

MODULE 12: PERSONAL PROTECTION

THIS MODULE IS FOR	Noise manager Hearing protector specialist Nurse/medical staff Employee representatives OHS committee
PURPOSE	The purpose of this module is to assist organisations establish effectively managed and maintained hearing protection programmes.
CONTENTS	OVERVIEW HEARING PROTECTION GRADING SYSTEM HEARING PROTECTOR GRADING SELECTING HEARING PROTECTORS WITH ADEQUATE NOISE REDUCTION SELECTING THE RIGHT PROTECTORS FOR EACH PERSON COMPATIBILITY WITH THE WORK ACCEPTABILITY TO THE WEARER MONITORING THE USE OF HEARING PROTECTORS HEARING PROTECTOR MAINTENANCE CHECKLISTS PROBLEMS FURTHER READING

SETTING UP AN EFFECTIVE PERSONAL PROTECTION PROGRAMME

OVERVIEW The key requirements for an effective personal hearing protection programme are that:

- management clearly supports the programme in a written policy and by example;
- managers, supervisors and employees are aware of their responsibilities;
- each wearer is fitted with adequate, comfortable and acceptable hearing protectors;
- wearers are given information and training to provide necessary knowledge and skills;
- noisy areas are signposted;
- noisy, portable equipment is labelled;
- regular checks are made of wearing rates and practices;
- feedback is provided to wearers and managers of the results of checks;
- protectors are regularly cleaned;
- there are frequent maintenance checks of protectors and prompt replacement of worn or damaged items;
- wearer problems are dealt with promptly and sympathetically;
- wearers are aware that the programme is part of a more comprehensive noise management programme that aims, wherever possible, to reduce noise levels progressively to the point where hearing protectors will not be required.

Many of the above points are mentioned in Step 4 of the CORE. This module goes into a number of issues in greater detail and provides a list of useful publications.

HEARING
PROTECTION
GRADING SYSTEM

Hearing protectors are currently tested and graded in New Zealand by the Institute of Environmental Science & Research with the assistance of the National Audiology Centre, in Auckland.

The protectors are tested to the International Standard, ISO 4869 or Australian Standard AS1270. This uses a subjective method to determine how well they perform at reducing different frequencies of sound. It is an attempt, in the laboratory, to assess how they will perform when used properly in a work situation. Their effectiveness at reducing (attenuating) noise determines into which Grade they are placed.

For example, in order to be a Grade 1 protector, it must be able to reduce a noise level of 91 dB(A) outside, to no more than 85 dB(A) inside the device. This is a reduction of at least 6 dB(A). It will not get into Grade 2 if it cannot reduce the level by at least 12 dB(A), and so on.

HEARING
PROTECTOR
GRADING

Hearing protectors are assigned to one of five hearing protection grades according to their acoustic performance. They should be selected on the basis of the Noise Exposure Level ($L_{Aeq,8h}$) or the Peak Level (L_{peak}) to which an employee is exposed.

TABLE 1: NOISE
EXPOSURE
GRADES

<i>Hearing Protection Grade</i>	$L_{Aeq,8h}$ (dB(A))	L_{peak} (dB)	<i>Types of Suitable Hearing Protection Device</i>
1	86 - 91	141 - 46 ⁽¹⁾	Earplugs or earmuffs
2	92 - 97	147 - 152 ⁽¹⁾	Earplugs or earmuffs
3	98 - 103	153 - 158 ⁽¹⁾	Earmuffs
4	104 - 109	159 - 164 ⁽¹⁾	Earmuffs
5	110 - 115	165 - 170 ⁽¹⁾	Earmuffs
5		>140 ⁽²⁾	Earmuffs+earplugs

(1) Where $L_{CFMax} - L_{AFMax} < 5$ (L_{CFMax} is the Maximum, C-weighted, "Fast" time-response level)

(2) Where $L_{CFMax} - L_{AFMax} \geq 5$ (L_{AFMax} is the Maximum, A-weighted, "Fast" time-response level)

SELECTING
HEARING
PROTECTORS WITH
ADEQUATE NOISE
REDUCTION

There are two methods used for calculating the noise reduction required of hearing protectors for given exposure conditions:

- The GRADING SYSTEM (which uses a method similar to the Australian SLC80 method) requires only a single measurement, that is, of the A-weighted

sound pressure level ($L_{Aeq,T}$) of the noise to determine the Noise Exposure Level, $L_{Aeq,8h}$, together with the 'Peak' sound pressure level in the case of impactive or impulsive noise. This is the method normally used for hearing protector selection in industry.

