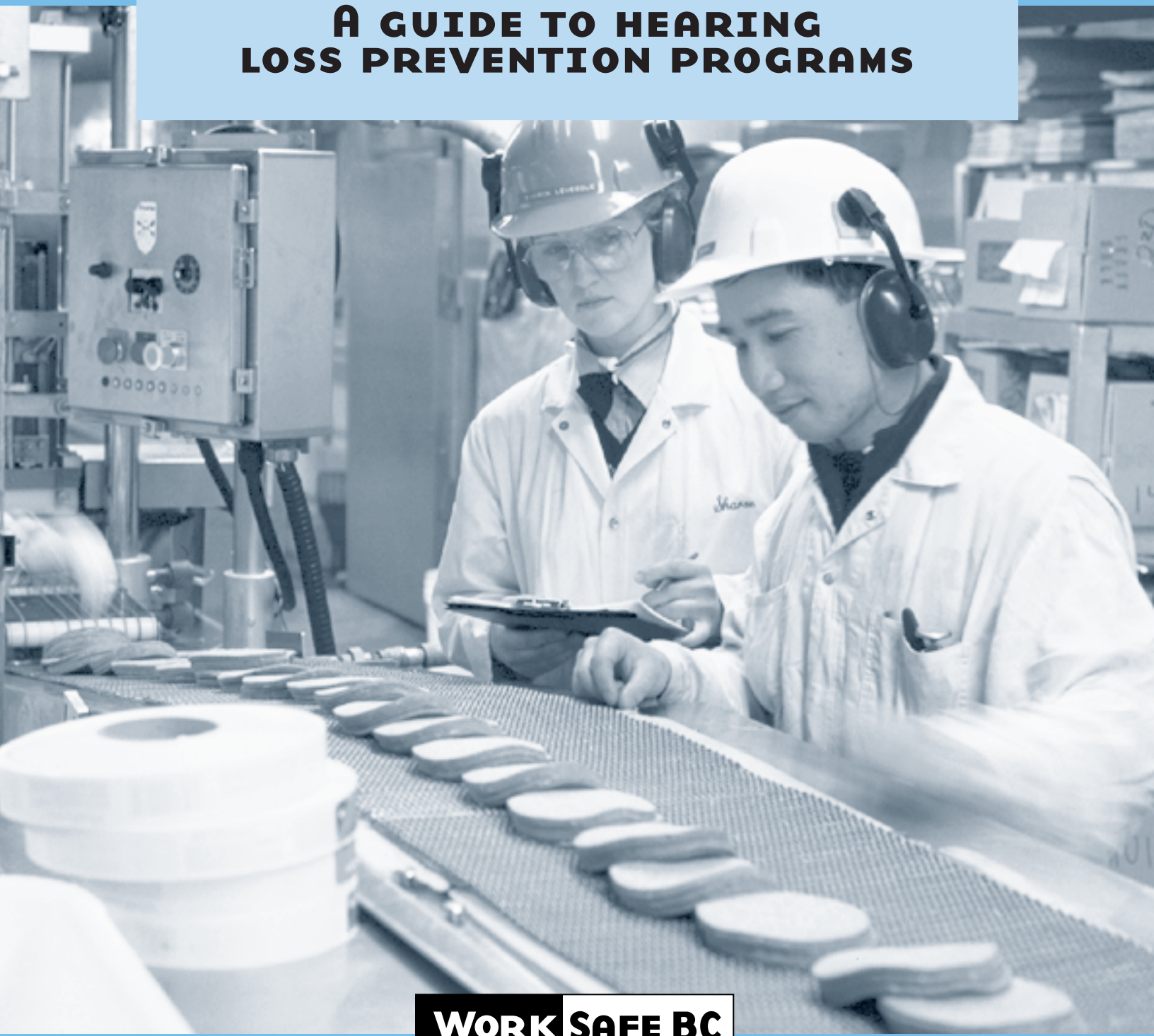
Sound Advice

A guide to hearing loss prevention programs



WorkSafeBC

WORKING TO MAKE A DIFFERENCE

worksafebc.com

Workers' Compensation Board of B.C.

About WorkSafeBC

WorkSafeBC (the Workers' Compensation Board) is an independent provincial statutory agency governed by a Board of Directors. It is funded by insurance premiums paid by registered employers and by investment returns. In administering the *Workers Compensation Act*, WorkSafeBC remains separate and distinct from government; however, it is accountable to the public through government in its role of protecting and maintaining the overall well-being of the workers' compensation system.

WorkSafeBC was born out of a compromise between B.C.'s workers and employers in 1917 where workers gave up the right to sue their employers or fellow workers for injuries on the job in return for a no-fault insurance program fully paid for by employers. WorkSafeBC is committed to a safe and healthy workplace, and to providing return-to-work rehabilitation and legislated compensation benefits to workers injured as a result of their employment.

WorkSafeBC Prevention Information Line

The WorkSafeBC Prevention Information Line can answer your questions about workplace health and safety, worker and employer responsibilities, and reporting a workplace accident or incident. The Prevention Information Line accepts anonymous calls.

Phone 604 276-3100 in the Lower Mainland, or call 1 888 621-7233 (621-SAFE) toll-free in British Columbia.

To report after-hours and weekend accidents and emergencies, call 604 273-7711 in the Lower Mainland, or call 1 866 922-4357 (WCB-HELP) toll-free in British Columbia.

Sound Advice

A guide to hearing loss prevention programs

WorkSafeBC

WORKING TO MAKE A DIFFERENCE

worksafebc.com

WorkSafeBC Publications

Many publications are available on the WorkSafeBC web site. The Occupational Health and Safety Regulation and associated policies and guidelines, as well as excerpts and summaries of the *Workers Compensation Act*, are also available on the web site: WorkSafeBC.com

Some publications are also available for purchase in print:

Phone:	604 232-9704
Toll-free phone:	1 866 319-9704
Fax:	604 232-9703
Toll-free fax:	1 888 232-9714
Online ordering:	WorkSafeBC.com and click on Publications; follow the links for ordering

2006 Edition

Library and Archives Canada Cataloguing in Publication Data
Main entry under title:
Sound advice : hearing conservation programs. -- [1996]-

Annual.
Issues for 2006- , have subtitle: A guide to hearing loss prevention programs.
Publisher varies.
ISSN 1497-2948 = Sound advice (Richmond)

1. Industrial noise - British Columbia. 2. Deafness, Noise induced - British Columbia - Prevention. 3. Ear − Protection − British Columbia. I. Workers' Compensation Board of British Columbia. II. WorkSafeBC. III. Title: Sound advice : a guide to hearing loss prevention programs.

TD893.5.C3S68 363.74'7'09711 C96-960257-X
Rev. 2006

Introduction

Noise is a serious and widespread problem in many workplaces. Over time, if noise from machinery, processes, and equipment is too loud, it can cause permanent hearing loss in workers. But if employers, supervisors, workers, and WorkSafeBC (the Workers' Compensation Board) work together to control noise exposure, occupational hearing loss can be prevented.

The most effective way to control noise exposure — and protect workers' hearing — is to implement a hearing loss prevention program. Such a program is required whenever noise is above regulated limits.

This guide explains what is required of a hearing loss prevention program that benefits both workers and employers. An effective hearing loss prevention program can prevent noise-induced hearing loss. *This guide does not replace the Occupational Health and Safety Regulation. It complements the Regulation and is a tool to help workplaces operate safely.* Note that when you see the word **must**, it means that a particular requirement is enforced under WorkSafeBC Regulation.

This guide provides general information on implementing a hearing loss prevention program. Be aware that some program requirements — such as measuring noise and noise control — need specialized technical knowledge, and have to be undertaken by qualified people.

WorkSafeBC and hearing loss prevention

The Hearing Loss Prevention Section of WorkSafeBC authorizes industrial audiometric technicians to test hearing and advise on the proper use and care of hearing protection.

For more information, contact:

Hearing Loss Prevention Section
WorkSafeBC
PO Box 5350 Stn Terminal
Vancouver BC V6B 5L5
Phone 604 273-3090
Toll-free 1 888 621-7233, local 3090

WorkSafeBC has a variety of other materials on noise and hearing loss prevention. These are available through WorkSafeBC.com. Visit the Safety at Work section and choose Hearing Loss Prevention under "Topics."

Contents

Hearing loss prevention program components

When noise exceeds regulated limits, employers **must** have an effective noise control and hearing loss prevention program.

The regulated limit set by the WorkSafeBC for noise exposure in B.C. is 85 decibels (dBA) for an eight-hour period, or an equivalent noise exposure of one Pascal-squared hour (Pa^2h). For impact noises (for example, pile driving or hammering), a 140 dBC peak sound level cannot be exceeded.

The goal of a hearing loss prevention program is to reduce the noise exposure of workers to a safe level and prevent occupational hearing loss. Hearing loss prevention programs must address:

- Noise measurement
- Education and training
- Engineered noise control
- Hearing protection
- Posting of noise hazard areas
- Hearing tests
- Annual program review

These elements are explained in more detail as follows.

Starting a hearing loss prevention program

If your workplace requires a hearing loss prevention program, here are the main steps in getting a program underway:

- Get a noise survey done, either in-house or by hiring a consultant. A publication, *Occupational Noise Surveys*, available from WorkSafeBC provides information on noise surveys.
- Inform workers that a program will be implemented and tell them what will be involved. Posters, pamphlets, videos, and DVDs are available from WorkSafeBC to provide more information to workers.
- Provide a selection of hearing protectors for workers. Information on use and maintenance is available from the distributor or from the WorkSafeBC Hearing Loss Prevention Section. Listen to workers' comments on their hearing protection.
- Organize hearing tests. (Consult the WorkSafeBC Hearing Loss Prevention Section on testing options, e.g., using an in-house or hired contractor.)
- Investigate options for engineered noise control.

