Part 16 Noise

Highlights

- The noise exposure limits in this Part are based on a 3 decibel (dB) exchange rate. This means that when the sound energy level is doubled (an increase of 3 dB), the corresponding exposure time is halved.

- Section 217 requires employers to ensure that new or renovated work sites, new work processes, or new equipment brought into a workplace achieve a noise level of 85 dBA or as low as reasonably practicable.

- Section 219 requires employers to do a noise exposure assessment if workers are, or may be, exposed to noise at a work site in excess of 85 dBA L_{ex}. An L_{ex} measurement averages a worker's total exposure to noise over the entire workday and adjusts it to an equivalent 8-hour exposure. Noise must be measured in accordance with the Canadian Standards Association's (CSA) noise measurement standard.

- Section 221 requires employers to develop a formal noise management program if workers are exposed to excess noise at a work site. The section lists the mandatory components of the program. (Section 8 of the *OHS Regulation* requires that the program be in writing and available to workers.)

- Section 223 presents the requirements for audiometric testing. Workers must provide their medical history when audiometric testing indicates a significant change in hearing ability. This recognizes that factors other than workplace exposure to noise can contribute to hearing loss. To ensure medical information remains confidential, only the person who performs the audiometric tests may retain medical history and test records.

Section 216 Duty to reduce

The employer is required to reduce worker exposure to noise in areas where workers may be present. Noise is a recognized workplace hazard. It must be assessed as required by section 7 of the OHS Code, and then eliminated and controlled as required by section 9.

The term "reasonably practicable" is not intended to provide an opportunity or an excuse for not meeting the requirements of this Part. Use of the term indicates the preferred action that should be taken and is usually associated with the minimum requirements that should be met.

As required by section 9, noise must be controlled through the use of engineering controls first, then administrative controls if engineering controls are not effective. Only if engineering or administrative controls do not or are impracticable to eliminate or reduce a hazard sufficiently is an employer permitted to use appropriate personal protective equipment.

Engineering controls

Four main types of engineering controls can be used to reduce or eliminate noise:

(1) *substitution* — replace noisy equipment, machinery or processes with quieter ones;

(2) *modification* — modify the way equipment operates so that it generates less noise. This may include installing a muffler, reducing equipment vibration by dampening or bracing, improved lubrication, balancing rotating parts or operating equipment at a lower speed. Alternatively, the area itself can be modified. Reverberation, for example, can be reduced by covering walls with sound absorbing materials;

(3) *Isolation* — this may involve isolating workers from a noisy area by having them work in an enclosed room. Examples of this approach include:
   (a) segregating noisy areas with sound barriers and partitions;
   (b) isolating noisy equipment by placing it in an enclosure; and
   (c) using sound absorbent material and covers over noisy equipment; and

(4) *maintenance* — malfunctioning or poorly maintained equipment generates more noise than properly maintained equipment. Noise control equipment must also be properly maintained to be effective.

Developing engineering controls may involve engineers, safety and industrial hygiene personnel and the workers who operate, service and maintain the equipment. The effectiveness of the controls will depend on a thorough assessment of the noise source and individual worker exposure. The contribution of each noise source to the overall noise level must be considered.

The control options available should be evaluated based on their effectiveness, cost, technical feasibility and implications for equipment use, service and maintenance. Enclosing a piece of equipment, for example, may cause it to overheat or create maintenance difficulties. Other potential complications such as effects on lighting, heat production, ventilation and ergonomics, should also be considered. The function and purpose of planned or existing controls must be fully discussed with workers so they understand the purpose of the controls and do not inadvertently interfere with them.

Administrative controls

Administrative controls involve changes in work schedules or operations that reduce worker noise exposure. Typical controls include rotating work schedules or changing production schedules to limit the amount of time workers are exposed to noise.

Protective equipment

When engineering and administrative controls cannot reduce noise exposure sufficiently, or where they are not reasonably practicable, the employer must provide workers with hearing protection (see section 222). Hearing protection is considered to be any device designed to reduce the level of sound reaching the eardrum. Earmuffs and earplugs are the main types of hearing protection typically used. A wide range of hearing protection can be found within each of these categories. The amount of protection or sound attenuation provided by a hearing protector depends on its characteristics and how it is worn. The selected hearing protector must be capable of keeping noise exposure at the ear below the occupational exposure limit for noise.

Section 217 Noise control design

The most effective method of dealing with noise at a workplace is to prevent or eliminate the noise from being produced in the first place. The purpose of this section is to ensure that employers consider noise reduction up front when constructing or modifying a work site or work area, when introducing a new work process or introducing equipment that is new to the work site or work area.

Considering noise control in the design, construction or alteration of a workplace can create a more effective control system that takes into account factors such as work area orientation and the types of equipment to be used. Retrofitting a work site or work area with soundproofing or using other noise control strategies often results in less effective noise reduction. This is because the strategies must fit the existing work area — they may not be the optimal design for reducing noise to the desired level.

The material used in the construction of buildings, machines, piping and tanks has a direct effect on noise control. Some materials and structures dampen sound extremely well. Others do not and should be avoided if noisy equipment or processes will be present in the work area.

