



# Hearing Protection

When engineering controls cannot eliminate the noise hazard, hearing protection provides a secondary means of reducing workers' noise exposure.

Hearing protection **must** be provided for workers exposed to greater than 85 dBA  $L_{ex}$ , or its equivalent – a noise dose of 1 Pascal squared-hour ( $Pa^2h$ ). The employer is responsible for knowing which workers are overexposed to noise and which must wear hearing protection.

Hearing protection **must** be provided and selected in accordance with *CSA Standard Z94.2* or another standard acceptable to the WCB. The CSA standard includes information on selection criteria such as:

- Daily noise exposure of the worker
- Worker hearing ability
- Communication demands on workers
- Use of other personal protective equipment
- Temperature and climate
- Physical constraints of workers or work activity

## Hearing protection devices

Hearing protection devices (HPDs) reduce the level of noise reaching the ear. The two main types of protection are earplugs and earmuffs. Earplugs may be inserted into the ear canal or placed over the ear canal (the latter plugs are called canal caps). Earmuffs consist of two dome-shaped cups that cover the entire ear and are held in place by a headband.

Earplugs and earmuffs reduce noise, but this involves reducing all sounds, not just unwanted noise but also sounds that workers need to hear such as voices and warning bells.

## Earplugs

Earplugs work by blocking the ear canal. Canal caps are a variation of earplugs. Unlike earplugs, which block the ear canal by being inserted into it, canal caps seal the opening of the ear canal by being placed over it.

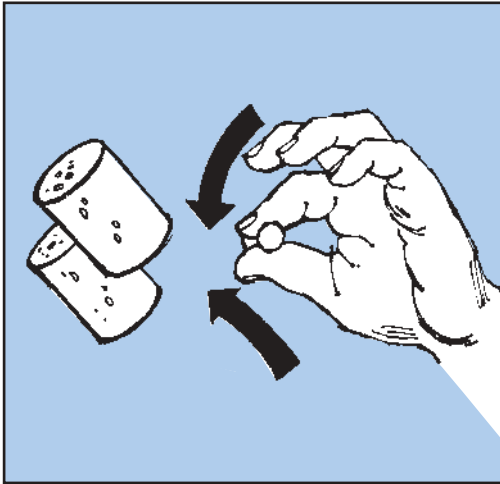
Properly inserted earplugs are not painful. The most common problem with earplugs is that they are not seated deeply enough in the ear canals. Partial insertion results in poor noise reduction, poor retention, and discomfort. When plugs are properly inserted, there will be a slight sensation of pressure, and the wearer's voice will sound louder and more resonant. There will also be some resistance when the user pulls gently on the earplug.

Workers should be individually instructed in how to insert earplugs. Instruction is best done at the time of the annual hearing test. Supervisors should also be taught to recognize the appearance of an improperly seated plug and how to counsel the worker on the correct way to insert it.

*Straighten the ear canal before inserting the plug.*



Several types of earplugs are available including:



*Roll compressible plugs between fingers before insertion.*

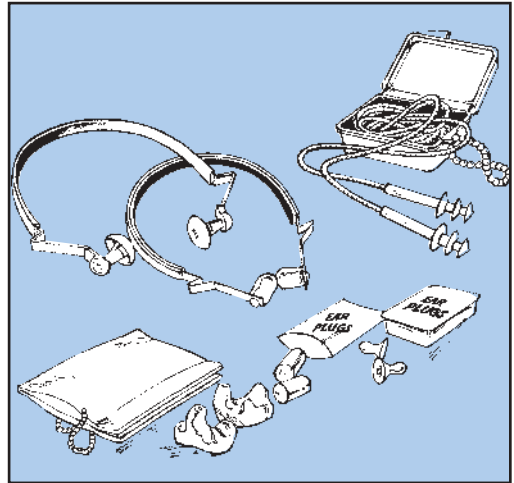
**Compressibles** These earplugs are usually made of compressible foam. The plugs are rolled between the fingers to compress them, then inserted into the ear canal where the foam expands to fill the canal. For proper insertion, the ear canal must be first straightened by pulling on the outer ear with your other hand; if this is not done, the plug will stick out too much and will not be effective. One size fits most workers; however, if ear canals are too small for a comfortable fit, the plug won't stay in place. Some compressible

plugs come in several sizes. Alternatively, reusable or custom-molded plugs could be selected.