Noise measurement

Employers are responsible for knowing which workers are overexposed to noise. The Occupational Health and Safety Regulation sets exposure limits for noise at 85 dBA L_{ex} and a peak noise level of 140 dBC.

What are L_{ex} and Pa^2h?

The risk of hearing loss depends on the loudness of the noise, **and** how long the workers are exposed to the noise. L_{eq} is the average noise level measured by an integrating sound level meter. **L_{ex}** is the L_{eq} that has been corrected for shift lengths other than eight hours. L_{ex} is the noise level, averaged over eight hours, which gives the same noise exposure as would the varying noise over a typical full work shift. L_{ex}, therefore, includes both loudness and length of exposure. Another way of expressing noise exposure is by "noise dose." Noise dose is measured in units called Pascal-squared hours, abbreviated as **Pa^2h**. A noise exposure of 85 dBA L_{ex} is equal to 1 Pa^2h.

When workers are or may be exposed to noise above 82 dBA L_{ex} employers **must** measure the noise exposure unless an exemption applies (see page 7). How loud is 82 dBA? If you have to raise your voice in your workplace to carry on a conversation, then the noise level is likely over 82 dBA.

Measuring workplace noise:

- Identifies significant sources of noise in the workplace and helps prioritize them for noise control measures
- Determines noise exposures of workers and identifies workers who require hearing protection, hearing testing, education, and training
- Determines workplace areas that should be posted as hazardous noise areas

Area noise measurements (measurements of general noise levels in a work area) or spot measurements (measurements taken near a piece of noisy equipment or during a specific work process) may be used as a first step to determine if there is a need for further measurement.

Area or spot measurements are **not** a substitute for personal exposure measurements (noise measurements taken to determine a particular worker's exposure) because area and spot readings do not incorporate information about the length of exposure. Area measurements may either overestimate or underestimate a worker's noise exposure, leading to inappropriate selection of hearing protection and inaccurate identification of workers who require annual hearing tests.

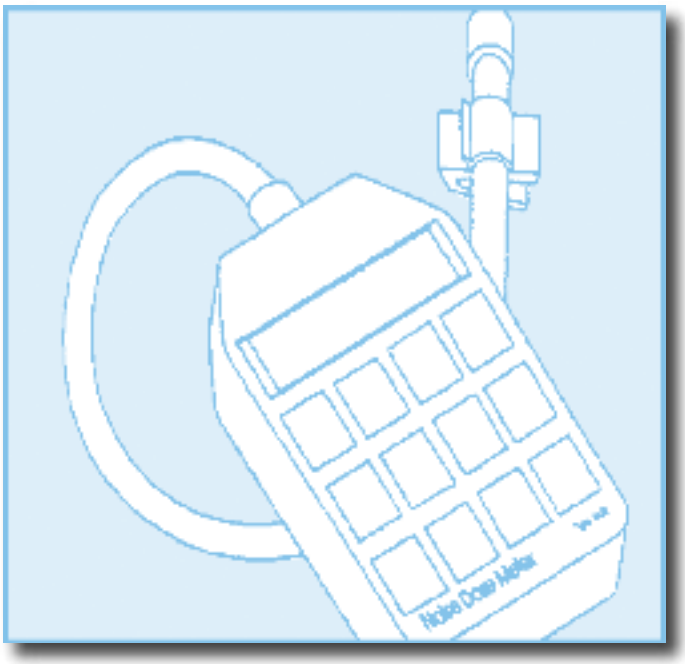
Noise-measuring equipment

Measuring noise exposure is done with noise dosimeters or integrating sound level meters. Both instruments average noise levels over time to provide L_{eq}. The integrating sound level meter is a hand-held instrument, while the noise dosimeter is a small device worn by the worker whose exposure is being measured. The dosimeter has a cable-mounted microphone that is usually placed on the worker's shoulder or collar.

What's the difference between dB and dBA?

The intensity of sound is measured in units called decibels (dB). Intensity is perceived as loudness. The notation dBA refers to decibels measured on a sound level meter using the A-weighting filter network. Sound level meters have built in filter networks. If a sound level meter is used with the A-weighting scale selected, the meter will mimic the way the human ear responds to sound. Occupational noise surveys must be done with a sound level meter using the A-weighting network.

An intergrating sound level meter averages noise levels over time.



A noise dosimeter is a small device worn by the worker.

Non-integrating sound level meters simply measure noise levels at a given moment. They can't integrate, or average, sound levels over time. These meters may be used to take spot or area noise measurements to determine if further noise exposure measurements are necessary. Non-integrating meters may be used to estimate a worker's noise exposure where the noise is steady or non-varying. In such cases, this requires measurement of all noise sources, the length of each exposure, and calculations to derive a noise dose or L_{ex}.

Detailed requirements for noise dosimeters are outlined in *American National Standards Institute (ANSI) Standard S1.25-1991, Specifications for Personal Noise Dosimeters.*

Noise-measuring procedures

Each time noise measurements are made, the equipment should be checked or calibrated. Calibrating the meter ensures that it is functioning properly and reading noise levels accurately. Calibrating the equipment for a survey is known as a field calibration. A complete calibration of the equipment should be done in a properly equipped laboratory at least every two years. A laboratory calibration will check all of the instrument's functions to ensure correct operation.

Measurements are made with the sound level meter, with the microphone located in the hearing zone of the worker, close enough to the worker's ear to obtain a reliable indication of the noise to which the worker is exposed. If measurements are done with a dosimeter, the microphone should be clipped to the worker's collar or shoulder. The microphone should be placed on the side of the worker subject to the most noise.

It may not be necessary to measure the noise for an entire shift. A worker's noise dose (or L_{ex}) can be calculated from measurements over shorter periods, provided the measurements are representative of the exposure throughout the day.

To ensure that the measurements are representative, managers, supervisors, and workers should be asked by the noise surveyor about:

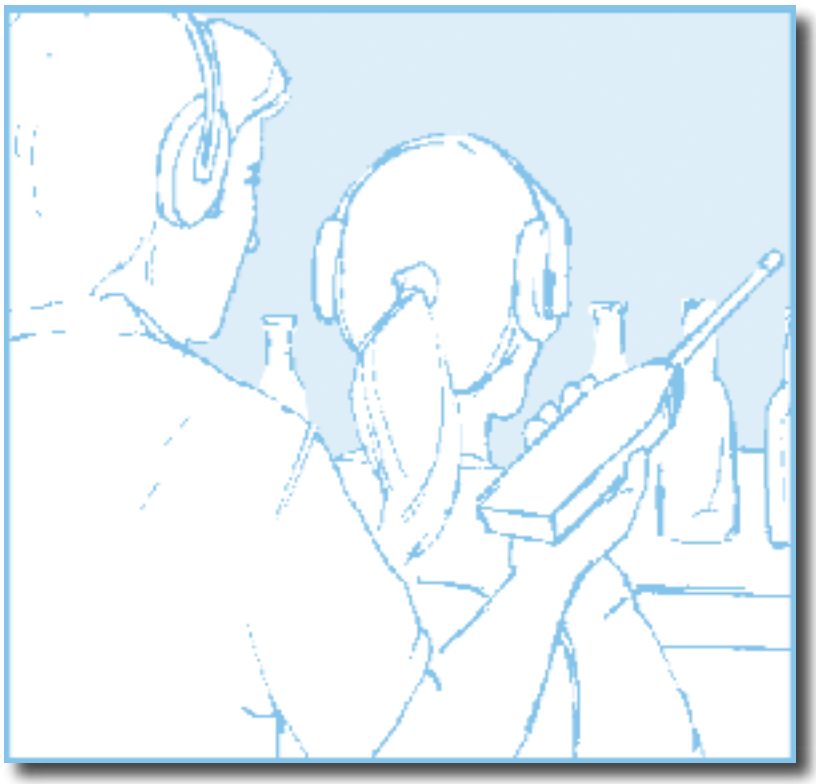
- Major noise sources, noisiest areas, and previous complaints.
- How the work pattern compares to a typical work day. Do the noise levels change? What are the number and duration of breaks? Is there downtime, delays, product changes, or job rotation?

Calibrating a sound level meter before a survey will ensure it is functioning correctly.

- If noise measurements are not taken on a typical day, what is the probable impact on the measurements, and will measurements need to be re-done.
- If noisy equipment was added, removed, or modified since the last noise measurements were taken.
- If any noise control measures were instituted.

Noise measurements must be carried out in accordance with acceptable standards. *Canadian Standards Association (CSA) Standard Z107.56-94, Procedures for the Measurement of Occupational Noise Exposure*, provides guidance on the type of equipment to use, which workers to test, and how to test. For a detailed discussion of noise measurement techniques and sampling strategies, please see the booklet, *Occupational Noise Surveys*, available from WorkSafeBC.

Noise evaluation needs to be done by knowledgeable, trained personnel such as in-house safety or hygiene staff, or by an acoustical consulting firm (see the Yellow Pages under "Acoustical Consultants"). If consultants are hired to conduct noise measurements, ensure they are familiar with the WorkSafeBC booklet, *Occupational Noise Surveys*, and can meet its requirements.



When measuring noise levels, place the microphone in the "hearing zone" of the worker on the side subject to the most noise.

Exemptions from noise measurement requirements

If workers are identified as being exposed to noise based on other information (see below), and an effective noise control and hearing loss prevention program is in place, employers do not have to measure the actual noise exposure of the worker.

Other information that demonstrates that workers are exposed to noise in excess of the limits might be:

- Labels on tools or specifications for equipment indicating there is a strong likelihood of overexposure to noise as a result of using the equipment
- A database of worker noise exposures indicating most members of a trade are overexposed on a daily basis (one such database is kept by the WorkSafeBC Hearing Loss Prevention Section)
- The peak noise level limit of 140 dBC is exceeded daily
- Short-term noise measurements suggest L_{ex} of 85 dBA is exceeded daily (e.g., 100 dBA for 15 minutes a day)

If no previous information on sound levels exist, and it is possible workers could be overexposed to noise, noise exposure measurements **must** be completed.