The construction or design of a new work site or significant physical alterations, renovations or repairs to an existing work site or work area must achieve a noise level of no more than 85 dBA, or as low as reasonably practicable. In determining whether noise has been reduced to the lowest level reasonably practicable, the employer needs to take into account:

(a) the orientation and size of the work area;
(b) the number and location of workers in the work area;
(c) physical parameters such as temperature, pressure and humidity;
(d) the types of building materials and construction techniques available to reduce noise levels;
(e) the type of equipment that will be used in the work area; and
(f) cost constraints.

The employer should document the assessment process, particularly if conditions at the work site are likely to change in the future.

Employers and workers need to stop buying new noise problems. Equipment or processes that involve high speeds, high pressure and high flow velocities, combined with light building structures and minimum floor space, can lead to noise problems if noise limits are not specified. Employers should target noisy equipment or operations for noise reduction through replacement, set noise level criteria for new equipment in purchase documents and request noise level specifications from manufacturers. Workers should be members of the purchasing team since they will be directly affected by the new equipment.

It is not just the noise that the equipment or process itself generates, but how much noise it will make once installed or introduced at the work site. Factors to consider include the total energy of the sound sources, how sound travels at the workplace, the ability of the room or area to absorb sound, and the degree to which the noise is concentrated in a certain direction as opposed to sound that radiates evenly in all directions.

The employer is required to ensure that new equipment is designed, constructed and installed to achieve the lowest noise level practicable. In some cases, it may be practicable to modify the equipment or substitute less noisy equipment. In other cases, the ability to control noise will be limited by

(a) technological constraints — some equipment is inherently noisy and advances in technology are unable to reduce its noise below a certain level;
(b) the availability of equipment or materials — there may be no alternative;
(c) space constraints — quieter equipment may be too large to fit into the available space;
(d) workplace conditions such as temperature, pressure, humidity, etc.; and
(e) cost constraints.

In these cases, other methods of noise control will be required to reduce worker exposure.

Section 218 Worker exposure to noise

Table 1 of Schedule 3 of the OHS Code specifies occupational exposure limits for noise and is shown below as Table 16.1. Table 16.2 is an expanded version of Table 1 of Schedule 3, showing exposure durations at each incremental exposure level. Additional entries can be calculated using either of the following formulas:

$$dB(A) = 10\log_{10}\left(\frac{2.53\times10^{9}}{T}\right)$$

where:

T is the exposure duration in hours

or

$$T = \frac{480}{2^{(L-85)/3}}$$

where:

T is the time of exposure, in minutes
L is the exposure level, in dBA

Table 16.1 presents the occupational exposure limits for noise based on exposure duration. As noise intensity increases, the amount of time an unprotected worker can be safely exposed to that noise decreases. The limits represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. The values should not be regarded as fine lines between safe and dangerous noise levels.

A 3 dB exchange rate is used to determine when time of exposure needs to be reduced. Exchange rate is the relationship between noise level and exposure duration. The 3 dB exchange rate is also known as the equal-energy rule or hypothesis (equal amounts of sound energy produce equal amounts of hearing damage, regardless of how the sound energy is distributed in time). On an energy basis, the 3 dB exchange rate permits the calculation of a true time-weighted average exposure to noise. Based on the mathematical relationship for sound power level,

$$L(dB) = 10\log_{10}\left(\frac{W}{W_0}\right)$$

where:

L is the sound power level
W is sound power
W_0 is a reference sound power,

every doubling of energy results in an increase in L of 3 dB. The same relationship does not hold true for the 5 dB exchange rate which was previously used. Therefore, for every 3 dB increase in noise level, the exposure time must be halved.

A ceiling limit of 115 dBA is included in the exposure limits — no unprotected worker exposure is permitted above this ceiling. Above this level it is assumed that the unprotected ear is damaged instantly by the noise (animal research suggests that the critical level is between 115 and 120 dBA).

When daily noise exposure consists of different periods of different noise levels, the daily dose should not exceed 100, as calculated by the following equation:

$$D = \left(\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots \frac{C_n}{T_n}\right) \times 100\%,$$

where:

D is the daily dose, expressed as a percentage
C_n is the total time of exposure at a specified noise level
T_n is the exposure duration permitted at the specified noise level (eg 8 hours for 85 dBA).

Table 16.1 Occupational exposure limits for noise
(appears as Table 1 of Schedule 3 of the OHS Code)

Exposure Level (dBA)	Duration
82	16 hours
83	12 hours and 41 minutes
84	10 hours and 41 minutes
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	8 minutes
106	4 minutes
109	2 minutes
112	56 seconds
115 and greater	0

Note: Values have been rounded to the nearest digit.

Table 16.2 Expanded version of Table 16.1

Exposure Level (dBA)	Duration
82	16.0 hours
83	12.7 hours
84	10.1 hours
85	8.0 hours
86	6.3 hours
87	5.0 hours
88	4.0 hours
89	3.2 hours
90	2.5 hours
91	2.0 hours
92	1.6 hours
93	1.3 hours
94	1.0 hour
95	48 minutes
96	38 minutes
97	30 minutes
98	24 minutes
99	19 minutes
100	15 minutes
101	12 minutes
102	9 minutes
103	8 minutes
104	6 minutes
105	5 minutes
106	4 minutes
107	3 minutes
108	2 minutes
109	2 minutes
110	1 minute
111	1 minute
112	56 seconds
113	45 seconds
114	35 seconds
115 and greater	0

Section 219 Noise exposure assessment

The first step in a noise management program or in efforts to control noise is to assess existing workplace noise levels. This section requires employers to conduct an assessment where workers are or may be exposed to noise levels in excess of the occupational exposure limits shown in Table 1 of Schedule 3 and exceed a noise level of 85 dBA L_{ex}.

