

CONTROL GUIDE

MANAGEMENT OF NOISE AT WORK

Acknowledgment

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PREFACE

The Occupational Safety & Health Service (OSH) *Control Guide: Management of Noise at Work* has been prepared in response to a problem which resulted in over 9,000 workers' compensation claims to ACC in the 1991-92 year for industrial deafness and cost the nation \$38 million in compensation payments alone.

Noise-induced hearing loss (NIHL) is one of the priority areas for action of the Occupational Safety & Health Service. The Service's national strategy for the prevention of occupational noise-induced hearing loss, which sets a framework for national action on this issue, has been endorsed by employer and employee organisations.

Elements of the national strategy include the promotion of preventive measures; development of materials to assist workplace prevention, training and education; research; and the development of legislation, standards and an approved code of practice.

The legislative framework for noise exposure prevention, which sets noise exposure limits and responsibilities for employers and employees, is in place. The Occupational Safety & Health Service has developed regulations on occupational noise and issued an approved code of practice for the management of noise and the protection of hearing at work.

Legislation on its own, however, is not enough. It is important to understand that effective prevention requires that managers, workers and the general public have a better understanding of the potential for noise-induced hearing loss and access to information about how to control noise.

The *Control Guide: Management of Noise at Work* provides step by step guidance to assist organisations to effectively manage workplace noise and prevent noise-induced hearing loss.

The best way to control noise is to purchase quieter equipment in future, and to apply noise control measures to existing noisy equipment.

For some workplaces in some industries, achieving safe noise levels may require the application of noise management policies, planning and budgeting over a number of years.

While these control measures are being formulated and implemented, employees need to be protected from the effects of unsafe levels of noise through personal hearing protection programmes. To be effective, such programmes must be carefully managed. This guide therefore provides comprehensive information to assist organisations to conduct an effective personal programme as an interim measure for those employees at risk.

To summarise, this guide provides the information needed by management to implement a comprehensive programme and strategy for managing noise. The essential ingredient from management is commitment to action, shown through personal involvement and the allocation of adequate resources.

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STRUCTURE OF THE CONTROL GUIDE

The control guide consists of a core and twelve modules. The core comprises five basic steps and provides an overview of what is involved in organising a complete noise management programme. A short chapter explains what is involved in each step.

The twelve modules provide supporting information which can be drawn on in implementing each of the steps. The flow chart on page xii illustrates the implementation process and indicates the links between the core and the modules. It also highlights the need to involve a range of people in the programme.

While the entire control guide is intended to be a resource accessible to everybody involved in the organisation's noise management programme, the table below indicates which modules are most relevant to specific functional sub-groups. The noise manager especially will find all the modules useful in co-ordinating the programme and developing reports to, for example, the chief executive officer, production engineer and health and safety committee.

<i>Module</i>	<i>Chief Executive Officer</i>	<i>Production Engineering Staff</i>	<i>Maintenance Staff</i>	<i>Nurse/Medical Staff</i>	<i>Purchasing Staff</i>	<i>Employee Reps/OHS Committee</i>
1	✓	✓				✓
2		✓	✓			✓
3		✓	✓			
4		✓				
5		✓				✓
6	✓	✓				
7	✓	✓				✓
8		✓			✓	
9		✓				
10	✓	✓	✓	✓	✓	✓
11				✓		✓
12				✓		✓

USING THE CONTROL GUIDE

The material in the guide can be approached in many different ways, depending on the user's needs. The following notes suggest how three key groups might most efficiently use the guide.

CHIEF EXECUTIVE OFFICERS:

- Scan CORE pages 1 to 6 for overviews of your organisation's legal obligations regarding noise and of the costs and benefits of managing noise effectively.
- Scan the Overview (page v).
- Scan CORE pages 14 to 16 for suggestions regarding delegation of responsibilities for the programme.
- If time permits, scan other parts of the guide that interest you, especially modules 1, 6, 7 and 10.
- Delegate responsibility for detailed management of the noise management programme to an appropriate person (the guide refers to this person as the noise manager) and pass the guide on to this person with an indication of your personal support for the programme.

NOISE MANAGERS:

- Read through the entire core section to get a clear overview before starting work on the programme itself — if you set aside ten to fifteen minutes a day, this will take no more than two weeks.
- Arrange a meeting to inform and consult with others who will be involved in or be affected by the programme (see ESTABLISH CONSULTATIVE PROCESS, page CORE 8).
- As necessary, photocopy relevant modules and sections of the guide and distribute them to others (see the table on page ix).
- Systematically work through the programme steps (see the flow chart on page CORE xii for an overview), referring to specific modules as the need arises.

EMPLOYEE AND HEALTH AND SAFETY REPRESENT- ATIVES:

- Read *Module 10: Fact Sheets* for a general review of the effects of noise on hearing and approaches to prevention.
- Read Step 1 (CORE pages 1 to 6) for an overview of

legal and other reasons your organisation should tackle noise problems.