**Reusables** These are generally made of plastic with single, double, or triple ridges that help seal the ear canal. Many brands come in different sizes. These plugs are suitable for workers whose hands may become soiled at work since the ear canal portion of the plug is not touched. (Compressible plugs rolled between the fingers can become dirty.)

For proper plug insertion, the ear canal must be straightened and the plug inserted with a slight twisting motion. When properly inserted, the plug should not fall out. Some resistance should be felt when the plug is gently tugged—the wearer should not be able to pull it out easily.

**Custom-molded** These plugs are custom made by taking an impression of a worker's ear, making a mold of it, and casting the plug. It is vital that a proper impression of the ear be taken or the finished plugs won't fit well. The plugs must fit the contours of the ear snugly to provide proper noise reduction. Since these plugs can be difficult to insert due to their unusual shape, workers must be shown how to insert them properly. New earplugs will need to be made if the external ear and ear canal change shape with age or extreme weight gain or loss.



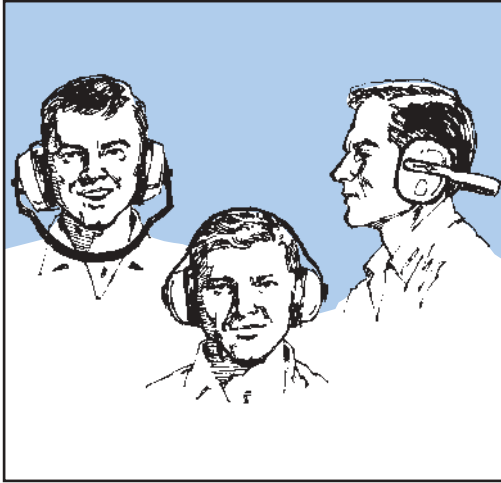
*Many types of ear plugs and canal caps are available. Connecting cords on many prevent loss.*

**Canal caps** These caps are held in place by a headband worn either over the head, behind the head, or under the chin, depending on the manufacturer. The cap, or pod, does not insert into the ear, but fits over the opening of the ear canal. The size of the ear canal is not as important in fitting these devices. Canal caps are widely used by workers with intermittent or interrupted exposure to noise.

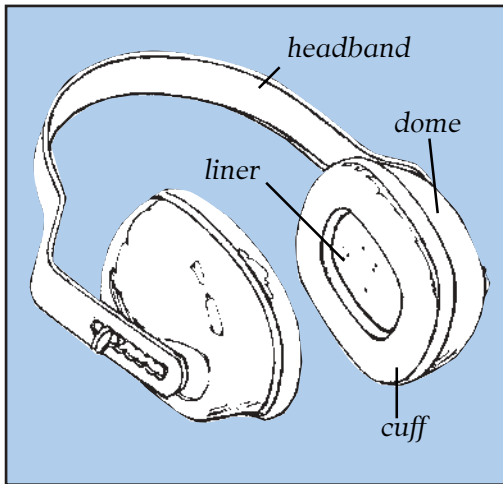
## Earmuffs

Earmuffs consist of four parts:

**Domes (ear cups)** Domes deflect noise. The deeper and heavier the dome, the greater the noise reduction. Domes are usually made of plastic.



*Earmuff headbands may be worn over the head, behind the head, or under the chin.*



*These are the key parts of a typical earmuff.*

**Dome liners** Liners are made of foam and/or ear “down”. Liners reduce noise reverberation inside the dome.

**Cuffs (ear cushions)** Cuffs may be filled with foam, liquid, or a combination of foam and liquid. The liquid-filled cuffs may make wearing safety glasses more comfortable. Foam cuffs are lighter weight.