A number of factors should be considered when analyzing the extent of the hazard to which workers may be exposed:

(a) sound from a source can travel by more than one path to the location where it becomes a hazard;
(b) many industrial sound sources are directional i.e. sound sources such as intake and exhaust vents radiate more sound in one direction than another;
(c) sound from equipment may be transmitted by vibration;
(d) the frequency of the noise has a large impact on how far it travels from the source as well as the measures needed to control it. In addition, a person's perception of noise is related to the frequency of the noise, with human hearing being best at frequencies between 500 and 5000 Hz. Noise at frequencies below 500 Hz and above 5000 Hz can still cause hearing damage, even though these sounds are not perceived to be as loud. Noise measurements made with an instrument equipped with an A-weighted network will discount the contribution of low frequency components to the overall noise measurement;
(e) if noise exposure changes due to seasonal or product variations, noise measurements need to be repeated; and
(f) where workers rotate irregularly between different jobs and activities, it may be more useful to determine noise exposure based on the job and worker noise exposure based on the time a worker spends at each job or activity.

An initial noise assessment should be performed in any work area where workers must significantly raise their voices to be heard over background noise. The assessment should include work areas that are indoors, outdoors and in mobile equipment. If the results of the initial assessment indicate that no workers are exposed to noise levels exceeding the exposure limits, then periodic assessments should be performed thereafter to make sure that conditions have not changed over time. Periodic assessments should be done on an annual basis and when

(a) new equipment or work processes that generate noise are introduced to the work site,
(b) noise levels change due to equipment deterioration,
(c) work practices or work procedures change, or
(d) workers complain of ringing in the ears, temporary changes in hearing or increased levels of noise in their work area.

The noise assessment should be done by an industrial hygienist, audiologist or professional with appropriate training and the noise must be measured in accordance with the CSA Standard Z107.56-06, *Procedures for the Measurement of Occupational Noise*. Workers should be permitted and encouraged to observe and participate in monitoring activities, as long as doing so does not interfere with the monitoring. Worker participation helps ensure valid results as workers can identify noise sources, indicate periods when noise exposure may differ, and recognize whether noise levels are typical or atypical. Workers can explain how different operating modes affect equipment sound levels and can describe their tasks and working positions.

Performing noise measurements

There are many ways of measuring occupational noise and a variety of instruments for doing so. The choice of a particular method or instrument depends on many factors, including the purpose of the measurement and the environment in which the measurement is made. Monitoring procedures need to be thoroughly defined to ensure consistency from one measurement to the next. Instrumentation, calibration, measurement parameters and methods for data analysis must be clearly described.

This section requires that noise measurements be performed in accordance with CSA Standard Z107.56-06 *Procedures for the Measurement of Occupational Noise Exposure*. Using this Standard ensures that a consistent procedure is followed when making noise measurements. The procedure determines a worker's long term noise exposure using measurements of equivalent sound level in the workplace. Procedures for measuring all types of noise — continuous, pure tones, impulse — are provided in the Standard. All types of noise are measured in terms of equal energy. The Standard can be used to measure the noise exposure of individuals or groups and measurements are taken using a 3 dB exchange rate. The Standard provides procedures for measuring noise and reporting the results.

While the CSA Standard does not address the frequency of the noise being measured, this is an important factor when determining noise exposure. In environments where the noise is mostly low frequency, measurements taken with an instrument equipped with an A-weighted filter will underestimate noise exposure. It is useful therefore to conduct a frequency analysis of the noise using a sound level meter with an octave band filter or, if this type of equipment is not available, to measure the noise with both C-weighted and A-weighted filters and compare the results.

If the results vary widely, the noise may have a large low frequency component to it. This will need to be taken into account when measuring noise exposure (correction may be applied to the A-weighted values) and when determining noise levels for the

purpose of implementing control measures. Table 16.3 shows the variations among readings taken with A-, B- and C-weighted filters.

Table 16.3 Selected relative response for A-, B- and C-weighted filters

Frequency (Hz)	A-weighting (dB)	B-weighting (dB)	C-weighting (dB)
20	-50.5	-24.2	-6.2
50	-30.2	-11.6	-1.3
100	-19.1	-5.6	-0.3
500	-3.2	-0.3	0
1000	0	0	0
2000	+1.2	-0.1	-0.2
5000	+0.5	-1.2	-1.3
10000	-2.5	-4.3	-4.4
20000	-9.3	-11.1	-11.2

Source: Earshen, John J. (1986) Sound Measurement: Instrumentation and Noise Descriptors, *Noise and Hearing Conservation Manual* 4th Edition, American Industrial Hygiene Association, pp 51

Notes:
(1) Although the B-weighted filter is rarely used in noise exposure measurements, its responses are presented for comparison purposes.
(2) How to use the table: A sound with a frequency of 1000 Hz has an intensity of 90dB. At this frequency, the readings in dBA, dBB and dBC are all the same (90). At 500 Hz, the reading corresponds to 86.8 dBA, 89.7 dBB and 90 dBC. At 50 Hz, the reading corresponds to 59.8 dBA, 78.4 dBB and 88.7 dBC.