- The OCTAVE BAND METHOD is more accurate but requires that the frequency content of the noise be measured in at least seven octave bands. In practice, its use is restricted to situations involving a very high level noise or noise with intense tonal, infrasonic or ultrasonic components. These situations are rare in industry.

WARNING:

An alternate single number rating — the NRR — is used to rate hearing protectors in the USA. The NRR value is usually much higher than the Australian SLC80 value and the reduction indicated by the grading of the device in New Zealand. NRR has not been standardised in either New Zealand or Australia and should not be used.

The appropriate type of hearing protector for a given exposure condition therefore normally requires only the determination of the Noise Exposure Level ($L_{Aeq,8h}$) and the Peak Level (L_{peak}).

Suppose hearing protectors are to be selected for an employee whose typical daily noise exposure pattern is as shown in the following table:

TABLE 2: TYPICAL DAILY NOISE EXPOSURE DETAILS FOR AN EMPLOYEE

<i>Machine/Process</i>	<i>Measured noise level</i> $L_{Aeq,T}$ <i>(dB(A))</i>	<i>Exposure Duration</i> <i>(Hours)</i>	<i>Partial Noise Exposure</i> (Pa^2h)
Furnace	105	0.5	6.5
Chipping hammer	96	4.0	6.4
Power hacksaw	88	1.5	0.4
Welding	90	2.0	0.8
Daily Noise Exposure (DNE)			14.1

The correct way to select an appropriate hearing protector is to determine the $L_{Aeq,8h}$ for this exposure and select the appropriate grade from Table 1 above.

In this example, a DNE of $14.1 \text{ Pa}^2\text{h}$ is an $L_{\text{Aeq},8\text{h}}$ of 96 dB(A). (See Core Module Appendix 2 for the method of determination).

The appropriate protector to be selected is therefore Grade 2.

A SIMPLE EXAMPLE: An operator works in an area for eight hours where the noise level is 88 dB(A). There are also transient noises present which produce Peak levels of 155 dB. The transient noise gives a maximum C-weighted fast response level of 112 dB(C), and a maximum A-weighted fast response level of 110 dB(A). What is the hearing protection grade for the area and what type of hearing protection should be worn?

The employee is exposed to an $L_{\text{Aeq},8\text{h}}$ of 88 dB(A), and a L_{peak} of 155 dB with an $L_{\text{CFMax}} - L_{\text{AFMax}} < 5$.

The type of protection required to protect against the $L_{\text{Aeq},8\text{h}}$ of 88 dB(A) is Grade 1.

The L_{peak} of 155 dB requires Grade 3 protection.

The Hearing Protection Grade required is therefore the highest of these requirements, Grade 3. The type of hearing protection to be selected is therefore Grade 3 earmuffs.

ANOTHER APPROACH: A common approach to selection of a protector is to use the highest dB(A) level to which the employee is exposed. This is a “super safe” approach since it means the employee will be adequately protected even if exposed all day to the highest dB(A) level measured in their working environment.

In the present example in Table 2, the highest noise level is 105 dB(A). The hearing protector selected using this “super-safe” approach would need to be Grade 4 (which gives protection up to 109 dB(A)).

Two qualifications to this basic procedure are worth remembering.

AVOIDING UNDER-PROTECTION: It should be noted that the grading system does *not guarantee* adequate protection for all wearers, even

when the correct grade device is used. The system will only give adequate protection in approximately 84% of cases. Also, when an unusual noise is present, particularly one containing high levels of low-frequency sound, adequate protection may also not be achieved.

It is therefore common practice to select a protector with a grading of 1 greater than the calculated requirement.

In the present example, in which the requirement is Grade 2, common practice would be to select hearing protectors with a grading of 3.