Noise survey records

A written report on the results of the noise survey can follow any format, but should contain the following information:

- A list of jobs that are overexposed according to the noise standards in the Occupational Health and Safety Regulation, and that require hearing protection and annual hearing tests for workers in those jobs.

- Locations that need to be posted with signs warning about high noise levels and the requirement to wear hearing protection.
- A statement noting that the measurements were taken under typical noise conditions (or otherwise) at the survey times. The dates of the measurements and the noise measuring equipment used should be recorded.
- Explanations to account for unusual or different noise measurement levels resulting from changes in the daily work routine, if necessary.
- An explanation of the calculation method used, if total daily noise exposures were calculated from partial noise exposures.

In addition to a written report, it may be useful to summarize the noise survey information in a table or write the noise levels on a general layout of the plant.

Employers **must** ensure that the current noise measurement results are readily available for reference by a WorkSafeBC officer, the company occupational health and safety committee, or a company health and safety representative.

When should noise measurements be redone?

Measurements **must** be redone whenever workers' noise exposures could have changed due to:

- Machinery being installed or removed
- Workload or equipment operating conditions changing, causing significant changes in noise levels
- A building's structure changing, (e.g., a wall removed or added)
- The length of time employees spend in noisy areas

Example of summarized survey information

Company Name	Division/Department	Address
Peacham Pill Co. Ltd.	*Manufacturing*	*221A Holmes Street, Burnaby BC, Canada, V1E 2T4*

Workers' name or job	Number of workers	L_{eq} dBA	Shift duration (hours)	L_{ex} dBA	Comments ($L_{ex} = L_{eq}$ + correction)	OK with Regs? (Y/N)	Recommendations
Bottling							
Feeder	1	83.5	10	84.5	(correction to 8h = +1dB)	Y	make ear plugs available, etc.
Filler	1	85.5	10	86.5	steady noise for long periods	N	do Noise Control (NC)
Capper	1	81	10	82	no significant impact noise	Y	make ear plugs available, etc.
Labeller	1	80	10	81	(job rotation to reduce	Y	no action required
Packer	1	78.5	10	79.5	average L_{ex} to 83.5 dBA)	Y	no action required
Tablet Pressing							
Acme Press #1	1	89	7	88.5	(correction to 8h = -0.6 dB)	N	Hearing Loss Prevention Program/NC
Acme Press #2	1	93.5	7	93	Signif Impact Peaks = 133	N	Hearing Loss Prevention Program
Acme Press #3	1	93.5	8	93.5	Signif Impact Peaks = 138	N	Hearing Loss Prevention Program
Shipping							
Forklift	1	82.2	12	84	(correction to 8 h = +1.8 dB) variable level. No significant	Y	make ear plugs available, etc. fit new muffler to F/L
Truck Driver	1	79	12	81	impact noise in Shipping	Y	no action required

Noise Surveyor: A.N. Other

Signature:

SLM/Dosimeter: Valiant

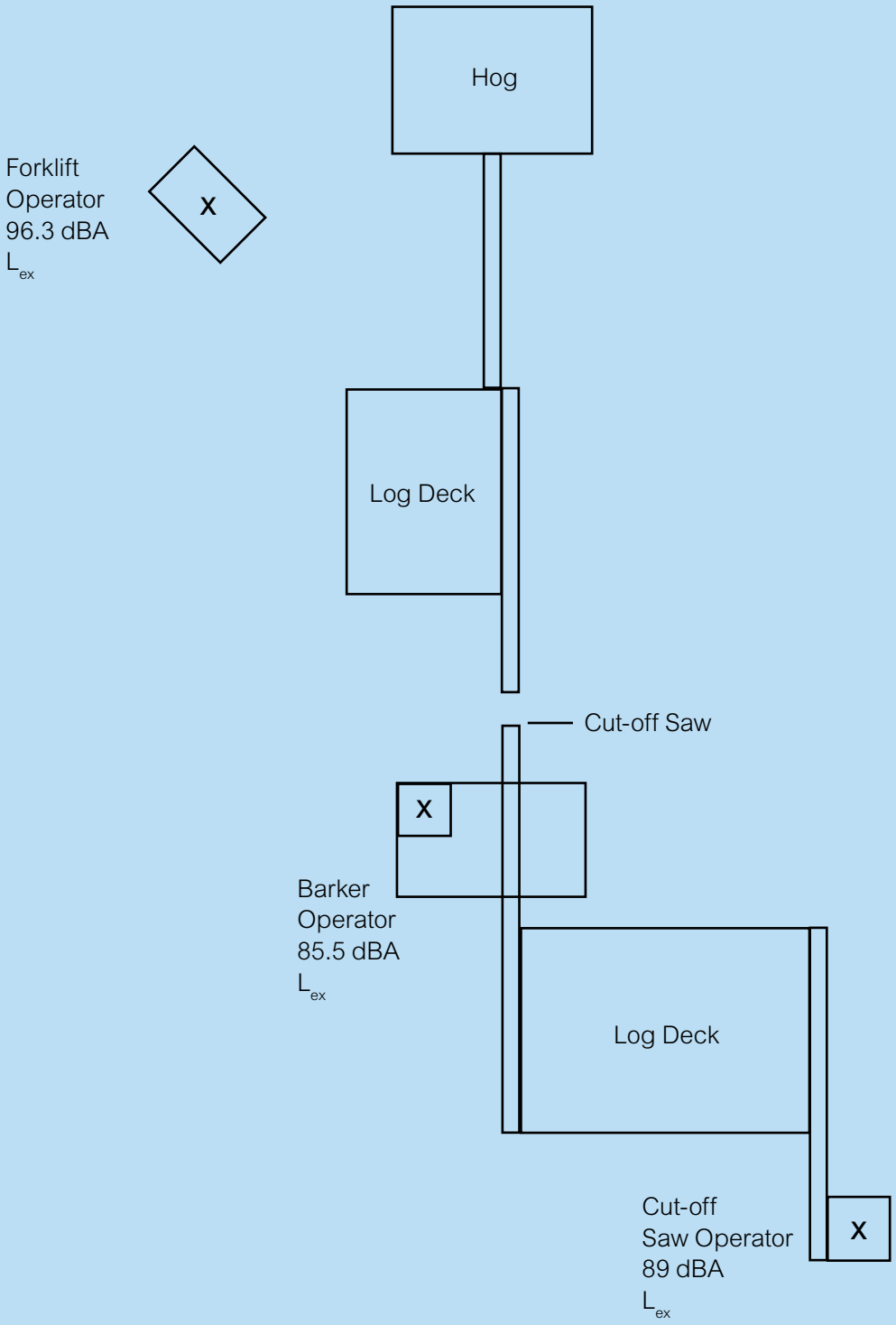
Model: N1S/N: XYZ1234

Survey Date: 2005-08-28

Calibrator: Valiant

Model: N2S/N: ABC987

Example of a general layout diagram



Partial sawmill layout with worker noise exposures (L_{ex})

Education and training

Workers need to understand the nature of the noise hazard they are exposed to, and how to protect their hearing. Employers **must** provide workers with certain information.

Where noise surveys are undertaken, employers **must** inform workers of the results of noise measurements and the possible risk of hearing loss.

When noise exposures are above the exposure limits (over 85 dBA L_{ex} or 140 dBC peak), workers **should** be informed about the:

- Results of the noise survey
- Effects of noise on hearing
- Purpose of annual hearing testing
- Proper use and maintenance of hearing protection

This education and training can be incorporated into short crew talks for workers and should be part of the health and safety training provided to new employees.

Another opportunity for worker education is during the annual hearing test. Workers must receive individual counselling from the audiometric technician regarding their hearing test results. This is a good time to also review the use and care of workers' hearing protection, and to reinforce information on the effects of noise on hearing and the purpose of hearing testing.

If your company has in-house audiometric technicians, they **must** have adequate training and attend periodic refresher courses to be authorized to conduct hearing tests. These courses include training in the selection, fitting, and use of hearing protection.

Education and training are also required for the coordinator of the hearing loss prevention program and for those who issue and fit hearing protection. Supervisors should receive sufficient education about company hearing loss prevention policies so that they can monitor the use and condition of hearing protection, and ensure workers attend their scheduled annual hearing tests.

WorkSafeBC Hearing Loss Prevention staff are available to consult with employers and safety committees about the content and design of an education and training program for workers.

Videos and other materials on the topic of hearing loss prevention are available from WorkSafeBC. Two WorkSafeBC brochures, *Testing Your Hearing – How and Why?* and *Hear for Good*, provide basic information to workers on hearing testing and hearing protection. *The Hearing Video*, produced by WorkSafeBC, provides similar information in an entertaining format. See page ii for information on obtaining copies of these and other WorkSafeBC publications.