Competent person

A competent person, otherwise known as a competent worker, performs the noise measurements. This person must be able to correctly use the instrumentation and be able to understand and interpret the measurement results.

Updating measurements

Noise measurements must be updated when equipment or processes change that could affect the noise levels or the duration of worker exposure:

Instrumentation

Four different types of instrumentation can be used to measure noise exposure:
(1) a sound level meter;
(2) a noise dosimeter;
(3) an integrating sound level meter; or

(4) other equipment acceptable to a Director of Occupational Hygiene.

The fourth option involves applying for an acceptance, a process described in section 10 of the *OHS Regulation*.

Sound level meter

This is the basic measuring instrument for noise. It consists of a microphone that converts sound pressure variations into electrical signals, a frequency selective amplifier, a level range control, frequency weighting to shape the frequency response of the instrument, and an indicator. For each particular application, the measurement technique must be carefully chosen and controlled to obtain valid and consistent results.

ANSI Standard S1.4-1983 (R2006), *Specification for Sound Level Meters*, provides three frequency weighting scales (A, B and C, although only A-weighted measurements are used in the OHS Code) and two exponential time averaging characteristics, slow and fast In most industrial settings, the meter fluctuates less if measurements are made with the slow response setting. The fast response setting is normally used to measure how noise fluctuates over time rather than noise exposure.

The Standard specifies three grades of instruments:
(1) Type 0 — intended for use in a laboratory as a reference standard;
(2) Type 1 — intended for precision measurements of sound in the field and laboratory; and
(3) Type 2 — designated for general field use to measure typical environmental sounds where high frequencies do no dominate.

The accuracy of a sound level meter is dependant on the type of meter, the frequency being measured, the orientation of the sound relative to the microphone and the time variation of the sound pressure. Selection of a particular sound level meter should be made following a review of the need for accuracy, the frequency and other characteristics of the sound being measured.

Correct use of the microphone is very important to obtaining accurate measurements. Microphones are designed for use in a particular environment across a specific range of sound pressure levels and frequencies. They also differ in directionality as some must be pointed directly at the sound source and others at an angle to the sound source. Equipment users need to follow the manufacturer's instructions regarding the type and size of microphone and how it is to be used.

Noise dosimeter

A noise dosimeter is a sound level meter worn by the worker. It measures and stores sound levels during an exposure period and computes the exposure as a percentage of a criterion level such as an occupational exposure limit. The noise must be measured using an A-weighted filter with a 3 dBA exchange rate in order to compare the measured results to the exposure limits specified in the OHS Code. ANSI Standard S1.25-1991 (R1997), *Specification for Personal Noise Dosimeters*, provides acceptable characteristics for noise dosimeters.

In noise dosimetry, the microphone is attached to the worker whose noise exposure is being measured. Placement of the microphone is important in estimating exposure. The microphone is usually mounted on a shoulder, at the chest, or in the ear.

When noise levels are continuous and the worker remains essentially in one work area during the work shift, measuring noise exposure with a sound level meter is relatively straightforward. However, a noise dosimeter is preferred for measuring worker exposure when noise levels vary or are intermittent, when they contain components of impulse noise or when the worker frequently moves around during the work shift.

Integrating sound level meter

This instrument is a sound level meter with properties similar to those of a dosimeter. Like a noise dosimeter, it can be used to measure varying or intermittent noise and impulse noise and the worker can move around while wearing the instrument.

Typical applications for integrating sound level meters are identical to those for standard sound level meters. Integrating sound level meters can however be used to measure the average sound pressure level around noisy equipment or other sound sources where the integrating capacity can be used to determine the average sound level in space as well as time. The two main differences between sound level meters and integrating sound level meters are:

(1) averaging durations for an integrating meter are usually much longer than those for a standard sound level meter, extending to minutes or hours; and
(2) the integrating meter gives equal emphasis to all sounds that occur during the selected averaging period, while the standard sound level meter gives more emphasis to recently occurring sounds.

Instrument operation

To ensure that measurements are accurate, sound measuring equipment must be calibrated, maintained and operated according to the manufacturer's specifications. Calibrations are often required annually.

For more information

http://employment.alberta.ca/documents/WHS/WHS-PUB_hs003.pdf
Noise in the Workplace

Section 220 Results recorded

Written measurement results must include the date of the measurement, the workers or occupations evaluated, the type of measuring equipment used, the sound level readings measured and the work location evaluated. For quality control purposes, the measuring equipment should be uniquely identified by number or other appropriate designation. A worker affected by noise at the workplace must be able to access a copy of the measurements on request. The employer must also make measurement results available to an officer on request. As long as the employer continues to operate within Alberta, a copy of the measurements must be kept on file at the employer's premises.