AVOIDING OVER-PROTECTION

While it is obvious that under-protection should be avoided, over protection is also undesirable. This is because it may lead to the selection of unnecessarily heavy or tight protectors, create communication problems and make the wearers feel isolated from their surroundings. Protectors may be tampered with or used only part-time as a result, and the effective protection will then be much less than would have been obtained with more carefully chosen devices (see figure 1 (page10)).

This point can be illustrated by further analysis of the example considered above. Suppose Grade 5 hearing protectors were chosen for the person whose typical daily noise exposure was shown in Table 1. The dB(A) levels to which the employee would be exposed when wearing the protectors may be estimated by subtracting 30 dB(A) from each of the dB(A) levels. This leads to the situation shown in Table 3.

TABLE 3:
ESTIMATED DAILY
NOISE EXPOSURE
DETAILS FOR THE
EMPLOYEE IN
TABLE 2, WHEN
WEARING GRADE
5 HEARING
PROTECTORS

<i>Machine/Process</i>	<i>Noise level LAeq,T (dB(A))</i>	<i>Effective Noise Level LAeq,T (dB(A))</i>	<i>Exposure Duration (Hours)</i>	<i>Partial Noise Exposure (Pa²h)</i>
Furnace	105	75	0.5	0.0065
Chipping hammer	96	66	4.0	0.0064
Power hacksaw	88	58	1.5	0.0004
Welding	90	60	2.0	0.0008
Daily Noise Exposure (Pa ² h)				0.0141

The protectors have reduced the employee's daily noise exposure from 14.1 to 0.0141 Pa²h, a very considerable reduction and much more than is really necessary. 0.0141 Pa²h is equivalent to an $L_{Aeq,8h}$ of 66 dB(A).

Hearing protectors with lower noise reduction could safely be considered. Suppose, for example, that Grade 2 protectors were selected (as they should have been). Then the employee's estimated exposure would be as shown in Table 4. It may be assumed that Grade 2 protectors reduce the noise level by 12 dB(A).

TABLE 4:
ESTIMATED DAILY
NOISE EXPOSURE
DETAILS FOR THE
EMPLOYEE IN
TABLE 2, WHEN
WEARING GRADE
2 HEARING
PROTECTORS

<i>Machine/Process</i>	<i>Noise Level $L_{Aeq,T}$ (dB(A))</i>	<i>Effective Noise Level $L_{Aeq,T}$ (dB(A))</i>	<i>Exposure Duration (Hours)</i>	<i>Partial Noise Exposure (Pa²h)</i>
Furnace	105	93	0.5	0.40
Chipping hammer	96	84	4.0	0.40
Power hacksaw	88	76	1.5	0.02
Welding	90	78	2.0	0.05
Daily Noise Exposure (Pa ² h)				0.87

The employee's estimated daily noise exposure is still only 0.87 Pa²h, which is equivalent to a noise exposure level, $L_{Aeq,8h}$ of 84 dB(A). Clearly, Grade 2 protectors would be quite adequate in this situation.

This example shows that selecting hearing protectors solely on the basis of noise levels, that is, without taking account of exposure duration, can lead to unnecessary over-protection with potential problems for the wearer.

If such problems are likely to arise, the solution is to undertake a more detailed analysis of the exposure conditions, taking account of exposure duration as well as noise levels, and select a protector with less — but still adequate — noise reduction, as in Table 4 above.

SELECT THE
RIGHT
PROTECTORS
FOR EACH
PERSON

Once the range of available protectors is narrowed to those with adequate noise reduction, the next objective is to ensure that each wearer is correctly fitted with a suitable and acceptable device. No single hearing protector suits everybody so it is important for wearers to be individually fitted.

EARMUFFS

To ensure that earmuffs fit, a wearer should be able to answer “yes” to the following questions:

- Can the ears be fitted comfortably inside the earmuff shells?
(The cushions should not press the ears against the head but should surround them. Some earmuffs are deliberately designed so that the openings into the shells are fairly narrow while the shells themselves are quite spacious. This is done to improve noise reduction. It may be necessary to manipulate the ears through the openings when putting the earmuffs on. Provided the ears can resume their normal shape once inside the shells, this is not a problem.)
- Can the headband be adjusted so that the earmuffs are held firmly in place?
- Can the headband be adjusted so that the cushion pressure feels evenly distributed around the ears?
- Is the weight of the muffs comfortably supported?
- Is there a close fit between the cushions and the head so that there are no gaps?
(Some common causes of gaps are prominent cheekbones, a deep groove behind the jaw below the ear, thick hair and beards).
- Is there a noticeable reduction in the loudness of sounds?
(The best place to fit hearing protectors is in noisy surroundings, ideally the workplace in which they will be worn. If a reduction in loudness is not clearly noticeable, the fit is inadequate).