- Read *Module 7: Noise Policy*.
- As time permits, read modules 2, 5, 11 and 12 for further information and ideas.
- Cooperate in the development of your organisation's noise management programme, using the guide as a general reference.

NOISE MANAGEMENT FLOW CHART

Time Frame	Programme Steps (see details in Core)	Consultation	Module Reference
Immediate	<div style="border: 1px solid black; padding: 5px; text-align: center;"> 1 Establish a Basis for Action </div>	Inform all levels of management Advise employee representatives	1 Case Studies 6 Costs/Benefits 10 Fact Sheets
Short Term	<div style="border: 1px solid black; padding: 5px; text-align: center;"> 2 Assess your present position </div>	Consult through existing mechanism, (e.g. OHS Committee, Employee Reps)	2 Walk Through Audit 4 Consultants 5 Using Surveys
	Nominate a Noise Manager	Report/ recommend to senior management	11 Training and Information 12 Personal Protection
	Establish a Consultative Process		
	Conduct a Walk Through Audit	Interim Noise Management	Inform/involve supervisors and workers in assessments
	Evaluate present Measures	Implement obvious or simple control measures immediately	Consider formalising consultative mechanisms (e.g. establish noise committee)
	Conduct a Noise Survey	Implement and upgrade hearing protection programme	
Medium Term	<div style="border: 1px solid black; padding: 5px; text-align: center;"> 3 Set Goals and Policies </div>	Implement buy quiet programme	7 Noise Policy
	<div style="border: 1px solid black; padding: 5px; text-align: center;"> 4 Establish a Noise Management Strategy </div>	Implement noise control plan	3 In-house noise Control 8 Buy Quiet 9 Evaluating Options 11 Training and Information
		Implement hearing protection programme	
Ongoing	<div style="border: 1px solid black; padding: 5px; text-align: center;"> 5 Monitor and Evaluate </div>	OHS Committee and Employee Representatives	

STEP 1: ESTABLISH A BASIS FOR ACTION

INTRODUCTION

Your organisation needs a noise management programme because noise problems won't go away if you ignore them. If anything, they are likely to get worse.

To deal with noise problems, you need to follow a systematic sequence of steps. The purpose of this guide is to lead you through those steps.

The guide consistently uses standard terminology which is explained in *Appendix 1: Glossary of Technical Terms* and *Appendix 2: Measures of Noise Exposure*. Spend some time reading these and refer to them regularly until you are well acquainted with the terms.

WHAT DOES THE LAW SAY?

The Health and Safety in Employment Act 1992 and the Health and Safety in Employment Regulations require the control of the exposure of people to noise at work. You should obtain a copy of this legislation. *Appendix 3: Directory of Products and Services* gives details of where you can obtain a copy.

Generally the legislation requires employers to protect employees from excessive noise exposure by:

- quietening plant and equipment;
- reducing the amount of time individuals spend in high noise levels;
- providing hearing protectors and appropriate training for people working in areas that have not yet been quietened.

Generally the legislation requires employees to:

- use any noise control equipment provided in the workplace;
- wear personal hearing protectors in noisy areas.

**WHAT HARM
DOES NOISE
DO?**

The following effects of noise have serious implications for individuals and organisations.

HEARING
LOSS

Too much noise causes permanent hearing damage and a reduced quality of life. There is no remedial medical treatment and hearing aids are of very limited benefit.

The most serious effect is impairment of the ability to take part in conversations and discussions. Enjoyment of television, radio and films is reduced. Social withdrawal and feelings of isolation can result, especially when hearing deteriorates even further as a result of ageing.

TINNITUS

Many people with noise-induced hearing impairment also suffer from tinnitus — ringing, buzzing or roaring sounds in their ears. These sounds, audible only to an affected person, can be extremely disturbing and can interfere with sleep.

SAFETY

Noise can be a safety hazard. It can distract attention. It can drown out the sound of a malfunctioning machine, an alarm signal or a warning shout.

FATIGUE/LOW
PRODUCTIVITY

Many people find that noise adds to the fatigue of work and makes it difficult to concentrate. Productivity can suffer as a result.

COMMUNICATION
PROBLEM

Trying to understand speech in noisy surroundings requires extra concentration and strain. Messages or instructions can be misunderstood. This can create confusion, frustration and safety problems. Constant shouting to be heard above noise can lead to throat irritation.

ANNOYANCE
AND STRESS

Noise is a common source of annoyance and stress. It has been found in workplace surveys that noise is often the chief complaint workers have about their working conditions.

Additional information on the effects of noise are contained in *Module 10: Fact Sheets*.

**WHAT IF WE
DON'T DO
ANYTHING?**

Failing to act on the problem of noise increases the risk of hearing damage and increases costs as outlined below.