Engineered noise control

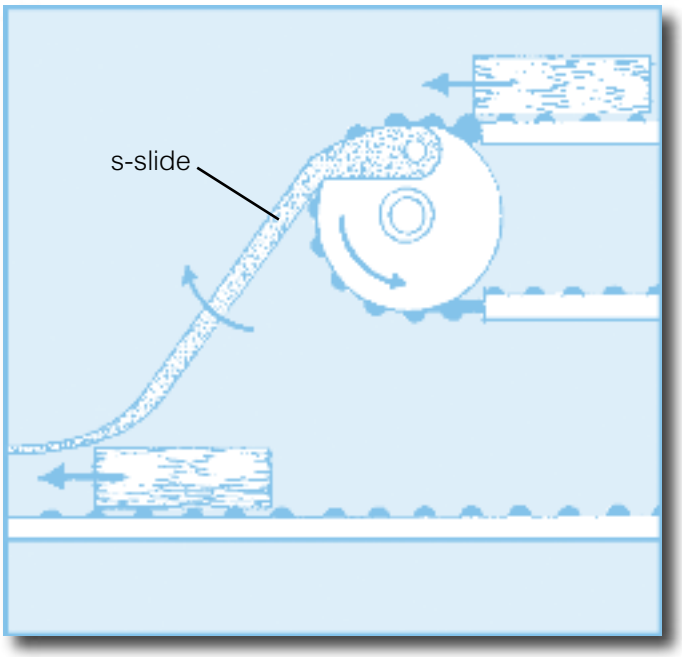
The best method of dealing with noise in the workplace is reducing the noise at the source with engineering controls. At best, engineering controls can eliminate the need to provide hearing protection, hearing testing, and other elements of a hearing loss prevention program altogether. Even if noise cannot be reduced to safe levels, reducing noise at the source makes it more likely that hearing protection will be effective in reducing noise exposures below 85 dBA. At a minimum, noise control can improve speech communication and reduce annoyance due to noise.

Employers **must** investigate options for engineered noise control when workers are exposed to noise above the exposure limits. Investigating noise control options requires a knowledgeable professional such as an acoustical engineer. Staff who understand the operational requirements in the workplace should provide input to the acoustical engineer.

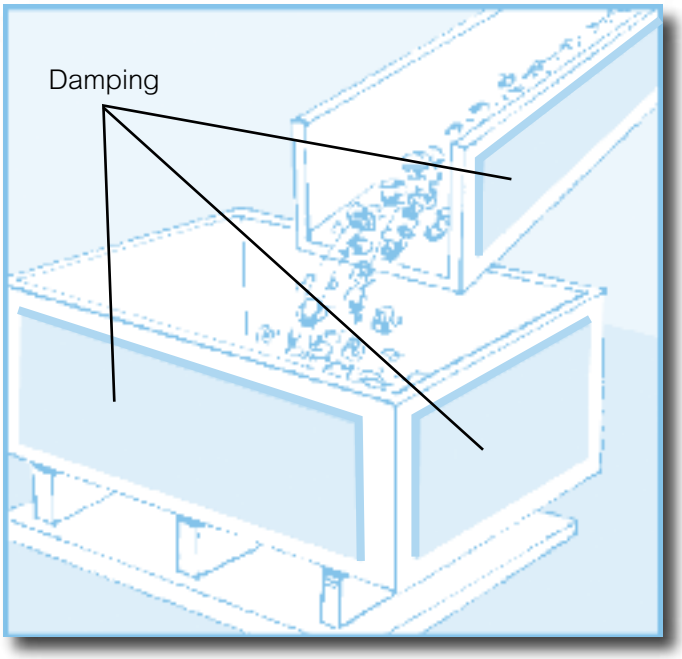
When practicable, one or more options for engineered noise control to reduce worker noise exposure below the exposure limit must be implemented. Options include the following:

Reduction at source

Many potential noise problems can be solved by choosing quieter equipment. When new equipment is purchased, specifications should include either a limit on the noise, or a requirement for the vendor to provide noise performance data. If noise is not engineered out in the design stage, retrofitting existing equipment with noise control devices such as mufflers, silencers, special nozzles, or isolators can sometimes be effective. Substituting quieter equipment for noisy equipment is another method of noise reduction at source. For example,



An s-slide will reduce drop height and deliver material quietly.



Damping applied to delivery chutes and bins will reduce noise.

substituting a large slow speed fan for a smaller high speed fan often reduces noise. When purchasing mobile equipment, specify that sound levels in the cab should be below 85 dBA. The higher initial cost of soundproofed mobile equipment could be lower than the cost of retrofitting the cab with special materials and devices.

A surprising amount of noise can occur in materials handling. Although the speeds of conveyors often cannot be changed for productivity reasons, drop heights can often be reduced, and impact points can be fitted with long-wearing rubber or plastic cushions that reduce noise. Compressed air exhausting from door or gate actuator ports also generates noise. Exhaust air (and noise) can be led away through hoses or pipes to remote spots or led to exhaust silencers.

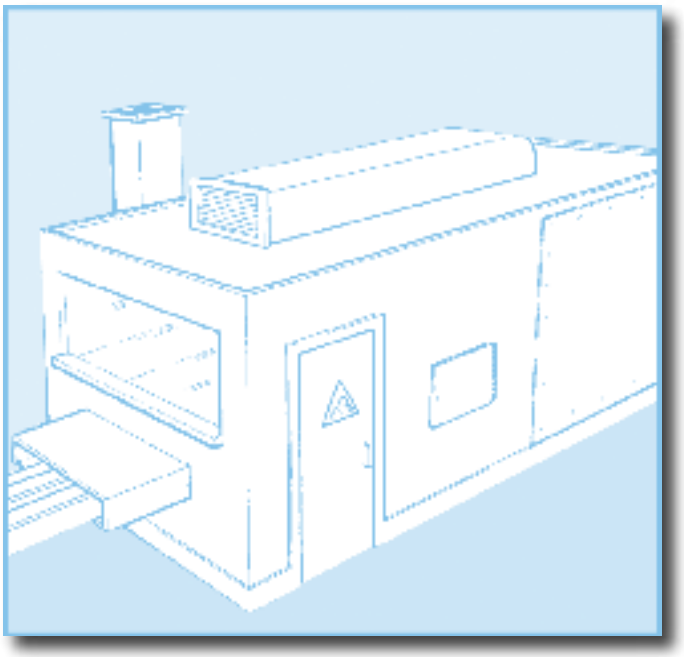
Another common noise source is air jets used to cool, dry, move, or clean objects. Special air nozzles are available that reduce the noise of a plain nozzle by up to 20 dB while reducing the compressed air flow requirements.

Sheet metal panels, when struck, can produce significant noise by vibrating. The noise can be reduced by damping the vibrations. For example, vibration damping on punch press collection and delivery chutes can reduce noise by 5 to 10 dB.

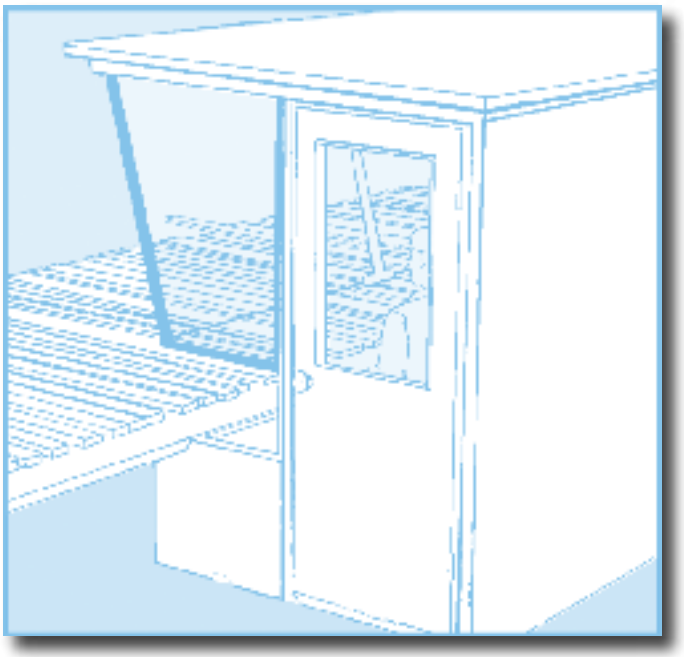
Some pneumatic hand tools are very noisy. Tools with reduced noise emissions may be available. Whenever possible, purchase this type of equipment.

Enclosure of the noise source

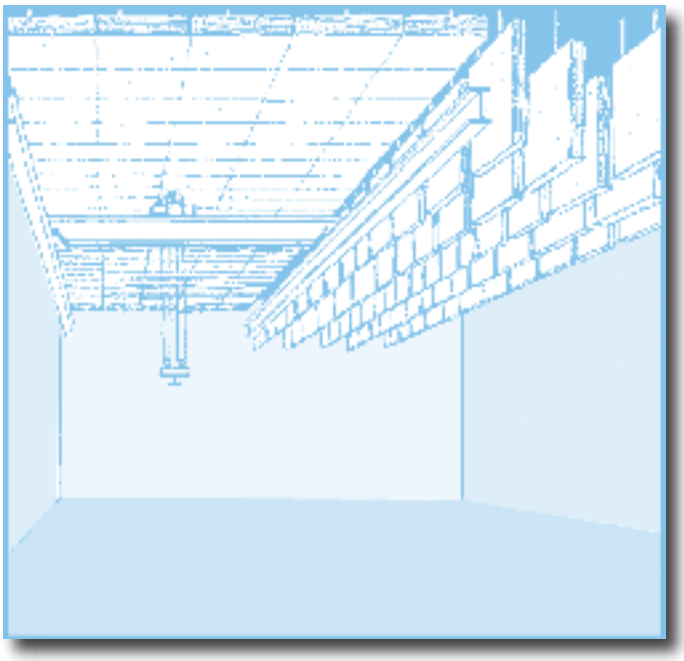
Enclosing the noise source is especially useful when the enclosure doubles as a safety guard or as an environmental control device. Enclosures reduce workers' noise exposure by acting as a barrier and as a sound absorber. Noise reductions of 25 dB are common with noise enclosures. The ceiling and walls of the enclosure should be lined with material that absorbs sound, otherwise noise will reverberate inside the enclosure and escape through small openings — often where workers are stationed. The size of all enclosure openings should be kept to a minimum.



Enclosing machinery will reduce noise levels.



A partial operator booth allows the operator to handle material.



Sound absorbing baffles reduce reflected noise effectively.