EARPLUGS

It takes time and practice to fit earplugs correctly. People who have never worn earplugs before should, if possible, be shown what to do by an experienced fitter or user. Techniques for earplug fitting are illustrated in *Module 10: Fact Sheets*.

To ensure that earplugs fit, a wearer should be able to answer “yes” to the following questions:

- Can the earplugs be fitted without difficulty?
(Persons with impaired finger dexterity, as a result

of arthritis or injury for example, may be unable to use earplugs).

- Are the earplugs comfortable?
(It takes 2-3 weeks for people who have not worn earplugs before to get used to them. Early judgments of comfort may not be reliable).
- Do the earplugs appear to be firmly seated in the ear canals?
- Do you experience a noticeable reduction in the loudness of sounds?
(If not, the fit is inadequate).

COMPATIBILITY
WITH THE
WORK

It is essential that the selected hearing protectors do not interfere with the wearers' work and, conversely, that the requirements of the job do not interfere with the proper functioning of the protectors. Problems of equipment compatibility have recently been addressed by several safety equipment manufacturers. Shop around if compatibility problems arise.

EARMUFFS

To ensure that the wearing of earmuffs is compatible with the work, wearers should check if:

- they are able to move freely without dislodging the protectors;
- they are still able to gain access to confined spaces (for example, for machine maintenance) without having to remove the protectors;
- there is any interference between the protectors and other equipment worn, such as a welding shield, a cap, a respirator, eyeglasses or goggles.

EARPLUGS

To ensure that the wearing of earplugs is compatible with the work, wearers should check if:

- There is a need to remove and replace protectors frequently. If there is, earmuffs or ear caps may be more convenient.
- Their hands are likely to be soiled by work. If they are, earmuffs may be more convenient.

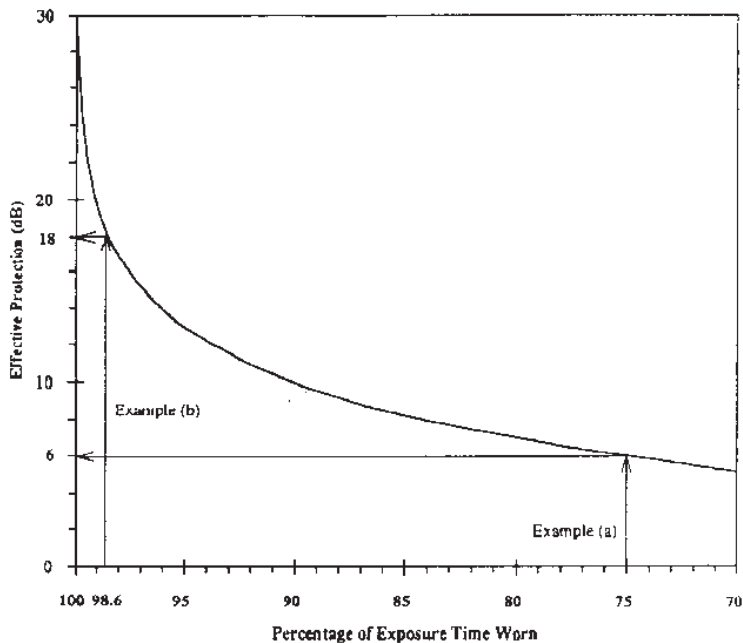
ACCEPTABILITY
TO THE
WEARER

To be effective, protectors must be worn all the time whenever the wearer is in the presence of hazardous noise. To be worn all the time, the protector must be highly acceptable to the wearer. Giving employees free choice from a range of protectors, subject of course to satisfactory fit and comfort, has been found to significantly improve acceptability. Once three or four adequate protectors have been identified, therefore, employees should be given free choice between them.