PENALTIES

There are now heavy penalties under the Health and Safety in Employment Act 1992 for failing to provide a safe place of work and for breaches of the noise regulations.

ACC CLAIMS

Employees can lodge a claim for compensation with the ACC for hearing damage caused by noise at work, which will have consequential financial penalties for the organisation.

OTHER
COSTS

Other possible costs arise from accidents caused indirectly by a noisy working environment.

Loss of productivity results from:

- errors in work caused through instructions not being heard or properly understood;
- an inability to concentrate in a noisy environment;
- increased absenteeism;
- increased turnover with associated costs of recruiting and training replacement personnel;
- difficulty in competing for highly skilled staff because of unattractive working conditions.

Rehabilitation costs may result if an employee needs to be relocated and retrained.

Module 6: Costs/Benefits provide a more detailed analysis of the costs associated with occupational noise exposure. The results are summarised below:

<i>Source of cost</i>	<i>Estimated annual cost per noise exposed employee</i>
Insurance	\$130
Absenteeism	\$570
Turnover	\$100
Employee quality	\$330
Productivity	\$660
Personal protection programme	\$90
Total Cost	\$1,880

**HAVEN'T
WE DONE
ENOUGH
ALREADY?**

If noise levels are hazardous to the health of employees, management must take action. Some common rules of thumb for managers wanting to estimate whether potentially hazardous noise levels exist in their workplaces are:

- If noise levels are as loud as or louder than heavy city traffic;
- If voices have to be raised to communicate with someone about 1 metre away;
- If people who have worked in the noise for a while seem to be a bit deaf.

Perhaps hearing protectors have been issued to everyone in noisy areas. Isn't that enough? Simply making hearing protectors available is not enough! The most effective noise control is applied at source, and even where protectors are used as an interim measure they should be accompanied by comprehensive consultation, information and maintenance.

Perhaps your organisation has managed to reduce noise levels so that no one's daily noise exposure level exceeds 85 dB(A) (the maximum permissible exposure). Isn't that enough?

Scientific studies in noisy industries show that a significant risk of hearing damage remains even when daily noise exposures are reduced to an 8-hour average of 85 dB(A). Authorities such as the International Organisation for Standardisation (ISO) (through ISO International Standard 1999) claim that risk becomes negligible only when exposures are reduced to 75 - 80 dB(A).

The lowering of the maximum permissible exposure level to 85 dB(A) is under consideration by a number of States in Australia. It is the maximum recommended by the National Health and Medical Research Council. It is also the level specified in regulations in New Zealand, the United States of America, United Kingdom and Europe. Many Australian organisations have already adopted this level. Noise exposures should be reduced to the lowest level practicable below 85 dB(A).

WHAT DOES IT COST TO DEAL WITH NOISE?

This control guide sets out a number of steps for the effective management of noise. Indicative costs associated with some of the activities are outlined below.

NOISE SURVEY

A comprehensive noise survey, with recommendations, will cost \$800 or more, depending on the size and complexity of the workplace.

ENGINEERING CONTROLS

Types of engineering controls vary greatly and so do their costs. Straightforward and relatively inexpensive treatments can often make the difference between hazardous and non-hazardous noise exposures.

Australian case studies (see *Module 1: Case Studies* for details) highlight the potential for significant noise reduction for minimal financial outlay. For example, Johnson & Johnson Pty Ltd. were able to reduce noise levels in their Cotton Buds® making machines from 92 dB(A) to 84 dB(A) by lining the inner faces of metal enclosures with a marine noise reducing material. Total cost per machine was \$500.

Waratah Wire Products took noise levels into account when purchasing new barbed wire making machines. The new machines were supplied with a complete enclosure and a sliding opening to allow full access. Noise levels were reduced from 98 dB(A) to 82 dB(A), with the cost being included in the price of the machine.

Examples of other such cases taken from the Health and Safety Executive (UK) publication, *100 Practical Applications of Noise Reduction Methods* (HMSO, London, 1983) are shown in the following table:

<i>Problem machine</i>	<i>Control method</i>	<i>Noise Level (dB(A))</i>		
		<i>Before</i>	<i>After</i>	<i>Cost</i>
Paper reeler	replace steel with bronze gears	99	86	\$825
Paper cutter	replace steel with plastic gear	93	85	\$275
Plastic grinder	redesign feed hopper	95	83	\$110
Book binder	line case guard with polyurethane	95	85	\$45
Grinder	replace steel with plastic exit chute	92	82	50% less
Band saw	enclose in acoustic curtains	101	91	\$2,500

Work done to control noise can also pay off in other ways. For example, analysing sources of excessive noise and designing engineering controls often reveals opportunities to improve the operational capabilities of machines or processes. To take another example, reducing noise by lining the underside of a roof or ceiling with reflective-coated sound-absorbent material could improve lighting and thermal comfort at the same time.