Machines that have solid safety panels can often be modified to convert the guarding into effective local noise enclosures. For example, the engine compartments of trucks and buses can be lined with noise absorbents on the bulkhead and hood.

Enclosure of workers

Enclosing workers in a booth is practical when workers leave the enclosure only occasionally, for example, to make adjustments, or clear trapped material. Operator booths can achieve large reductions in noise levels; 20 dB is typical. Partial operator booths are effective for graders in sawmills.

Acoustical treatment of the room

Lining the walls and ceiling with sound-absorbing panels or hanging baffles reduces reflected noise effectively. This method doesn't interfere with workers' access to machinery or require special building structures. However, close to the noise source, where workers are usually stationed, direct noise will remain a problem. Reductions of only 2 to 5 dB are typical when acoustical treatment of the room is used. The benefit of acoustical treatment is that all workers in the room will experience these noise reductions.

Reduction of the length of exposure

On-the-job hearing loss is due to two factors — the level of the noise **and** its duration. Reducing the length of time workers are exposed to noise can reduce exposure below the allowable limits. For example, a worker exposed to 86 dBA for four hours could exchange jobs with another worker for the rest of the shift. If the noise level for the second half of the shift is 80 dBA, the total exposure for the full shift for both workers would be 84 dBA L_{ex}. Such arrangements are examples of administrative controls. Workers on canning and bottling lines, for example, change workstations at regular intervals so that none receives a very high noise exposure.

Separating the worker from the noise source

Noise levels fall as the distance increases from the noise source. The rate at which noise is reduced with distance is increased with acoustical treatment of the room. Using this concept to plan workstation locations may be practical when designing new facilities.

Sometimes, a combination of noise control methods is required to reduce noise, for example, room treatment and a partial machine enclosure.

If engineering controls are put in place, the noise reduction achieved should be measured and the results documented. This will demonstrate compliance with noise control provisions of the Regulation, and may be useful in solving other noise control problems.

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 Z94.2-02*. 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.

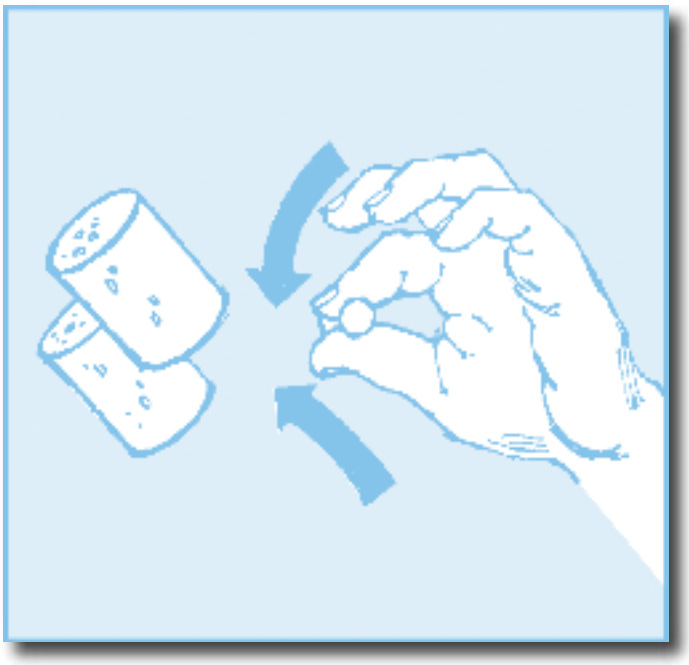
Earplugs

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.



Roll compressible plugs between fingers before insertion.

Several types of earplugs are available including:

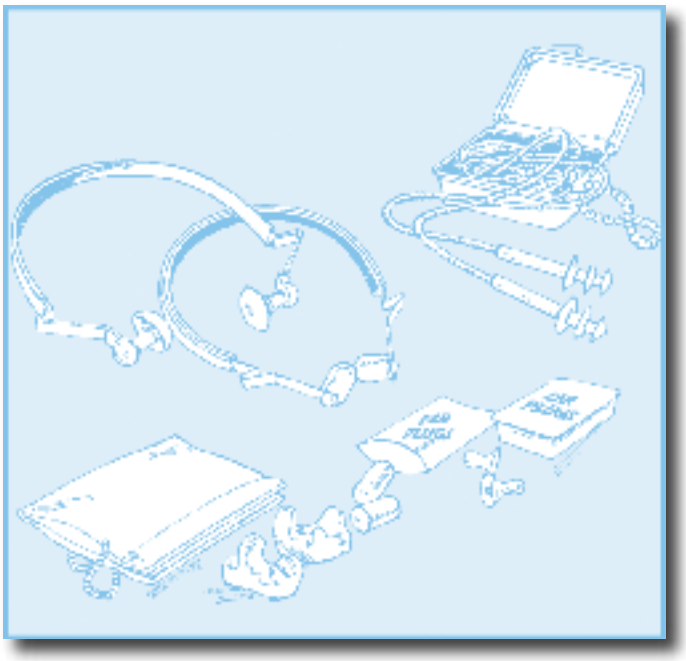
Compressibles These earplugs are usually made of compressible foam. The plugs are rolled between the fingers to compress them, then inserted into the ear canal where the foam expands to fill the canal. For proper insertion, the ear canal must be first straightened by pulling on the outer ear with your 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.

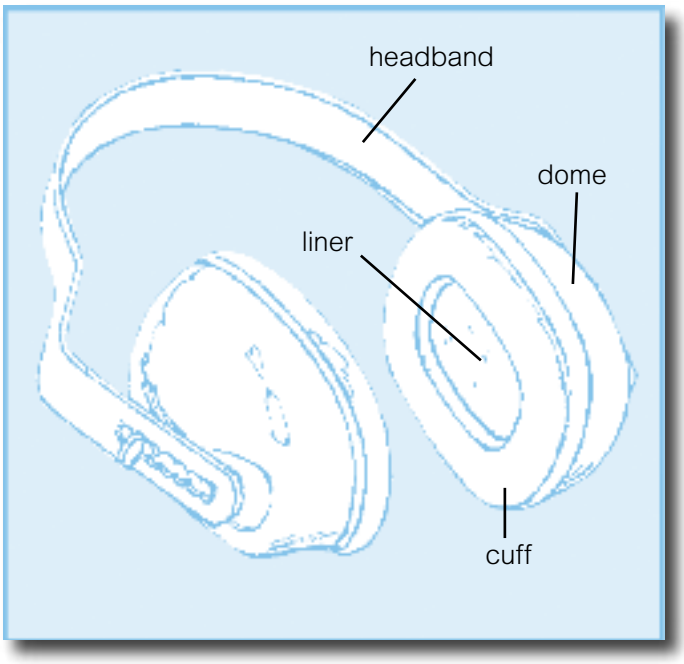
Custom-molded These plugs are custom made by taking an impression of a worker's ear, making a mold of it, and casting the plug. It is vital that a proper impression of the ear be taken or the finished plugs won't fit well. The plugs must fit the contours of the ear snugly to provide proper noise reduction. 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.

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.



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

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



These are the key parts of a typical earmuff.

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.

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 Z94.2-02* has a selection guide. This CSA standard makes recommendations for the grade of hearing protector in addition to the class. Noise exposure is referred to as $L_{ex,8}$ which is the worker's daily eight-hour equivalent noise level. 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

	Recommended	
$L_{ex,8}$ (dBA)	***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 Z94.2-02)

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.

	Minimum Attenuation, dB		
Frequency (in Hertz)	***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	
Grade	*SNR*
0	≤ 9
1	10–13
2	14–17
3	18–21
4	≥ 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

CSA Class	*CSA Grade*	*NRR (approximate)*
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.

Protection Outcomes at Various Resulting Sound Levels

Sound level resulting from the use of the protector (dBA)	*Protection outcome*
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 are 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.

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.

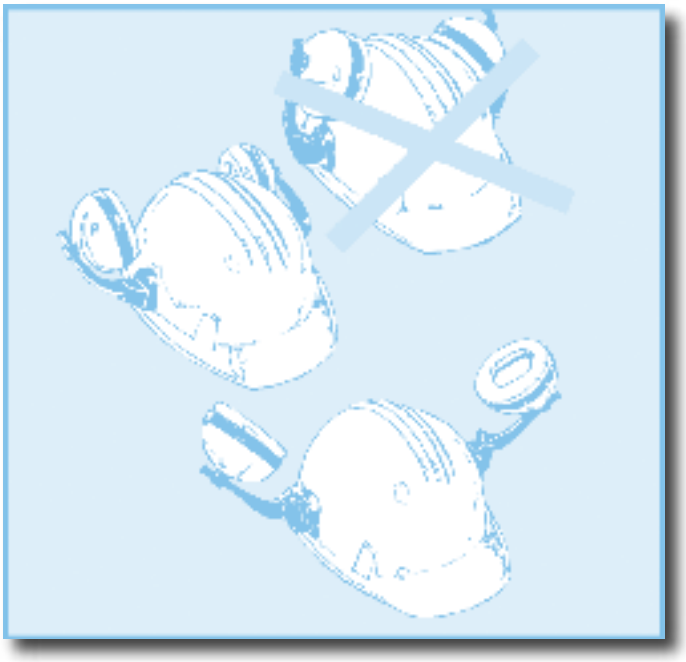
The liner material inside the dome should be kept clean. If the liner is discoloured, hardened, or extremely soiled or mildewed, it should be replaced.

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.

