noise levels.

At the source, measures are aimed at reducing or eliminating the noise being generated.

Along the path, barriers can be introduced to reduce the amount of noise reaching the worker.

At the worker, measures involve personal protective equipment being properly selected, fitted, and worn. This PPE must be used in high noise environments **all the time.**

Failure to provide preventive or control measures will result in temporary and ultimately permanent hearing losses.

IHSA can assist workplaces by providing useful information, research, and training. For more information, including e-learning videos on the Basics of Hearing Protection, visit the personal protective equipment (PPE) topic page on our website.