**Headband assembly** This may be made of plastic, metal, or a combination of both.

Depending on their design, earmuff headbands may be worn over the head, behind the head, under the chin, or the muffs may be mounted on a hard hat. Hard hat-mounted earmuffs have less pressure exerted against the side of the head, and are more comfortable than muffs with headbands. The attachment for a hard hat may be fitted into slots on the hard hat, or clipped onto the brim with an adaptor. The proper size adaptor must be selected, and may vary according to the brand of hard hat.

The effectiveness of an earmuff is determined by the headband tension and fit of the domes over the ears. If headband tension decreases either by routine usage or by deliberate modification by the wearer, noise reduction decreases.

The domes must fit over the entire external ear to provide a proper seal. Modification to domes, such as drilling holes, is not permitted. Wearing safety glasses, caps, or facial hair may interfere with the seal of the dome. Hair should be pushed behind the ears or pinned up out of the way. Thin frames for glasses are preferred to thick ones. Temple pads are available to improve the seal and decrease discomfort caused by the pressure of the dome against glasses. Wearing thick cloth caps should not be permitted if the headband of the earmuffs must fit over the cap. Using earmuffs with a swiveling band will help with this problem.

Jaw size and head shape may also pose a fitting problem – some muffs may not fit properly against the side of the head. Workers should try earplugs in such cases.

Some earmuffs are made to be worn a certain way to obtain a proper fit. The top and bottom may be designated, either by the shape of the muffs, or by the manufacturer's instructions.

As with earplugs, fitting muffs individually at the time of the annual hearing test will help ensure the worker is properly instructed in earmuff use. Workers should bring their hearing protection to their annual hearing re-test so that the fit can be assessed yearly.

The wearing of earmuffs is easy to monitor by supervisors, but supervisors should watch out for improperly worn muffs, particularly hard hat-mounted ones in the “snap-out” position. This position reduces the pressure of the cuff on the ear, and is meant to be used for very short periods of time only.

## Specialty products

Using ordinary, or conventional, hearing protection can result in distorted speech, machinery, and warning signals with undesirable consequences such as more difficulty in understanding speech and safety issues around machinery. This is a problem especially for people with hearing loss or for any people with high listening demands in their job, such as supervisors, tradespeople, instructors, and hospitality workers. When faced with these problems, many wearers simply take the protection off, thereby risking hearing damage. To combat this, a new family of hearing protection has been developed. These new products are designed to enhance listening while providing effective noise or sound reduction, also called attenuation. There are two main categories of these specialty products: active and passive.

**Active** These protectors use electronic means to reduce noise at the ear or to enhance the user’s awareness of surrounding activity:

- Noise-attenuation communication headsets — these are earphones encased in earmuffs or earplugs that allow the wearer to adjust the signal coming through the earphones with a volume control. However, only products that will not amplify the signal to a hazardous level (over 85 dBA) should be chosen.

- Active noise reduction (ANR) devices — this system consists of a microphone that picks up sound outside the earmuff, an electronic circuit that processes this signal, and a small speaker that generates a signal that is out-of-phase to the incoming signal. When the incoming signal combines with its out-of-phase (or “mirror-image”) version, then the incoming signal is cancelled out, or eliminated. This only works for incoming sounds below 500 Hz, otherwise known as low frequency sounds.
- Sound restoration devices — a microphone receives the incoming sound and amplifies it, usually up to a maximum of 85 dBA. If the incoming sound is already at or above 85 dBA, then the amplifier automatically shuts down and the protector reduces sound like a conventional earmuff. So, sounds below 85 dBA are amplified; sounds at or above 85 dBA are blocked out.