PERSONAL
HEARING
PROTECTION

<i>Hearing protectors</i>	<i>Cost</i>
Earmuffs per pair	\$9.00 - \$60.00
Earplugs per pair	
- Reusable	\$1.80 - \$10.00
- Disposable	\$0.40 - \$1.00 (new each day)

Maintenance and Replacement Costs

Varies a great deal depending on the protector purchased. Average earmuff life may be 6 months to 2 years, and reusable earplug life 3 - 6 months.

Signposting

A typical “Hearing Protectors Area” sign (required by regulations) could cost \$30 - \$60.

Training and Education

Typical cost per hour of hiring a trainer: \$50 - \$100.

CONCLUSION

Expenditure on the management of noise is an investment that will:

- ensure responsible occupational health and safety practice in your workplace;
- help meet your legal obligations;
- reduce your liability through compensation claims;
- make for a safer, more productive, more pleasant working environment;
- reduce the likelihood of employees suffering hearing loss;
- enhance the image of your company because it acts responsibly towards its employees.

STEP 2: ASSESS YOUR PRESENT POSITION

NOMINATE A “NOISE MANAGER”

A noise management programme requires careful planning, that is, the development of a noise management strategy which is tailored to the specific needs of the organisation. Its implementation requires the coordination of a number of activities. A “noise manager” should be nominated to perform this role, check that the steps described in this control guide are worked through and that the necessary work is coordinated.

If the organisation is small, this coordinating role could be carried out by the chief executive officer.

In a larger organisation, the role of coordinator could be delegated to the safety manager (if there is one) or to an appropriate line manager such as a production engineer or workshop manager.

A still larger organisation may require separate coordinators for different parts of the programme (for example, noise control and personal protection), with a senior manager or committee overseeing broad direction and coordination.

Whatever the size of the organisation, the chief executive officer should appoint one or more senior managers to:

- provide a report to management which assesses the problem and proposes a strategy (an outline of such a report is provided in *Module 11: Training and Information*);
- ensure that a noise policy is developed, publicised and implemented;
- coordinate the development of the strategy and the day-to-day operation of the noise management programme;
- keep senior management informed of progress and problems.

Everyone in the organisation should be informed who the noise manager is, either by word of mouth, notice or staff circular.

ESTABLISH A CONSULTATIVE PROCESS

The Health and Safety in Employment Act 1992 includes a requirement for employee consultation and cooperation.

Employee consultation and cooperation makes good sense. Employees know their machines well and can often make practical suggestions about reducing noise without interfering with the function of the machine.

Direct involvement of employees in the development of the noise management strategy also helps build commitment to its implementation.

Others who should be consulted are managers, supervisors, health and safety representatives and employee representatives.

One of the noise manager's first tasks should be to arrange for these groups to be informed and consulted. This may be done initially through existing consultative mechanisms (for example, the occupational health and safety committee) or informal communication channels. However, once the problem has been assessed as requiring long-term management, the noise manager may recommend the establishment of a special noise committee or task force.

In large organisations, such a committee could be a subcommittee of the health and safety committee. In a small organisation it may be sufficient simply to hold a meeting, tell employees that a noise management programme is to be set up and invite their comments and participation in its development.

CONDUCT A WALK- THROUGH AUDIT

A walk-through audit or assessment of noise sources, possible noise controls and management measures to reduce noise exposure can help to define the noise problem and provide the basis for a noise control plan.

The objectives are to:

- identify problem noise areas/machines;
- identify obvious noise control methods;
- evaluate the effects of major changes expected in the workplace;
- identify the need for a detailed noise control study or design.

The assessment should involve people familiar with the work processes as well as management: some of the best noise control solutions are generated on the shop floor.

The assessment should be coordinated by the noise manager and documented as it proceeds.

Module 2: Walk-through Audit sets out a procedure for a walk through audit of the workplace.

**EVALUATE
PRESENT
MEASURES**

As an adjunct to the walk-through audit, the effectiveness of measures already in place to reduce noise exposure or protect hearing should be evaluated.

Assess the effectiveness of:

- existing noise control treatments (e.g. enclosure doors and linings);
- administrative measures to reduce noise exposure (e.g. job rotation arrangements);
- the personal hearing protection programme (e.g. the use and condition of personal hearing protectors);
- noise information (e.g. do the employees know what noise levels they are exposed to and when and where to wear personal hearing protection? Are noisy areas signposted and noisy portable equipment labelled?)

**INTERIM
NOISE
MANAGEMENT**

Where the walk-through audit identifies simple solutions to noise problems (e.g. lining a component bin with rubber), arrange for these changes to be implemented as quickly as possible. If there are problems with existing control measures and hearing protection programmes, initiate action to improve performance while the more comprehensive programme is being developed.