Employees are also likely to find hearing protectors more acceptable if they are aware that the organisation is working towards progressive noise reduction. Publicising the organisation's noise policy and noise control plan will also help boost hearing protector acceptability.

The removal of hearing protectors for even short periods of time can dramatically reduce their effectiveness and lead to under-protection for the wearer (see figure 1 below).

FIGURE 1:
REDUCTION IN
THE EFFECTIVE
PROTECTION
PROVIDED BY A
GRADE 5 HEARING
PROTECTOR WITH
DECREASED
WEARING TIME IN
A GIVEN NOISE
ENVIRONMENT



Due to the difficulties of wearing hearing protectors for long periods of time in some environments, it is important that regular brief rest periods in quiet areas be provided, to maximise the proper use of protection when needed.

Over a working day, periods of a few minutes unprotected exposure are easy to accumulate, for example by placement and removal of the protectors while in the noisy area rather than before entering and after leaving it; or by removing hearing protectors briefly for purposes of comfort, communication or any other reason.

EXAMPLES

- (a) If not worn for 15 minutes during a total exposure time of 1 hour (worn 75% of the time), the effective protection provided by a Grade 5 (30 dB) hearing protector is only 6 dB. This means that worn in this way, the Grade 5 protector effectively gives the same protection as a Grade 1 protector worn all the time (for the full hour of exposure).
- (b) If not worn for 5 minutes during a total exposure time of 6 hours (worn 98.6% of the time), the effective protection provided by a Grade 5 hearing protector is only 18 dB; the effective protective value is 2 Grades (12 dB) lower than expected.

It cannot be overemphasised that, in order to give adequate protection, a hearing protector must be worn for the entire time of exposure to excessive noise. If there is any exposure to excessive noise through lack of wearing, the use of a higher grade protector than necessary when it is worn will not compensate for this exposure.

Once accumulated, noise exposure cannot be taken away.

MONITORING
THE USE OF
THE HEARING
PROTECTORS

Frequent checks should be carried out to ensure that hearing protectors are worn correctly and consistently. This is especially important in the early stages of a personal hearing protection programme and for new employees who may not have used hearing protectors before, or who have not previously been shown how to use them correctly.

Correct wearing means always fitting and wearing the protector according to instructions supplied with the device. If no instructions are available, use the general fitting instructions in *Module 10: Fact Sheets*, which

also illustrates some common fitting errors to avoid.

Consistent wearing means *always* wearing protectors whenever the surrounding noise level is such that voices have to be raised to communicate over a distance of a metre, that is, when the noise level is over 85 dB(A).

The safest and most practical rule for hearing protector users is always to wear protectors whenever the noise level reaches 85 dB(A), regardless of exposure duration, and many organisations now incorporate this rule in their hearing protection programmes.

WHO SHOULD CHECK? Supervisors are usually best placed to undertake these checks since they are in constant contact with wearers. Other managerial staff, especially the noise manager, should also be involved. Anyone undertaking these checks should be familiar with the contents of this module and the Fact Sheets on hearing protectors. Ideally they should also have received some basic training from the hearing protector supplier(s).

FEEDBACK To sustain interest in the personal protection programme and to encourage consistent and correct usage of earmuffs and earplugs, provide feedback to employees on the results of monitoring usage. For example, graphs or “thermometer-type” scales could be used to post weekly “per cent wearing rates” and “per cent correctly worn rates” results on a prominent notice board. These data should also be given to management. They are especially useful for highlighting problems, but are also useful for demonstrating progress. Several research studies have confirmed the value of this type of feedback in helping develop optimum usage rates.

HEARING PROTECTOR MAINTENANCE CHECKLISTS All hearing protectors except disposable earplugs should be checked at least once a month, using the following checklists. All types of protectors should be inspected for cleanliness and, where necessary, cleaned.

EARMUFFS If the answer to any of the following questions is “yes”, then the relevant part should be replaced:

- Has the headband lost tension?
(Lay the muffs on a bench and check that the gap between the cushions is no greater than on a new pair of the same kind).
- Is there any possibility of an air leak where the headband is attached to the shells?
- Are there any holes or cracks in the plastic shells?
- Are there any creases or grooves in the cushions?
- Are the cushions torn or split?
- Are the cushions harder than new ones?
- Are the foam liners inside the shells damaged or hardened?