Posting the noise hazard

Where noise levels cannot be reduced to or below the exposure limits by engineered noise control, warning signs must be posted stating that:

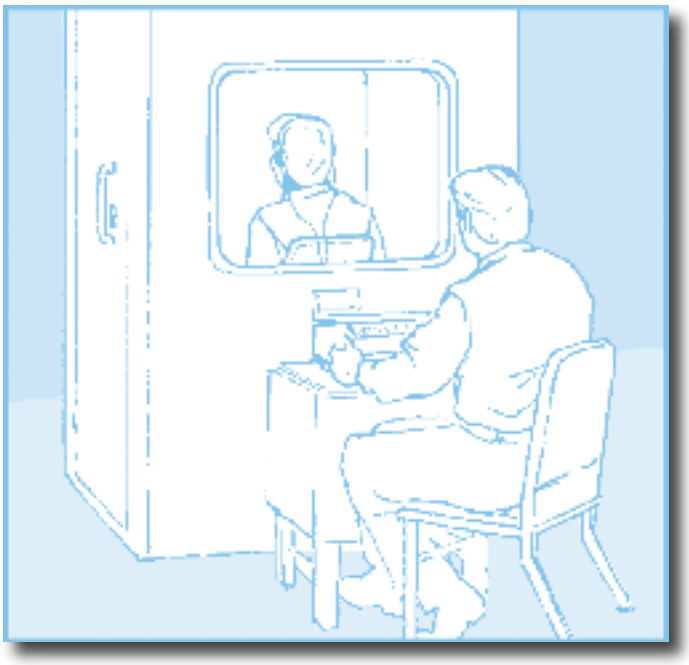
- A noise hazard exists
- Hearing protection must be worn by all workers working in that area

Warning stickers are available for printing from WorkSafebc.com. Go to "Publications" and click on "Signs and Stickers."

It is not necessary to post the actual measured noise levels. It is inappropriate to specify on these signs that a certain class of hearing protection must be worn, based on the noise level measured in an area. Selection of hearing protection is determined for each individual worker, based on selection criteria in the CSA standard. The worker's daily noise exposure (not the area noise level) is only one of the six that must be considered.

Employers must ensure that employees working in areas where noise exceeds 85 dBA L_{ex} are provided with and use hearing protection.

Hearing testing



During the hearing test, the worker is seated in a soundproof booth.

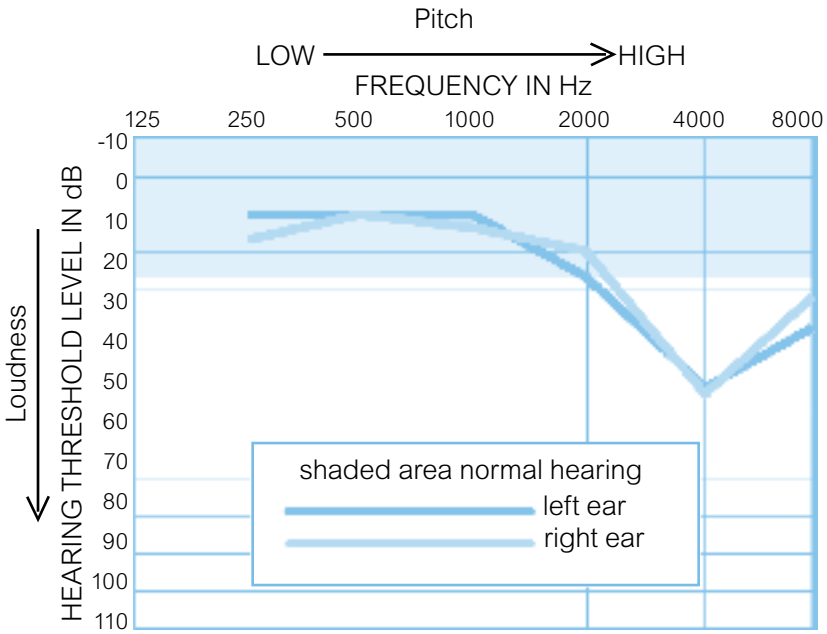
Once a hearing loss prevention program is in place, the only way to ensure that the program is effective is by periodically measuring the hearing of workers.

Hearing tests are required for workers exposed to noise greater than 85 dBA L_{ex} for eight hours, or its equivalent, a noise dose of one Pascal-squared hour (Pa^2h).

Hearing tests are vital because they identify the beginning of noise-induced hearing loss long before workers notice it. As part of the test, workers are individually counselled about the results, the follow-up required, and when a repeat test will occur. Workers are also counselled about the type of hearing protection to use.

Hearing tests **must** be conducted annually to effectively monitor the hearing of noise-exposed workers. The hearing test, including counselling, takes approximately 15 to 20 minutes.

During a hearing test, a worker is seated in a soundproof booth with a window and a set of earphones are placed over the ears. When the worker is ready, the audiometric technician sends a series of tones through the earphones to one ear, and then the other. The worker signals the technician as the tones are heard. The workers' responses are recorded for each ear. Then the results are graphed on a chart called an audiogram.



During the hearing test, the worker is seated in a soundproof booth.

The audiogram shows how loud a tone must be to be barely heard by the worker, at a number of different pitches or frequencies. In the early stages of noise-induced hearing loss, the audiogram will show some hearing loss for high-pitched sounds. As hearing loss advances, the audiogram shows a hearing loss for many pitches. Workers with more advanced hearing loss will notice the sounds of speech and surrounding sounds becoming muffled.

As part of the hearing test, workers are counselled about the necessity, use, maintenance, and replacement of hearing protection.

Hearing testing and counselling must be performed by trained and authorized technicians. Technicians must complete a training course and attend periodic refresher classes to maintain their authorization. For further information about training and authorization, contact WorkSafeBC's Hearing Loss Prevention Section (see pg. iv) or visit WorkSafeBC.com. Visit the Safety at Work section and choose Hearing Loss Prevention under "Topics."

Duties of the industrial audiometric technician are:

- Performing the hearing test
- Categorizing the test results
- Counselling workers on the state of their hearing, comparing it with previous tests whenever possible
- Advising workers on appropriate hearing protection
- Submitting paperwork to WorkSafeBC and keeping records
- Maintaining the audiometric equipment
- Interpreting hearing test statistics to assist the company in evaluating the effectiveness of the hearing loss prevention program

Testing options

Employers may arrange to have their workers tested in several ways. Employers can set up their own in-house facility, send workers to a neighbouring firm's testing facility, or hire a contractor. Often contractors have a mobile unit to bring to the employer's worksite, or workers can go to the contractor's premises.

In-house testing

Employers may select one or more employees to be trained as industrial audiometric technicians and install a hearing test booth and testing equipment (audiometer). An in-house program has some advantages over the other options. One is having a technician on-site familiar with company policy and available to answer questions on hearing protection and noise-induced hearing loss.

The technician can re-test workers who had unreliable or unusual audiograms. Another advantage is the ease of scheduling. Tests may be spread out over the year at the company's convenience, whereas contractor testing is usually scheduled over one or two days, which can cause some disruption to the workday — and miss testing workers who are away.

Since the equipment needed for an in-house facility represents a large financial outlay, such a facility is probably better suited to a large company with many noise-exposed workers. A company with a very small work force may wish to send workers to a nearby employer's facility.

A mobile facility visiting the worksite is convenient.

Contractor testing

Many companies throughout B.C. supply hearing testing and counselling on contract. These companies have facilities that meet WorkSafeBC minimum standards and often have mobile testing facilities that can be brought on-site. Their technicians are trained and authorized to conduct hearing tests. A list of authorized hearing test contractors is available at WorkSafebc.com. Click on Safety at Work and choose Hearing Loss Prevention under "Topics."

Employers must be aware of the contractor's responsibilities. The hearing test contractor must:

- Have an approved testing facility and authorized audiometric technician.
- Choose an appropriate site for the hearing test, using an approved noise monitor if using a mobile facility. The noise monitor alerts the technician if allowable noise levels inside the test booth are momentarily exceeded.

Additional duties of the contractor are the same as those of the in-house technician listed previously.

If hiring a contractor, the employer must:

- Select a company representative to act as a liaison between the company, its workers, the audiometric contractor, and WorkSafeBC.
- Establish a schedule for the hearing tests.
- Inform workers about the hearing loss prevention program. The WorkSafeBC brochure, *Testing Your Hearing – How and Why*, is available for this purpose.
- Assist the audiometric contractor in finding a suitable area for the mobile testing facility.
- Provide a list and samples of hearing protection supplied to workers.
- Ensure that the technician counsels each worker privately and individually about his or her test results.
- Maintain records.
- Review hearing test data and WorkSafeBC statistical reports annually, to ensure program effectiveness.

Hearing test results

The *first* hearing test a worker has is called the **baseline** test. The results are categorized as:

- ***Normal Test*** is normal or near normal
- ***Early Warning Test*** shows the start of noise-induced hearing loss
- ***Abnormal Test*** shows significant hearing loss requiring medical follow-up

Repeat tests are called periodic tests. They are categorized as:

Normal Change Test shows no significant change from previous test; hearing has remained stable.

Early Warning Change Test shows there has been a high-frequency deterioration in hearing, likely due to noise exposure.

Abnormal Change Test shows significant change from the previous test requiring medical follow-up.

The technician is not qualified to determine the cause of abnormal or abnormal change hearing tests.