Section 221 Noise management program

If a noise exposure assessment confirms that workers are exposed to noise in excess of the occupational exposure limits listed in Table 1 of Schedule 3, the employer must develop and implement a noise management program (sometimes referred to as a hearing conservation program). Section 8 of the *OHS Regulation* requires that the program's procedures be in writing and available to workers. Workers are required to cooperate with the employer in implementing the program.

The program must include the following seven components:
(1) worker education;
(2) measuring or monitoring worker exposure to noise;
(3) posting warning signs in any work area where the noise level exceeds 85 dBA;
(4) use of noise control methods;
(5) selection, use and maintenance of hearing protection devices;
(6) audiometric testing; and
(7) annual program review.

Worker education

The success of a noise management program largely depends on effective worker education. Workers need to understand the reasons for, and requirements of, the program. Workers must also understand their role in the program. Worker education should be ongoing and meet the specific exposure and prevention needs of each worker or group of workers.

At a minimum, the worker education component of the program should include the following elements:

(a) regulatory requirements and responsibilities;
(b) occupational exposure limits — what they are and why they are needed;
(c) the effects of noise on hearing;
(d) the employer's policy on eliminating noise as a hazard, including the noise controls already in place or planned for the future;
(e) identification of hazardous noise sources at the workplace;
(f) training in the use of protective equipment i.e. purpose of hearing protectors, types of protectors available, advantages and disadvantages of the various types of hearing protectors available, selection, fitting, use and care, troubleshooting. This training should include supervised, hands-on practice in the proper fitting of hearing protectors;
(g) audiometric testing i.e. its role in preventing hearing loss, a description of the test procedure, interpretation and implications of test results; and
(h) individual responsibilities for preventing hearing loss i.e. compliance with the program, noise exposure and hearing loss in non-occupational settings.

Measuring or monitoring worker exposure to noise

What needs to be done to protect workers depends on the level and type of noise they are exposed to at the workplace. Measuring sound levels identifies noise sources and those workers most likely to be exposed to noise exceeding the occupational exposure limits.

Posting warning signs

Warning signs must be posted at the periphery of any work area where the noise level exceeds 85 dBA. The signs should include a statement that hearing protectors must be worn while in the area. A supply of several types of hearing protectors should be readily accessible to those entering the area. Signs should present their warning graphically and in words. The words should be written in English and if workers are unable to read English, the words should also appear in the predominant language of the workplace.

Audiometric testing

Workers exposed to noise levels exceeding the occupational exposure limits listed in Table 1 of Schedule 3 must undergo audiometric testing. The purpose of testing is to establish a baseline measurement of the worker's hearing and to then monitor the worker's hearing at regular intervals to detect changes in hearing ability. Audiometry is discussed in more detail in section 223.

Use of noise control methods

When reducing worker exposure to noise, engineering controls are preferred, then administrative controls, and finally appropriate personal hearing protection. Engineering controls try to minimize or eliminate exposure by altering or removing the source; administrative controls try to control exposure by modifying the circumstances of the worker's exposure; personal hearing protection reduces exposure when the other approaches have not reduced the hazard to an acceptable level. Noise control methods are discussed in more detail in section 217.

Selection, use and maintenance of hearing protectors

Hearing protectors are generally defined as anything worn to reduce the level or volume of sound entering the ear. Examples of hearing protectors are shown in Figure 16.1. Hearing protectors are subject to many problems and should be considered the last resort against hazardous noise situations. Hearing protectors can fail to provide adequate protection in many situations due to discomfort, incorrect use with other safety equipment, dislodgment, deterioration and abuse. Hearing protectors provide their greatest protection against high frequency noise and significantly less protection against low frequency noise. Nevertheless, hearing protectors can protect against noise-induced hearing loss if their use is carefully planned, evaluated and supervised.

Workers should be provided with a choice of two or three types of protectors from the class of hearing protection considered to be most appropriate for each worker's work area noise level and hearing deficit (if any). The type of protection most appropriate for a particular worker depends on the other equipment that must be worn such as safety headwear, protective eyewear, respirator, etc., the shape and size of the worker's head and ear canals, and relative comfort. Comfort is very subjective and is not related to the Class of protector i.e. a Class C protector is not necessarily any more or less comfortable than a Class B protector.

Workers do not always know when their protectors are defective or worn out. Some premoulded earplugs shrink and/or harden when exposed continuously to ear wax and perspiration. Flanges may break off and plugs may crack. Earmuff cushions may harden or crack, and headbands may lose their tension. Workers need to know how

to recognize when a hearing protector requires repair or replacement. Defective and poorly or improperly fitting protectors need to be identified and repaired, replaced or refitted.

Annual program review

The noise management program must be reviewed on a regular basis to make sure it is effective. The extent of the review should be based on the sophistication and complexity of the program, but must at least include review of the training program, an assessment of the need for further noise measurement and the adequacy of control measures.

The key measure of a program's success is whether it prevents work-related noise-induced hearing loss. The employer should consider information from the physician or audiologist when evaluating the effectiveness of the education and training programs related to noise, and the effectiveness of noise control measures. Overall results can be compared from year to year to identify trends among individuals, within occupations, for various processes, between different departments, or between different work sites. It is easier to identify specific problems when results are grouped in this way.