**CONDUCT A
NOISE
SURVEY**

The Health and Safety in Employment Regulations require that, where an employee is or may be exposed to an hazardous level of noise, the employer is required to take all practical steps to ensure that the noise hazard is eliminated. In order to facilitate this, a noise survey should be conducted in premises where noise exposures are likely to be hazardous to determine the extent of the problem. Where a noise hazard is known to exist,

suitable interim personal protection must be made available to exposed employees.

A noise survey report is primarily a basis for action. It should not be seen as a menu for personal hearing protectors, as though this were the end point of noise management.

The noise survey differs from the walk-through noise audit in degree and precision. The walk-through audit and subsequent interim noise management action are useful preliminary activities to commissioning a noise survey. By dealing first with problems that are easily fixed, you will be able to have the more comprehensive noise survey concentrate on the more difficult noise problems.

The noise survey provides basic technical information about the workplace to enable you to:

- Set noise control priorities by:
 - identifying which employees are exposed to noise above the target exposure goal;
 - identifying which areas and operations pose the greatest risk.
- Provide relevant information to managers and employees on noise in the workplace (e.g. by labelling noisy areas and equipment, charts summarising results, and training programmes).
- Select a range of appropriate hearing protectors for employees in noisy areas.
- Define any further statutory obligations which may have to be fulfilled. For example:
 - keep a copy of the survey on file,
 - communicate results to employees,
 - repeat the noise survey in say five years.
- Evaluate the success of your noise management strategy by comparing successive noise surveys.

Many organisations will engage consultants to undertake their noise survey (see *Module 4: Consultants*). It is worthwhile requesting the consultant to go beyond what is normally provided in a noise report of this kind. Ask them to provide the information in a user-friendly form with conclusions and, where appropriate,

recommendations in each of the areas specified above. A well-chosen consultant should recommend specific control solutions for the most pressing noise problems.

Module 5: Using Surveys provides further details on the use and interpretation of noise surveys.

STEP 3: SET GOALS AND POLICIES

INTRODUCTION

A noise policy lays down the general rules an organisation intends to follow in dealing with its noise problems.

Policy decisions which set noise exposure goals, specific responsibilities for managers, supervisors and employees, and preferred methods of dealing with the problem are needed to underpin the noise management strategy.

Full consultation with employees is essential for the development of noise policy. In medium to large organisations, this is best achieved through a formal workplace health and safety committee including employee health and safety representatives.

POLICY ISSUES

NOISE EXPOSURE GOAL

A noise exposure goal will provide a baseline against which progress in noise control and buy quiet programmes can be measured and evaluated.

Legislation currently specifies noise exposure limits — a noise exposure level, $L_{Aeq,8h}$ of 85 dB(A) and a peak level of 140 dB. However, organisations should seriously consider adopting a goal lower than the current legislative requirements to:

- anticipate possible changes to legislation;
- take advantage of the health, safety and economic benefits of lower noise levels

BUY QUIET

Set up a system to ensure that, wherever possible, the organisation does not buy more noise than it already has.

Because noise control can be more effectively dealt with at the design stage, buying quiet is almost invariably better and cheaper than trying to control noise once machinery is installed. Quiet machines are often better designed, better made and more reliable.

Specify a maximum acceptable noise level for new machinery. This level will usually need to be significantly lower than the noise exposure goal for the working environment to allow for the addition of the noise of the new machine to the existing noise levels on site.

It is also necessary to take account of additional noise effects when more than one machine is purchased for the same work area. Generally, two identical machines working near one another will make about 3 dB(A) more noise than either one alone; four machines will make up to 6 dB(A) more. To keep the total noise level of four machines below 80 dB(A), the noise level of individual machines would have to be no more than 74 dB(A).

NOISE CONTROL

The preferred approach to noise management, as reflected in the Health and Safety in Employment Act, is based on a hierarchy of controls: reduce noise levels as far as possible; if there is still a problem then reduce exposure duration as far as possible; and if a problem still remains, as an interim measure supply personal hearing protectors, backed up by appropriate training and education.

While some inexpensive control options can be immediately implemented, many noise problems will be solved only through medium- and long-term planning and budgeting. Consider allocating a budget each year for noise control.

PERSONAL PROTECTION

Effective protection requires a properly managed and maintained personal protection programme. Someone in the organisation should be trained to take the role of hearing protector expert.

Employees working in noisy areas should be informed of the noise levels and their potential effects, provided with a choice of effective hearing protectors and with training in how to fit and wear them.

Employees at risk must be required to wear hearing protection supplied to them and encouraged to do so through supervisors, fellow workers and training and information programmes.

Visitors to noisy areas, including employees from other parts of the plant, should be issued temporarily with hearing protectors and requested to wear them.

Managerial staff should set an example. Few people actually enjoy wearing hearing protectors and if managerial staff are allowed to walk through noisy areas unprotected, some employees will oppose wearing

hearing protectors themselves on the basis that what is good enough for managers is good enough for them.