Requirements for hearing test facilities

Hearing test facilities need to meet certain minimum conditions so that the results of the hearing tests can be reliable. Following are some basic requirements:

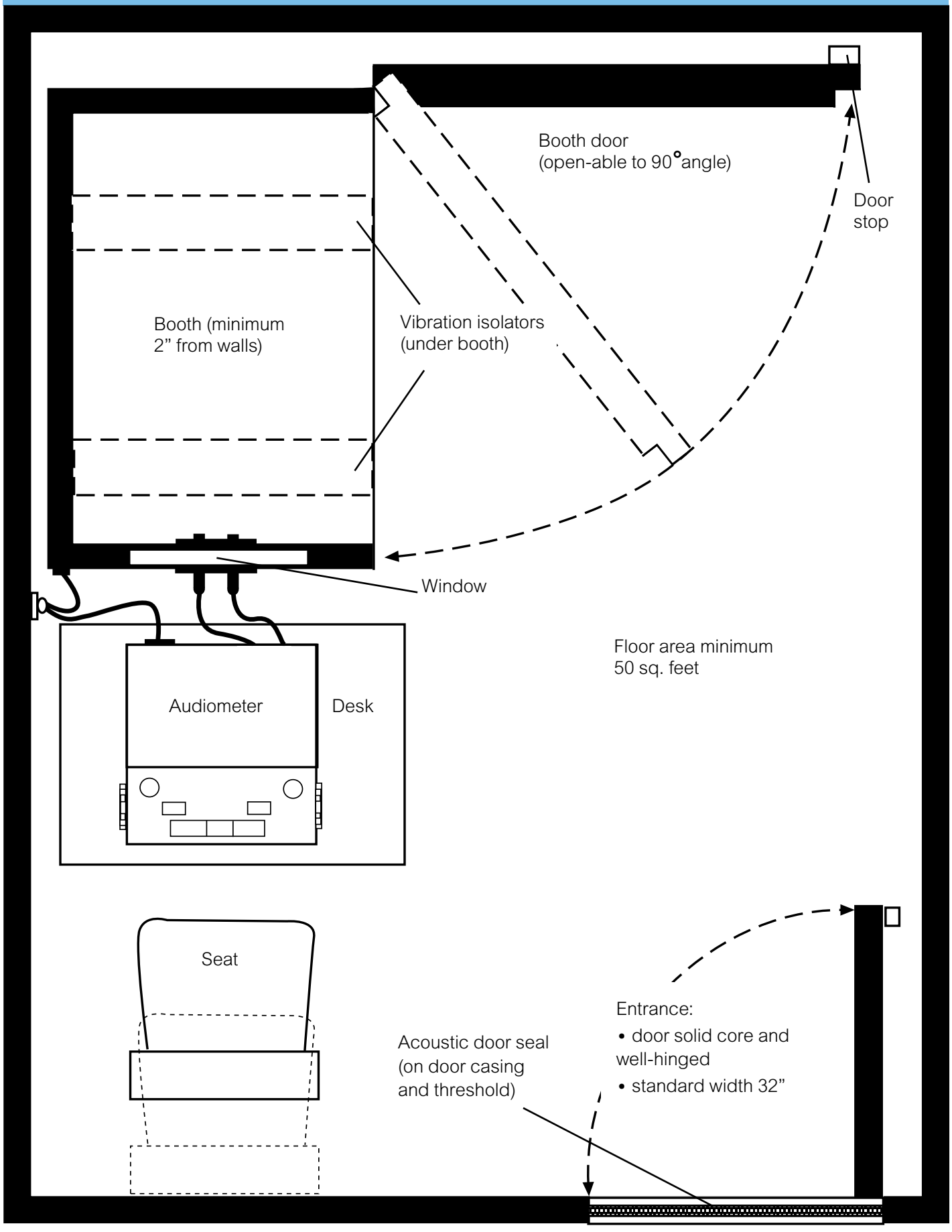
Location and design

A private, self-contained room or area of at least 50 square feet is necessary. This room will contain an audiometric booth, an audiometer, a table or desk, a minimum of three chairs, and a filing cabinet. There must be privacy for counselling, and no distractions for the worker or technician.

A typical layout for a hearing test facility is shown on the facing page. The location of the facility is at the option of the employer, but should be located in as quiet an area as possible.

The maximum allowable sound level outside the booth is 40 dB SPL at 500 Hz, to ensure that counselling can be conducted with workers who may be hard-of-hearing. Workers may have difficulty understanding speech if the sound level is higher.

Hearing Test Facility (acceptable layout)



The hearing test facility should not be located near uncontrolled noise sources and noise pathways. The site for the hearing test area should be as far away as possible from stairways, elevators, outside walls, windows and doors. Surrounding traffic patterns should also be considered, as they may contribute to the ambient noise in the hearing test area. Additional acoustical treatment of the testing room walls, ceiling, floor, doors, and windows may be required if a quiet location cannot be found.

A minimum of one double power outlet located near the booth and audiometer should be installed so that the electrical cord from the booth light, fan, and audiometer do not cause faulty connections or electrical shock or tripping hazards.

Any light source placed overhead, or daylight from windows in the hearing test room, should not cause reflections in the booth window, preventing a clear view of the individual being tested.

Lighting, heating, and ventilation must be provided in accordance with the standards set out in the Occupational Health and Safety Regulation.

The hearing test booth

A sound-treated booth is required for all hearing testing. Any make of audiometric booth meeting *ANSI Standard S3.1-1999* is acceptable. The following table shows the maximum sound levels acceptable inside the booth for noise at different frequencies.

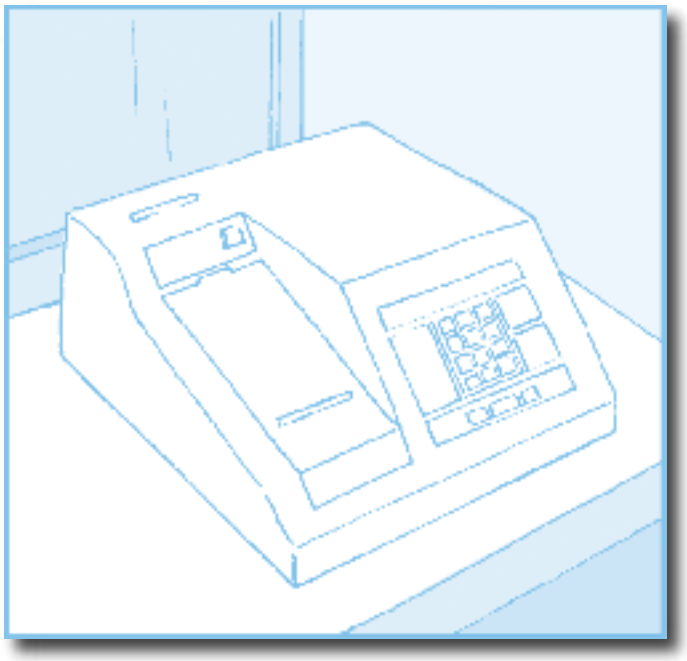
American National Standards Institute ANSI S3.1-1999	
Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms	
Test Tone Frequencies in Hz	Octave Band Levels in dB re: 20 µPa
125	45.0
250	35.0
500	21.0
1000	26.0
2000	34.0
4000	37.0
8000	37.0

Audiometric booths are available for industrial purposes in both single- and double-wall thicknesses (2", 4", and 4" double wall). The type required will depend on the background noise level at the site where the booth is to be located, i.e., how much noise reduction is needed to make the inside of the booth meet the ANSI standard.

If a ventilation system is incorporated into the hearing test room or booth, the noise caused by it must not exceed the maximum permissible ambient noise levels. Acoustically treated fans and ventilation ducts are available and booth manufacturers provide test booths with silent fan systems. When an audiometric booth is installed, sound level checks must be made. These checks can be arranged by contacting the WorkSafeBC Hearing Loss Prevention Section (see pg. iv).

The audiometer

The audiometer must meet the following standard: *ANSI Standard S3.6-1996, Specifications for Audiometers*, or another standard acceptable to WorkSafeBC.



This is an example of one type of audiometer.

The audiometer must be calibrated annually by a service agency acceptable to WorkSafeBC. The calibration certificate issued by the agency should be kept with the audiometer.

There are three types of audiometers commonly used for hearing testing in industry: manual, self-recording, and microprocessor audiometers. The decision as to type of machine purchased rests with the company, but the following guidelines may be of assistance:

Manual audiometer The technician is responsible for changing the ear, frequency, and intensity settings of the machine and for following a standard method of presenting tones. The person being tested responds by raising a finger when a faint tone is heard. The technician has a high degree of control over the testing.

Self-recording audiometer This audiometer automatically changes the frequency and intensity, and the ear to which tones are delivered. Results are recorded on a graph as the subject presses a response switch. Again, the technician may do other quiet work during this test, but may not leave the room and must periodically check the graph to ensure the worker is responding appropriately. Approximately two percent of workers find the test, or using a self-recording audiometer, difficult and respond poorly.

Microprocessor audiometer This machine automatically delivers tones to the subject according to a standard method, and may also print the results. It has an audible alarm to notify the technician if the subject is responding inappropriately. The technician may not leave the room, but may do other quiet work during the test. The technician may override the automatic mode and do the test manually when necessary.

The use of the latter two audiometers allows the technician some freedom during the test, to do the required paperwork or other quiet duties. The use of the manual machine allows the technician to adapt the test to slow responders. The manual mode on the microprocessor also permits this control and flexibility.

Hearing test records

Employers **must** keep copies of hearing test forms on file for each worker for as long as the worker is employed by them. These records must be available for comparison with each new hearing test. Comparisons will assist the technician in determining how to categorize the hearing test results, and what counselling the worker needs.

Hearing test records are confidential, and are accessible only by the worker, the technician, or the company's occupational health nurse or physician. If records are kept on the employer's behalf by a hearing test contractor, a written release must be provided by the employer.

WorkSafeBC also keeps copies of hearing test records sent by audiometric technicians in a mainframe database. A brief medical history of the worker (part of the baseline test) is also maintained on file. The employer does not keep a copy of the medical history of the worker.

WorkSafeBC records are used for research. These records have been valuable for investigating the trends in noise-induced hearing loss and use of hearing protection in B.C. workers.

Information from WorkSafeBC records is not available to anyone except in the form of statistical analysis. The only exception to this rule is that workers may (in writing) authorize the release of their record, for example, to their family doctor or to a WorkSafeBC claim file.