EARPLUGS Compressible Foam Types

Compressible foam plugs are maintenance-free as they are basically disposable, though they can be re-used several times if kept clean. They should be washed in warm soapy water as necessary and allowed to dry before being worn again.

Rubber or Plastic Types

If the answer to any of the following questions is “yes”, then the rubber or plastic earplugs should be replaced:

- Are any parts missing?
- Does the plug have any splits or holes?
- Is the plug harder than a new one?
- Is the plug a different shape from a new one?

PROBLEMS A system should be established for dealing with problems which wearers experience with hearing protectors. A basic system would be for wearers first to approach their supervisor, then to be referred to the noise manager and/or hearing protector specialist if the supervisor is unable to resolve the problem.

PROBLEM-SOLVING RESOURCES Those responsible for supervising the use of hearing protectors and dealing with problems need relevant basic training. Other sources of help include

Management of Noise at Work: Resource Kit, other supervisors, the organisation's noise manager, hearing protector specialist, nurse, safety officer, the hearing protector supplier and the occupational health and safety services of relevant employer associations, employee representatives and Occupational Safety and Health. Some helpful publications are listed at the end of this module.

DISCOMFORT It can take 2-3 weeks for people to become accustomed to wearing hearing protectors. If discomfort persists after that time the problem needs to be investigated carefully and sympathetically.

If the wearer has chosen his or her own hearing protector from a suitable range in accordance with the selection guidelines above, the incidence of discomfort problems will be minimised. However, some discomfort problems become apparent only after a period of actual use (for example, there might be a slowly developing sore spot where earmuffs are pressing eyeglass arms against the head). Possible solutions are to fit special foam pads over the arms (contact the earmuff supplier, hearing in mind that these pads can reduce noise reduction by up to 1 Grade (3-6 dB)), try different earmuffs, fit narrow eyeglass arms or change to earplugs. If the problem persists it may be necessary to refer the wearer to an experienced audiologist, hearing conservation consultant or doctor.

NON-WEARING A person may not be convinced of, or seriously concerned about, the risk of hearing damage. If so, check that they have been given the relevant fact sheets from *Module 10: Fact Sheets* and talk over the main points, refer to the workplace noise survey to point out places and equipment where hazardous noise levels have been measured, explain the organisation's plans for future noise reduction, and point out that employees are under a legal obligation to use hearing protectors in designated areas.

RELUCTANCE TO WEAR In situations where employees are reluctant to wear hearing protectors even if they are aware of the risk,

there may be an underlying problem. For example, some employees may already have some degree of hearing impairment and be concerned that they will not hear warning sounds. Such problems need careful investigation and may require referral to an audiologist or other specialist.

LONG-TERM
WEARING OF
PROTECTORS

Difficulties experienced by employees are not uncommon, especially if hearing protectors have to be worn for long periods. The use of hearing protectors introduces uncertainties into this mode of risk control and highlights the importance of long-term planning to remove noise hazards wherever possible.

FURTHER
READING

Australian Standard *AS 1269, Acoustics - Hearing Conservation*.

Gasaway, D.C., *Hearing Conservation - A Practical Manual and Guide*, Prentice-Hall Inc., New Jersey, 1985.

Gasaway, D.C., "Motivating Employees to Comply with Hearing Conservation Policy", *Occupational Health and Safety*, June, p. 62-7, 1984.

National Acoustic Laboratories, *Attenuation of Hearing Protectors*, 7th Edition, AGPS, Sept 1994. (Available from Australian Government Publishing Service Bookshops which are in all capital cities and from the National Acoustic Laboratories, Chatswood, NSW, phone (+61 2) 412 6920 or (+61 2) 412 6890.)

Occupational Safety and Health Service, *List of Graded Hearing Protectors*, available from your local branch of the Occupational Safety and Health Service, Department of Labour (included in *Management of Noise at Work: Resource Kit*).

Royster, J.D. and Royster L.H., *Hearing Conservation Programmes, Practical Guidelines for Success*, Lewis Publishers, 121 South Main St, Chelsea, Michigan, 1990.

Several manufacturers and suppliers of hearing protectors also produce excellent information and training materials.