RESPONSIBILITIES AND OBLIGATIONS

If noise management is to be effective, everyone concerned needs to know the areas they are responsible for and what they have to do to carry out their responsibilities.

This information should be written down in job descriptions or duty statements so that people have a permanent record to which they can refer.

A suggested division of responsibilities, appropriate for a medium-sized organisation, is shown below. The arrangement is flexible. In smaller organisations one person may have to take on more than one of the roles listed but in larger organisations some roles could be shared by several people.

The important point is to ensure that someone is clearly responsible for each of the listed functions.

NOTE: Managerial and legal responsibility for dealing with an organisation's noise problems rests with its senior management. Senior management backing is vital to the success of a noise management programme.

CHIEF EXECUTIVE OFFICER

The chief executive officer should:

- Accept personal responsibility for co-ordinating the noise management programme (smaller organisations) or delegate this responsibility to a designated noise manager (larger organisations);
- Approve and publicise the organisation's noise management policy;
- Plan for the ultimate elimination of hazardous noise from the organisation's working environment;
- Approve a reasonable allocation of money for noise control in each year's budget;
- Ensure that appropriate management systems are established. In particular, ensure that everyone involved in the noise management programme knows what their responsibilities are, preferably by means of a written notice, job description or duty statement;

- Set up management reporting systems. For example, require the occupational health and safety committee to review the noise programme at least quarterly, and the noise manager to submit a quarterly report to senior management.
- Ensure that responsibility is built into the purchasing system by requiring that anyone approving the purchase of potentially noisy machinery must either certify that it is the quietest available or else justify the purchase.

NOISE
MANAGER

The noise manager should:

- Consult with workers, other managers, supervisors, health and safety personnel, and others as appropriate, and develop a noise management policy for approval by senior management;
- Be a reference point for information about the noise policy and coordinate its implementation;
- Monitor noise control measures.

PURCHASING
DEPARTMENT

The purchasing department should:

- Advise all purchasing staff of the existence of the buy quiet policy;
- Develop and implement an approval procedure for ensuring that noise is taken into account in the purchase of all plant, equipment and powered tools.

HEARING
PROTECTOR
EXPERT

A hearing protector expert should:

- Become a reference point for information and expertise on the correct use of hearing protectors;
- Monitor hearing protector use and rectify problems;
- Establish a hearing protector maintenance programme.

SUPERVISORS

Supervisors should:

- Make sure employees know how to use the engineering noise controls, know which areas and equipment

are noisy and ensure that employees in them are supplied with hearing protectors and adequate training;

- Set an example by wearing hearing protectors themselves;
- Make suggestions for the engineering control of noise.

WORKERS

Workers should:

- Participate in workplace consultation on noise control;
- Use the engineering controls where installed;
- Wear hearing protectors in noisy areas;
- Report faults in engineering controls and hearing protectors;
- Participate in training and contribute to the noise management strategy.

EMPLOYEE REPRESENTATIVES

Employee representatives should:

- Represent the views of workers to management and on occupational health and safety committees;
- Report to workers on the progress in formulating the noise management strategy and implementing the programme.

STEP 4: ESTABLISH A MANAGEMENT STRATEGY

INTRODUCTION

A noise management strategy needs to be tailored to the needs of the organisation. Key elements of a noise management strategy are buying quiet equipment, noise control and personal hearing protection. Some of the factors influencing its design include:

- Existing noise levels;
- Economic environment of the organisation, that is, budget, production and resource constraints;
- Availability of solutions for identified noise problems;
- Negotiations with employee representatives or pressure from the occupational health and safety committee or health and safety inspector;
- Future plans for the expansion or contraction of the organisation's activities.

The consultative process will play an important role in achieving a workable strategy.

BUY QUIET PROGRAMME

A buy quiet programme requires the integration of a set of procedures with the organisation's established purchasing arrangements. Write a "buy quiet" circular to inform everyone who buys new machinery for the organisation to take noise into account. Don't overlook powered hand tools which are major noise sources in many workplaces.

An outline of buy quiet procedures provided below is based on categorising a purchase as minor or major.

Module 8: Buy Quiet provides a more detailed treatment.

MINOR PURCHASES

For minor purchases:

- Ask equipment suppliers to provide noise emission information.
- Use this information to compare brands and short-list on the basis of cost, technical specifications, noise

emission and other safety requirements such as guarding.