**Passive** These protectors use mechanical means to alter the sound characteristics:

- Flat, or uniform — earplugs or earmuffs have a sound channel and use a special type of filter to provide nearly equal attenuation at all frequencies. This results in a signal that sounds more natural, or normal. In contrast, conventional protectors reduce high frequency sounds more than low frequency.
- Frequency-sensitive — these protectors have small openings in them that allow sounds of certain frequencies to pass through, while blocking other frequencies.
- Amplitude-sensitive, or level-dependent — these protectors provide a small amount of attenuation in low noise levels, but will provide more attenuation as the noise levels increase. They are primarily used to protect against impact or impulse noise, such as gunfire.

## Selection of hearing protection

Selecting appropriate hearing protection is not difficult. Factors that **must** be considered are as follows:

**Daily noise exposure of the worker** One criterion for selecting hearing protection is the noise exposure of the worker. *CSA Standard Z94.2* has a selection guide. The 1994 standard (Z94.2-94) makes recommendations for the *class* of hearing protector and uses  $L_{eq}$  and  $L_{ex}$  (as explained on page 2). The CSA standard developed in 2001 makes recommendations for the *grade* of hearing protector in addition to the class. In the 2001 standard, noise exposure is referred to as  $L_{ex,8}$  which is the worker's daily eight-hour equivalent noise level. Either standard is acceptable to the WCB, but you will find that hearing protectors may now be labelled with grades, classes, or both.

Care should be taken to select a protector that will reduce a wearer's exposure to below 85 dBA but not below 70 dBA. If the exposure is reduced to below 70 dBA, then the wearer's HPD has too much attenuation. This is called "overprotection" and leads to the wearer feeling isolated. Additionally, sounds such as speech, machinery noises, or warning signals may be significantly altered, affecting productivity or safety.

The recommendation for the class, or grade, of protection is based on a worker's eight-hour noise exposure, not a spot measurement of noise in a given area or near a particular machine. For example, a faller's chainsaw may produce noise levels up to 110 dBA, but a

typical faller’s eight-hour noise exposure is 102 dBA because the worker does not have the saw running for eight hours continuously. There will be breaks for lunch, coffee, moving through the bush, and so forth.

The class, or grade, of hearing protection is based on the sound reduction provided by the protector at certain pitches or frequencies. Earplugs and earmuffs alike may be Class A, B, or C, or Grade 0, 1, 2, 3, or 4. Grade 0 protection is not recommended for occupational use.

**Selection of Hearing Protection Devices Based upon Grade and Noise Exposure in dBA, Presuming a Desired Effective Exposure when the Hearing Protection Devices Are Worn of  $L_{ex,8} = 85$  dBA**

$L_{ex,8}$ (dBA)	Recommended	
	Grade	Class
≤ 90	1	C
≤ 95	2	B
≤ 100	3	A
≤ 105	4	A
≤ 110	Dual*	
> 110	Dual**	

\* Dual hearing protection required. Use a minimum of a Grade 2 or Class B earmuff and a Grade 3 or Class A earplug.

\*\* Dual hearing protection required. Also, it is recommended that exposure durations be limited, octave-band analyses be conducted for attenuation predictions, and twice-annual audiometry be provided to the affected individuals.

The assignment to a class is based on minimum attenuation, or sound reduction, at various frequencies.

## Sound Attenuation Requirements for Hearing Protectors (from CSA Standard Z94.2)

The minimum attenuation (sound reduction) in decibels at different frequencies is given for each class of hearing protection below. Hearing protectors must comply with, or exceed, these standards to meet the class.

Frequency (in Hertz)	Minimum Attenuation, dB		
	Class A	Class B	Class C
125	10	5	None
250	18	12	None
500	26	16	None
1000	31	21	11
2000	33	23	13
3150	33	23	13
4000	31	21	11
6300	33	23	13
8000	33	23	13

Tested Using the Procedures Specified in *ANSI Standard S3.19 - 1974*.