All components of the program should be reviewed for compliance with the employer's policies and procedures, for completeness and accuracy, and for compliance with regulatory requirements.

Section 222 Hearing protection

The following factors must be considered when selecting hearing protectors:
(a) who will be wearing the equipment;
(b) compatibility with other safety equipment;
(c) workplace conditions such as temperature, humidity and pressure;
(d) comfort — protectors that are not comfortable will not be worn;
(e) ease of use and handling; and
(f) impact on the wearer's ability to communicate.

The hearing protectors selected must meet the requirements of CSA Standard Z94.2-02, *Hearing Protection Devices — Performance, Selection, Care and Use*. This Standard provides performance requirements for personal hearing protection devices. The Standard classifies muffs and earplugs as Class A, B or C depending on the level of protection they provide. Class C provides the least degree of protection while Class A provides the greatest. Table 2 of Schedule 3, indicates the class of hearing protection to be used at various noise levels.

The classification of hearing protectors is based on how much they attenuate or reduce sound levels at nine different frequencies: 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3150 Hz, 4000 Hz, 6300 Hz and 8000 Hz. The manufacturer must provide this information to the equipment user.

The CSA Standard has introduced a 0 to 4 grading system for hearing protection devices. A device with a "0" grading provides the least protection, a device with a "4" grading provides the most. Grades are assigned to hearing protection devices based on laboratory attenuation measurements. The purpose of using a grade system is to be able to make a "go" or "no-go" determination i.e. either the hearing protection is right for the noisy situation or it is not. Such absolute decisions require the actual hazard to be known i.e. both sound pressure levels and duration of exposure must be assessed.

Equipment manufactured in the United States may bear a Noise Reduction Rating (NRR) — a class will not be specified. The NRR is not comparable to the attenuation data required by CSA. However, the manufacturer must still provide the attenuation data required by the Standard and a comparison of this data with the information provided in Table 3 of the Standard, shown as Table 16.4 will allow the user to determine the class of the hearing protector. The equipment must, in addition, comply with other requirements specified in the CSA standard.

Table 16.4 Sound Attenuation Requirements for Hearing Protectors

Frequency, Hz	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

Source: CSA Standard Z94.2-02

The noise reduction rating (NRR) of a hearing protector cannot be used reliably to determine its classification. Because NRR values are calculated differently than the class definitions given in Table 16.4, there is considerable overlap of NRR values between Classes A and B. Generally however, a hearing protector with an NRR value of at least 24 and with mean attenuation values of at least 26, 31, and 33 dB at 500, 1000 and 2000 Hz, respectively, meets the Class A requirements.

A protector that does not meet the Class A mean attenuation requirements at 500, 1000 and 2000 Hz, but has an NRR value of at least 17, generally falls into Class B. Likewise, a protector with an NRR value of less than 17 generally falls into Class C.

Note that the attenuation values shown in Table 16.4 are determined in a laboratory by the manufacturer. When hearing protectors are worn, they generally provide much less protection. An often used rule of thumb is to reduce the manufacturer's attention value by half to estimate the actual noise reduction achieved in the field.

Use of dual hearing protection

If hearing protection has been chosen according to Table 2 of Schedule 3 to control worker exposure to noise, once a worker is exposed to noise greater than 105 dBA L_{ex} the worker must wear both a plug and a muff (dual hearing protection). At noise levels greater than 110 dBA L_{ex}, dual hearing protection must be worn *and* time of exposure reduced.

When dual hearing protection is worn, the noise reduction (attenuation) at each frequency is not the sum of the individual hearing protector's attenuations, it is usually much less. This is due to the fit of the hearing protectors and the volume of air trapped between them as well as limitations created by bone conduction. Bone conduction allows sound energy to be transmitted through the bones and tissues of the skull to the inner ear, bypassing the hearing protector. It poses a limitation on the protection that any hearing protector can provide, regardless of how well it seals to the ear canal and prevents sound from entering the ear.

Hearing protectors do not work well at noise levels greater than 110 dBA $L_{ex.}$ For this reason a worker's exposure time must also be reduced, even while dual hearing protection is worn. The time reduction should be based on a 3 dBA exchange rate, as shown in Table 16.5

Table 16.5 Exposure time reduction with dual hearing protection

Exposure Level (dBA L_{ex}[1])	Exposure Time [2] (hours)
110	8
113	4
116	2
119	1
122	0.5
125	0.25

1 Worker exposure must be measured in accordance with CSA Standard Z107.56-06, *Procedures for the Measurement of Occupational Noise Exposure.*

2 This is the total noise exposure that the worker may have over the work shift. For the remainder of the work shift the worker cannot be exposed to noise greater than 85 dBA.