- If possible, check the noise information by trialing short-listed equipment under typical operating conditions (for example, router cutting hardwood with a tungsten carbide bit) and select the one which does the job effectively with the least noise.
- Where possible, use noise measuring equipment at the position of the operator's ear. If measuring equipment is not available, use systematic observer comparisons to identify major differences in noise output.
- If the impact on the workplace noise environment is likely to be high and the cost of the equipment warrants it, consider using a more controlled, comprehensive noise measurement procedure. If in-house expertise is not available, hire a noise consultant to undertake an assessment of the short-listed items and rank them on the basis of noise emission

MAJOR PURCHASES

For major purchases:

- Specify a noise level range from “most desirable” to “acceptable”, in tender specifications.
- Include noise level testing in normal pre-purchase testing procedures and trialing. If noise levels are unacceptable, ask the manufacturer to install further noise control measures.
- Re-test equipment for noise level during commissioning and if necessary implement noise reduction measures (for example, acoustic treatment of the work area).

NOTE: While the decision to regard an equipment purchase as minor is normally made on the basis of low cost per item, consider whether the equipment should be regarded as a major purchase, based on an assessment of its likely impact on noise levels in the workplace. The following factors, as well as cost, should be taken into account:

- Existing noise levels in the workplace;
- Amount of daily usage;
- Number of these items to be purchased now or in the future.

AN EXAMPLE

Regional offices of an organisation purchased chainsaws in small quantities for medium duty shrub and tree lopping applications. As the number purchased for the organisation as a whole was considerable, the central office decided to undertake an evaluation of all available chainsaws to establish the best and quietest option for purchase. Among the many chainsaws which were technically acceptable, the noise level varied by as much as 10 dB(A). The relative price range was much smaller. One of the cheapest was also the quietest.

**NOISE
CONTROL
PLAN**

The noise policy (Step 3) will have established noise exposure goals for your workplace (or workplaces). In many organisations noise problems are complex and the achievement of goals may take some years. The information gathered (in Step 2) may also have highlighted a number of options for noise control. These options will need to be evaluated to assess their costs and benefits and a time frame developed in which the most effective measures can be carried out. This is noise control planning, and it needs to be integrated with the overall direction, productivity and financial planning of the organisation.

IDENTIFY
BROAD NOISE
CONTROL
OPTIONS

The noise manager should be able to specify a series of options for noise control in the workplace. For example:

Option 1: Replace machines A and B

Option 2: Enclose machines A and B

Option 3: Treat the area around machines A to F for reverberation by the use of acoustic screens together with absorptive lining of the building.

NOISE
CONTROL
ADVICE

If it is difficult to identify options for noise control, this may be a good time to call together relevant people in the organisation. These may include engineering, maintenance, production and health and safety personnel. Look at the results of the walk-through audit and discuss the options. It may also be the right time to involve an acoustical consultant who may be aware of further options.

The three main services for which you may find a consultant beneficial are to:

- obtain a detailed noise diagnosis to assess the sources of noise and potential for noise reduction;
- identify and evaluate the most cost-effective options for noise control;
- receive a detailed design of treatments for the preferred option and to supervise contractors.

The above services could be provided for either an existing plant or a proposed plant.

Where notification to reduce noise levels has been issued, the consultant may also liaise with the Health and Safety Inspector on the organisation's behalf.

A consultant may therefore be involved at several stages during the implementation of the noise management strategy. The following aspects of your involvement with a consultant are important.

Choice of consultant

You will need someone with appropriate instrumentation to diagnose the problems, and have experience in your type of industry or machinery.

Setting up the brief

You will get the best from your consultant by knowing what to ask them to do and by knowing what to expect.

Consultants and contractors

It is helpful to understand the role of a consultant (provider of expertise) versus that of a contractor (provider of skill).

Module 4: Consultants looks at these issues to enable you to “get the best from consultants and contractors”.

ADDITIONAL RESOURCE

The Safety and Health Accumulated Research Experience (SHARE) aims to identify successful solutions to common health and safety problems and promote widespread application of these solutions in workplaces. The SHARE registry may be able to help you find an existing solution used by another company for a similar problem. Copies of SHARE solutions in noise are available from:

The Victorian Department of Labour
 Public Relations and Information Branch
 Level 22, Nauru House,
 80 Collins Street,
 62 The Terrace
 MELBOURNE VIC 3000
 Telephone (+61 3) 655 6332

Occupational Safety and Health Service
 Department of Labour
 PO Box 3705
 62 The Terrace
 WELLINGTON
 Telephone (04) 471 2937.

EVALUATING
 COST/
 BENEFITS FOR
 NOISE
 CONTROL

Having identified some options for noise control strategies, it is in the organisation's interest to carefully evaluate the costs and benefits of each option. Costs and benefits of noise control can be in both dollar and non-dollar terms. Some approaches to evaluating the effectiveness of various noise control options are set out in *Module 9: Evaluating Options*.

There may be either costs or benefits to production which may increase with new machinery or may decrease if a machine is slowed down or enclosed.

Similarly, there may be either costs or benefits to product quality. While this would normally increase with new, quieter technology, some decrease within acceptable limits may be allowed in the interests of noise control.

Some of the considerations are summarised in the table below.