The assignment of grade is based on a system that uses a single number to express the attenuation of the protector. This system is called the SNR, or subject-fit noise reduction. To obtain the SNR, subjects who have never worn the protector are asked to put it on themselves and then the attenuation is tested. This gives a more accurate indication of real-world attenuation.

## Assignment of Grade Based upon the SNR

<i>Grade</i>	<i>SNR</i>
0	$\leq 9$
1	10–13
2	14–17
3	18–21
4	$\geq 22$

## Noise Reduction Rating (NRR)

Another system of classifying hearing protection is the NRR or noise reduction rating. This system uses a single number to express the attenuation of the protector but in this case the protector is placed on the subjects by someone else, which does not as accurately reflect the way protectors are worn. See the following table for roughly equivalent values of NRR and CSA classes.

### Comparison of Classification Systems

<i>CSA Class</i>	<i>CSA Grade</i>	<i>NRR</i> <i>(approximate)</i>
A	3, 4	24+
B	2	17–24
C	1	less than 17

The effectiveness of a hearing protector is *not* determined by its sound-reducing ability alone; it is determined by attenuation and the wearing time of the worker. If a protector is uncomfortable, or if a worker cannot communicate with co-workers, the protector is more likely to be removed by the wearer. Class A, Grade 4, protectors are not “the best”, they simply have the most attenuation. Class A, or Grades 3 or 4, protection is *not recommended* for workers whose noise exposure is less than 95 dBA. Hearing-impaired workers in particular resist wearing Class A, or Grades 3 or 4, protection because it makes them unable to hear warning signals or speech. For such workers, Class B, or Grade 2, protection is often more acceptable and, therefore, more likely to be consistently worn.

The goal of wearing the protector is to achieve “acceptable” or “optimal or ideal” protection.

<b>Protection Outcomes at Various Resulting Sound Levels</b>	
<i>Sound level resulting from the use of the protector (dBA)</i>	<i>Protection outcome</i>
85+	Insufficient
80–85	Acceptable
75–80	Optimal or Ideal
70–75	Acceptable
Less than 70	Overprotection

**Worker hearing ability** Workers with normal or near-normal hearing can wear any class of protector. Hearing-impaired workers may find hearing protection that greatly reduces noise levels unacceptable. Reduced ability to hear warning sounds, equipment sounds, or verbal instructions may make it difficult for these workers to perform their jobs efficiently or safely.

**Communication demands on workers** Where verbal communication is frequently required, hearing protection that greatly reduces noise levels is undesirable, because it will make speech hard to understand.

**Use of other personal protective equipment** Many workers who must wear hearing protection also wear other personal protective devices. The resulting combination of protective equipment must be comfortable for the worker. For example, workers wearing respirators, hard hats, and safety glasses may prefer earplugs to earmuffs.

**Temperature and climate** Earmuffs are often worn in low temperatures. Earplugs may be preferred in high temperatures or high humidity.

**Physical constraints of workers or work activity** Some workers may have ear canals that are too small for earplugs or ears that are too large for earmuffs. Workers with chronic external ear infections should wear earmuffs, those with skin problems such as dermatitis or eczema surrounding the ear should wear earplugs.

For workers who must do a lot of bending over and straightening, or manoeuvring in small places, earplugs may be better than earmuffs.

If employers are concerned about monitoring the use of hearing protection by workers, earmuffs are more easily visible.

The choice of an all-plastic earmuff or earplug may be necessary where possible contact with an electrical hazard is present.

Many workers have strong preferences for the type of hearing protection they use. If forced to wear a type they don't like or feel comfortable with, workers probably won't wear it. Workers should be allowed to help choose the hearing protection that fits them well and is comfortable. Fit and comfort of hearing protectors is key for worker acceptance.