Proper use of hearing protection

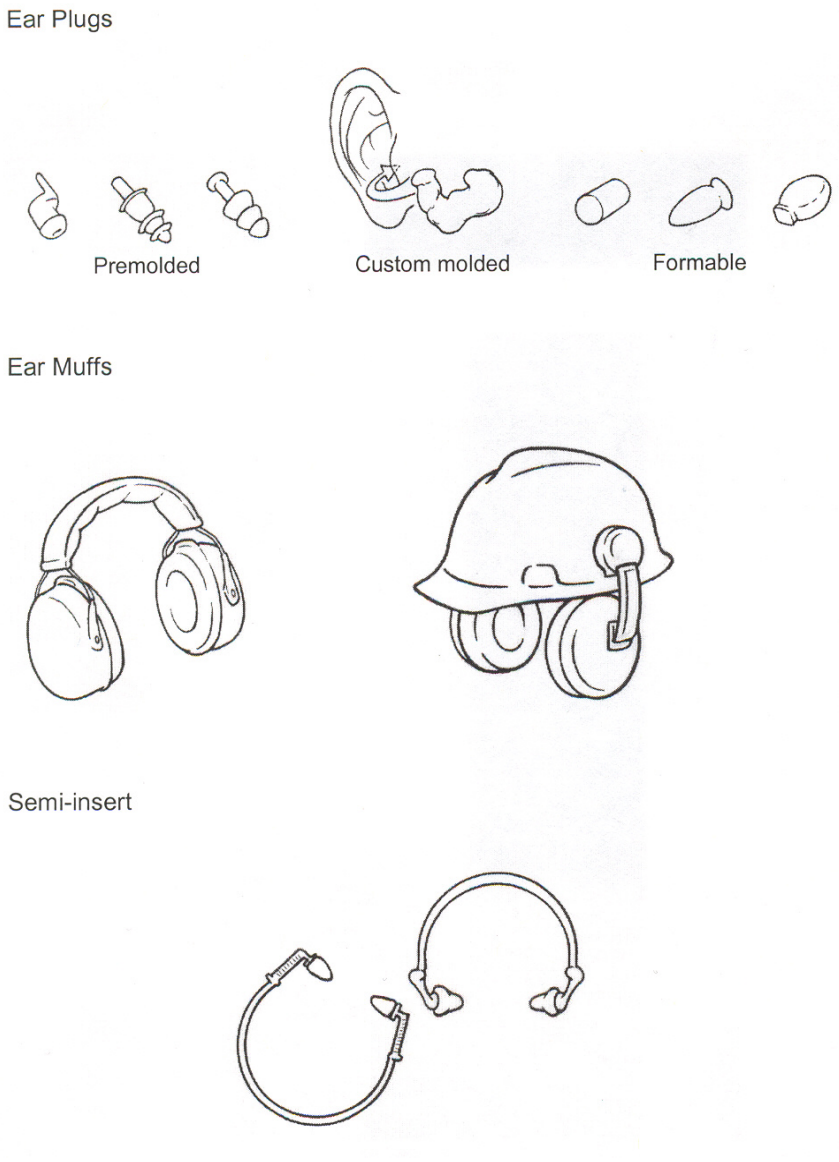
To be of value, hearing protection must be used properly and whenever the worker is in a noisy area. For this reason, workers must be trained in the selection, maintenance and proper use of the equipment. To ensure that noise-exposed workers are motivated to use and care for the equipment properly, they must understand the hazards associated with noise exposure.

It is critical that workers know how the equipment is to be worn. For maximum protection, a hearing protector must make a tight seal within the ear canal or against the side of the head. Earplugs or muffs that do not fit properly can lose 5 to 15 dB of their noise protection capacity. Modifying hearing protectors to reduce wearer discomfort by drilling holes in earcups or reducing earmuff headband tension can seriously compromise their effectiveness and is not permitted. More comfortable but equally effective protectors should be found.

While it is important to have manufacturer instructions describing the use and maintenance of the equipment, workers cannot be relied upon to receive effective instruction on fit, care and use by reading the instructions alone. Proper fitting techniques should be demonstrated and practiced by the worker under supervision.

Once hearing protectors are issued to workers, the employer must ensure they are worn. In turn, workers must use the equipment according to the training provided by the employer.

Figure 16.1 Examples of hearing protectors



Section 223 Audiometric testing

The employer is responsible for

(a) identifying noise-exposed workers,

(b) ensuring that noise-exposed workers have hearing tests conducted by an audiometric technician,

(c) paying the costs associated with a hearing test,

(d) keeping a log book containing audiometer calibration data, and

(e) keeping a record of whether the hearing test was done (but not a copy of the actual hearing test).

Any worker who is or may be exposed to noise in excess of 85 dBA L_{ex} and the noise exposure limits in Table 1 of Schedule 3, must undergo audiometric testing. By definition, this worker is considered to be a "noise-exposed worker". For example, any worker who is exposed or may be exposed to noise greater than an average of 85 dBA over 8 hours, or an average of 82 dBA over 16 hours, must undergo audiometric testing at the employer's expense.

Audiometric testing of workers' hearing is important to the success of a noise management program since it is the only way to actually determine if occupational hearing loss is being prevented. Because occupational hearing loss happens gradually over time, workers often fail to notice changes in their hearing ability until a relatively large change occurs. By comparing audiometric tests from year to year, hearing damage can be caught earlier and appropriate protective measures implemented to prevent further damage.