Hearing test statistics

The WorkSafeBC Hearing Loss Prevention Section can provide individual employers with an annual statistical report compiled from the hearing tests they have submitted.

The report includes:

- A list of workers tested the previous year, the date of the tests, and the category of the tests
- Annual statistics by type and category of test

The percentage of workers in each category, but particularly the Early Warning Change category, should be examined to evaluate the effectiveness of the hearing loss prevention program and to determine whether increased measures to prevent work-related hearing loss are necessary. Early Warning Change indicates the extent of noise-related hearing loss developing. The WorkSafeBC Hearing Loss Prevention Section can advise you about the results of your report.

Annual review of hearing loss prevention program

To ensure its effectiveness, the hearing loss prevention program **must** be reviewed once a year. This review should address:

The selection and use of hearing protection
Workers should be asked by the reviewer about their opinion on the hearing protection they are currently using. Does the protection interfere with any other personal protective equipment they use? Does it make communication difficult? Is it comfortable?

Adequacy of noise control measures
Technological advances that may make it possible to reduce noise levels need to be examined. When purchasing new equipment low noise levels should be specified. Equipment should be adequately maintained, so that worn and unbalanced parts won't cause increased noise and vibration.

The need for further noise measurement
Changes in the workplace, such as expansion or new processes, could change the noise levels.

Education and training of workers regarding noise exposure
Workers must understand the risks noise poses to their hearing. Workers must use and maintain hearing protection correctly.

Hearing testing information on the rate and extent of occupational hearing loss
Even though hearing protection is provided, it can fail to prevent hearing loss for a number of reasons including improper fit, poor maintenance, and lack of consistent use. The hearing test statistics will indicate whether noise-related hearing loss is still occurring.

A Hearing Loss Prevention Program Checklist, to assist with a review of the program, is provided on the following pages. The coordinator of the hearing loss prevention program can use the checklist to determine if all components have been put in place and documented.

If there is an occupational health and safety committee or representative at the workplace, the employer should ensure that the committee or a representative participates in the program review.

Example of a WorkSafeBC-Issued Hearing Loss Prevention Annual Report

Hearing Loss Prevention Section

2005/02/17 Page 1

Annual Statistics
Year of Test
2005

Registration Number	123456-001
Industry Class	010500 XYZ Sawmill
Number of Forms Processed for this Year	260

	Total	Normal		Early Warning		Abnormal	
	#	#	%	#	%	#	%
Baseline Tests	10	8	80	1	10	1	10

	Total	Normal Change		Early Warning Change		Abnormal Change	
	#	#	%	#	%	#	%
Periodic Tests	250	212	85	30	12	8	3

Occupations at this location with the highest number of early warning changes

	Occupation Code	Occupation Description	Number of Tests	Number of EWC
01	8584505	Millwright	8	7
02	9910390	Supervisor/Chargehand/Foreman	6	5
03	8238595	Planer Operator	5	4

Hearing Loss Prevention Program Checklist

1 Noise measurement

- ❒ Representative noise exposure levels have been determined for all noise-exposed job classifications in accordance with *CSA Standard Z107.56-94*
- ❒ Warning signs are posted in noisy areas, indicating that hearing protection is required
- ❒ A report of the noise survey findings is available for review

2 Education and training

Noise-exposed workers have received education on:

- ❒ The results of noise exposure measurements
- ❒ Effects of noise on hearing
- ❒ Proper use and maintenance of hearing protection
- ❒ Purpose of hearing testing

Staff responsible for administering the program have:

- ❒ Received education on hearing loss to understand the program goals and policies, and training in use and fitting of hearing protection

3 Noise control

- ❒ Major noise sources and options for engineered noise control have been identified
- ❒ Where practicable, noise control solutions have been implemented
- ❒ Noise control maintenance plan exists
- ❒ Equipment noise purchase specifications exist
- ❒ New facility planning includes noise control

4 Hearing protection

- ❒ Hearing protection use where required is strictly and consistently enforced
- ❒ Hearing protection is selected in accordance with criteria in *CSA Standard Z94.2-02*
- ❒ Each worker is individually fitted with hearing protectors and trained in use and care
- ❒ Hearing protection is replaced on a regular basis
- ❒ Each worker's hearing protection is re-checked during annual hearing test for condition, fit, and correct placement

5 Posting the noise hazard

- ❒ Warning signs are posted in all areas where a noise hazard exists
- ❒ Signs indicate that all workers must wear hearing protection in these areas

6 Hearing tests

For firms using a hearing test contractor:

- ❒ A suitably quiet location is selected to locate the mobile hearing test facility
- ❒ The hearing test contractor is provided with a list of the hearing protection available to workers at the firm

For firms with in-house programs and firms using a contractor:

- ❒ Workers are advised to bring their hearing protection with them to the hearing test
- ❒ Workers are privately and individually counselled on the hearing test results, and on the use and care of hearing protection
- ❒ Records of hearing tests are maintained in a confidential manner by the employer
- ❒ All noise-exposed workers are tested annually
- ❒ Test results are submitted to WorkSafeBC

7 Program review

- ❒ Program addresses the seven components listed in the Occupational Health and Safety Regulation
- ❒ Effectiveness of the program is reviewed at least annually
- ❒ Identified deficiencies are addressed by an action plan
- ❒ Action plan is implemented and documented
- ❒ Results of the review are shared with the joint safety committee

The review addresses:

- ❒ Need for further noise measurement
- ❒ Education and training
- ❒ Adequacy of noise control measures
- ❒ Selection and use of hearing protection
- ❒ Hearing test data on rate and extent of noise-related hearing loss

Educational materials available from WorkSafeBC

The publications below are available at WorkSafebc.com. Visit the Safety at Work Section and choose Hearing Loss Prevention under "Topics."

Hear for Good This pamphlet provides basic information on hearing protection for workers.

Testing Your Hearing — How and Why! This pamphlet introduces and explains hearing testing for workers.

These brochures, plus the following video and CD, can be ordered from WorkSafeBC (see page ii for ordering information).

The Hearing Video This award-winning video entertains as it informs workers about the effects of noise on hearing, use/care of hearing protection, and purpose of hearing testing.

Simulated Noise-Induced Hearing Loss This is a compact disc featuring filtered music and speech to simulate what it's like to have a high-frequency hearing loss. It also has samples of noise from different industries, as well as a selection about tinnitus (noises often present in the head or ears).

WorkSafeBC Hearing Loss Prevention Section staff can also provide information on all aspects of hearing loss prevention, and have lists available of authorized hearing test contractors, suppliers of sound-level measuring equipment, audiometers, and booths.

Glossary

Decibel A-weighted (dBA) means a unit of sound pressure level measured with an A-weighting filter.

Decibel C-weighted (dBC) means a unit of sound pressure level measured with a C-weighting filter.

L_{eq} is the equivalent steady sound level of a noise energy - averaged over time.

L_{ex}, or noise exposure level, is the sound level, energy- averaged over eight hours, which would give the same daily noise exposure as the varying noise over a typical full shift. (The CSA standard developed in 2001 uses $L_{ex,8}$ for the eight-hour equivalent.)

Pa^2h means Pascal-squared hour, a unit of sound exposure used by newer noise measuring equipment. (1 Pa^2h equals 85 dBA L_{ex} and 0.5 Pa^2h equals 82 dBA L_{ex}.)

Peak sound pressure level is the peak instantaneous pressure expressed in dB and measured on a sound level meter having a peak-hold capability.

3-dB exchange rate means that when sound energy doubles, the decibel (dB) level increases by 3.

Notes

WorkSafeBC Offices

Visit our web site at WorkSafeBC.com

Abbotsford
2774 Trethewey Street V2T 3R1
Phone 604 276-3100
1 800 292-2219
Fax 604 556-2077

Burnaby
450 – 6450 Roberts Street V5G 4E1
Phone 604 276-3100
1 888 621-7233
Fax 604 232-5950

Coquitlam
104 – 3020 Lincoln Avenue V3B 6B4
Phone 604 276-3100
1 888 967-5377
Fax 604 232-1946

Courtenay
801 30th Street V9N 8G6
Phone 250 334-8765
1 800 663-7921
Fax 250 334-8757

Kamloops
321 Battle Street V2C 6P1
Phone 250 371-6003
1 800 663-3935
Fax 250 371-6031

Kelowna
110 – 2045 Enterprise Way V1Y 9T5
Phone 250 717-4313
1 888 922-4466
Fax 250 717-4380

Nanaimo
4980 Wills Road V9T 6C6
Phone 250 751-8040
1 800 663-7382
Fax 250 751-8046

Nelson
524 Kootenay Street V1L 6B4
Phone 250 352-2824
1 800 663-4962
Fax 250 352-1816

North Vancouver
400 – 224 Esplanade Ave. W. V7M 1A4
Phone 604 276-3100
1 888 875-6999
Fax 604 232-1558

Prince George
1066 Vancouver Street V2L 5M4
Phone 250 561-3700
1 800 663-6623
Fax 250 561-3710

Surrey
100 – 5500 152 Street V3S 5J9
Phone 604 276-3100
1 888 621-7233
Fax 604 232-7077

Terrace
4450 Lakelse Avenue V8G 1P2
Phone 250 615-6605
1 800 663-3871
Fax 250 615-6633

Victoria
4514 Chatterton Way V8X 5H2
Phone 250 881-3418
1 800 663-7593
Fax 250 881-3482

Head Office / Richmond
Prevention Information Line:
Phone 604 276-3100
1 888 621-7233 (621-SAFE)
Administration:
6951 Westminster Highway
Phone 604 273-2266
Mailing Address:
PO Box 5350 Stn Terminal
Vancouver BC V6B 5L5
After Hours

Health & Safety Emergency
604 273-7711
1 866 922-4357 (WCB-HELP)

R06/05