**Employers should offer a variety of hearing protectors to workers, because there is no universal hearing protector appropriate or acceptable to all workers.**

The WCB publishes a booklet called *Hearing Protection in British Columbia*. This booklet lists the major brands and types of hearing protection sold in B.C. It also includes a brief description of each hearing protector and the CSA class. Addresses and telephone numbers of major suppliers are provided, and excerpts from the CSA standard are included as a reference.

## Using and maintaining hearing protection

Once hearing protection has been selected, it should be individually fitted to each worker. This ensures that the proper size and shape are chosen and that the worker understands how to use it correctly. If the protector is worn incorrectly, it will be ineffective, uncomfortable, and likely removed. The protector's effectiveness depends on a good seal between the surface of the skin and the surface of the protector. Leaks can destroy the effectiveness.

Hearing protection is not usually designed to be repaired. Damaged earplugs **must** be replaced. New parts are available for earmuffs if domes, cuffs or liners are damaged. Employers **must** supply enough hearing protection or replacement parts to ensure only well-maintained hearing protection is worn.

Proper cleaning of hearing protection will maximize its life span. Advice on caring for hearing protection is provided as follows:

**Earplugs** Compressible earplugs can be washed and re-used when dry, although usually they are discarded at the end of the day. Reusable, custom-molded plugs and canal caps should be washed at least once a week to remove wax build-up, which may reduce attenuation. Washing should be done at the end of the workday to allow complete drying. Use hand soap and warm water for washing. Do not use harsh solvents or alcohol – they will damage the plug. Most ear plugs come with a carrying case for

storage between use. Reusable plugs should last six months to one year and custom-molded plugs should last two to five years.

**Earmuffs** The hard plastic domes generally need no more than wiping with a damp cloth. The domes should last approximately two years.

Skin oil, perspiration, and some hair preparations have adverse effects on the cuffs. After continual use, the soft and compliant cuffs become hard and can even shrink. Ozone emissions from generators and some welding operations can cause the foam material in the domes to disintegrate and can also harden the seals. Most earmuffs have replaceable cuffs available. Cuff replacement is recommended every six months. Liquid-filled cuffs should be checked often to see if the liquid is still present. Cuffs that have leaked should be replaced.

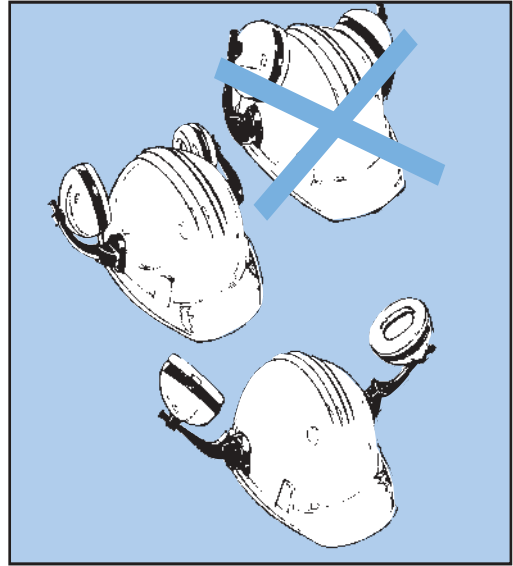
The liner material inside the dome should be kept clean. If the liner is discoloured, hardened, or extremely soiled or mildewed, it should be replaced.

Earmuffs must be sufficiently tight to form a good seal. Headbands should be adjusted or replaced as required to maintain adequate pressure.

When stored, earmuffs should be hung up by the headband on a hook in a well-ventilated area. They should not be thrown into a tool box or truck bed where the domes can crack, cuffs can rip, and headbands can bend.

Earmuffs should not be left outdoors. Bees, wasps, and spiders may make homes inside earmuff domes.

Earmuffs mounted on a hard hat should not be stored with the cuffs pressing against the hat. This constant pressure on the cuffs leads to rapid flattening of the cuffs. Instead, the earmuffs should be kept raised off the hat, or snapped out when not in use.



*Earmuffs should not be stored with the cuffs left pressing against the hard hat.*