When a worker is or may be exposed to noise in excess of the exposure limits shown in Table 1 of Schedule 3, the worker must receive a baseline audiogram as soon as practicable, but no later than six months after the start of employment. The requirement for a baseline audiogram also applies if a worker is exposed to such noise due to a change in activities (the introduction of new equipment or processes for example) or duties (reassigned to a new job or a new, noisier area within the workplace).

It is usually best that this test be done after a minimum 12 hour period during which the worker is not exposed to any noise. The baseline audiogram is conducted in a noise-free environment when the worker has been away from noise for 14 hours, including noise exposure away from work. For workers who have audiometric testing conducted during their work shift, hearing protection may be used to meet the no noise requirement.

Additional tests are then required 12 months after the baseline test and every two years thereafter. Ideally, these subsequent tests should be scheduled at the end of or well into the work shift so that temporary changes in hearing can be noted. The results can then be compared with the baseline audiogram to check for changes in hearing sensitivity and identify a temporary hearing loss before it becomes permanent. The employer must bear the costs of testing, including time from work, if that is required.

The audiometric test consists of pure-tone-air-conduction threshold testing of each ear at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. At each frequency, the threshold recorded for the ear is the audiometer's lowest signal output level at which the individual responds in a specified percentage of trials. Noise exposure increases hearing thresholds, resulting in threshold shifts toward higher values (poorer

hearing). Exposure to noise usually causes gradual development of hearing loss over time. During each overexposure to noise, the ear develops a temporary reduction in sensitivity, called a temporary threshold shift. This shift reverses over a period of hours or days if the ear is allowed to recover in a quieter environment. If the exposure is to a sufficiently high enough level of noise, of sufficient duration or repeated, the temporary threshold shift may not reverse completely and a permanent threshold shift begins to develop.

Who does the audiometric testing?

The employer is responsible for ensuring that audiometric tests are conducted by a qualified audiometric technician who works in consultation with a physician, audiologist or occupational health nurse. The audiometric technician must keep a log book that contains the audiometer's calibration records. The log book, and therefore the calibration records, must be kept with the audiometer throughout its useful lifetime. The audiometer must be calibrated at intervals specified by the manufacturer.

Testing area

To determine if the testing environment has acceptable background noise levels must be measured. Background noise levels must be less than those listed in Table 3 of Schedule 3 and must also be recorded and kept with the calibration records. This means that if test equipment is moved to a different location, noise levels must be measured at that new location.

The purpose of conducting background noise level measurements is to ensure that background noise does not interfere with the audiometric testing and give false results.

Record keeping

The audiometric technician must record the results of the hearing test as well as maintain the calibration log books.

Audiograms are confidential medical records and cannot be given to the employer. The employer must ensure that the audiogram and the worker's medical history are under the sole control of a health professional designated under subsection 223(2)(a). Audiograms can only be released with the worker's written consent.

Test results

The audiometric technician must give the worker a copy of the results of the audiogram. The worker is encouraged to keep a record of audiometric test results in case the worker develops a hearing loss. Because employers are only required to keep audiometric test results for 10 years, the worker needs to be responsible for documenting his or her hearing over the course of his or her working life.

If the results of the audiogram are abnormal, the audiometric technician must advise the worker of the test result and request the worker to provide a health history related to hearing. The audiometric technician must send the results of an abnormal audiogram or an audiogram showing an abnormal shift, the baseline audiogram, and the health history to the physician or audiologist designated by the employer to review audiograms.

Responsibility of designated physician and audiologist

The physician or audiologist designated by the employer reviews relevant medical information and the audiogram to ensure that the test results are valid. If the audiogram is valid, the physician or audiologist confirms the classification of the test results as being either an abnormal or an abnormal shift audiogram. The physician or audiologist can recommend follow-up which may include repeat testing or referral to another health care professional.

If the physician or audiologist confirms that the audiogram is an abnormal or an abnormal shift audiogram, the worker must be advised of this within 30 days of the physician or audiologist receiving the test results. With the worker's written consent, the physician or audiologist must provide a copy of the audiometric test results to the worker's physician.

The physician or audiologist must advise the employer as to the effectiveness of the noise management program in place at the work site as it relates to worker hearing. In order for the employer to evaluate the effectiveness of its program, the employer should also designate a knowledgeable person at the work site to consult with the physician or audiologist to provide specific details of the noise management program, such as hearing protection worn, work site noise levels, and personal dosimetry results. This person could be the audiometric technician.

When advising the employer as to the effectiveness of the noise management program, a list with the names of the workers and the dates when they were tested should be given to the employer, not the worker's actual audiograms. Audiograms should be categorized and an explanation of the group results given to the employer. Analyzing audiometric test results can provide a good indication of the program's effectiveness.

The audiometric technician or health professional must keep the audiogram and health history for at least 10 years.

Who pays for audiometric testing?

The employer is responsible for paying for audiometric testing and the interpretation of the results. Every effort should be made to have the audiometric testing conducted during normal working hours. If the testing takes place during the worker's hours of work, the worker's wages, salary or benefits cannot be deducted for the period of time the worker is being tested. If it is impractical for the worker to have the audiogram during his or her normal working hours, the employer must pay the worker for the time that is spent having the test conducted. If travel to or from the audiometric testing happens during working hours, the worker's wages, salary or benefits cannot be deducted for this period.