Costs

To treat or replace machines
 Cost per decibel reduction
 Cost per worker down-time during installation
 Cost of training workers in noise reduction technology
 Cost of maintenance of noise controls
 Extra cost of purchasing quieter machinery

Benefits

Cost reduction due to hearing loss claims
 Cost reduction in personal hearing protection/education programme
 Improved safety
 Improved verbal communication possible
 Better working relations
 Reduced vibration exposure of workers possible
 Reduced environmental noise
 Less discomfort from personal hearing protection
 Lower worker stress, increased productivity
 Improved thermal environment possible

To identify the most cost-effective option, the broad options for noise control can be evaluated against the cost/benefit criteria given above. Gathering the information for the cost-benefit analysis will require input from a range of people in the organisation, from engineering to personnel to production. This process could be coordinated by the noise manager.

ONGOING
MAINTENANCE,
MODIFICATION,
UPGRADING
OF PLANT

While the above processes are taking place in the planning of major noise controls, it is crucial that the continuing maintenance/modification/upgrading activities are also fitted into the noise control plan.

In the walk-through audit, problems such as loose or worn parts, machine imbalances and missing silencers may have been identified. These are matters for normal maintenance.

“Add-ons” (for example, a noisy blower added to clean a conveyor) may also have been installed without consideration of noise. Other machines may have been speeded up to increase production, thereby causing a noise hazard. These modifications and upgrades can occur without reference to any overall noise planning, resulting in a gradual increase in noise levels over a period of time.

Consider the need to:

- establish a maintenance regime specifically aimed at noise control;
- train maintenance staff to recognise and correct simple noise problems and carry out minor modification/upgrades so as not to increase noise levels overall;
- introduce a “condition monitoring” programme to detect possible machinery faults before they become a noise hazard and ultimately cause a breakdown;

Module 3: In-House Control provides information for maintenance staff to establish these procedures and perform in-house noise control.

**PERSONAL
PROTECTION
PROGRAMME**

Until noise is reduced to non-hazardous levels by means of engineering controls, individual workers must be protected by using personal hearing protectors.

It is not enough simply to buy hearing protectors and hand them out. Effective protection requires a properly managed personal protection programme. The key steps are outlined in the following subsections.

1. PROVIDE INFORMATION

Provide information to employees who are likely to be exposed, about:

- the harmful effects of high noise levels, especially permanent hearing impairment and permanent ringing in the ears;
- the organisation’s short-term and long-term plans for reducing noise exposures to non-hazardous levels;
- the organisation’s obligations to provide personal hearing protectors until the noise is reduced;
- the employee’s obligations to use hearing protectors in hazardous situations.

The use of a video is invaluable to demonstrate the effects of noise mentioned in the first point above. Alternatively, hire a hearing protector supplier or safety firm that specialises in providing this kind of education.

Information on the remaining points listed above could be supplied at the same session by the noise manager or other appropriate staff member.

2. IDENTIFY NOISY AREAS AND EQUIPMENT

Mark areas where noise exposure levels exceed the organisation’s exposure goal with signs indicating that hearing protectors must be worn. Standard signs are included in this kit (see also “Signs” in the Yellow Pages).

Label noisy power tools and portable equipment with a sticker saying “Do not use unless wearing hearing protectors”. To be on the safe side, regard as noisy any item capable of producing continuous noise levels greater than 85 dB(A) or peak noise levels exceeding 140 dB at the operator’s ear.

3. SELECT AND BUY HEARING PROTECTORS

For each individual, aim to buy protectors that:

- have been graded and have adequate noise reduction;
- are compatible with any other safety equipment the person has to wear;

- are comfortable;
- fit properly;
- do not interfere with work.

When selecting hearing protectors:

- contact several suppliers, tell them about your noise conditions and working environment and ask them for brochures of the graded protectors they would recommend for your needs;
- make a short list of suitable protectors in consultation with prospective wearers;
- ask suppliers to demonstrate the short-listed protectors, show the correct way of fitting them and answer questions from prospective wearers;
- contact as many suppliers as necessary until everyone has been fitted with a suitable device.

Wearers should be given a choice:

- between muffs and plugs (if they can get a good fit with both, and where plugs are appropriate);
- between different brands or models of suitable muffs or plugs.

Both types can provide effective protection if properly used. The following table summarises the advantages and disadvantages of each.

Earmuffs

<i>Advantages</i>	<i>Disadvantages</i>
Easy to use	Seal around ears can be impaired by spectacle frames, hair and caps
Careful fitting not as critical as with plugs	Can get in the way of other headgear
Some protection likely even if not used carefully	Can interfere with hair style
Can be used even if wearer has a minor ear infection	Can be a nuisance in confined work space
Easy for supervisor to see that they are being used properly	Can be uncomfortable in hot environments

Earplugs

Advantages	Disadvantages
Hair, glasses, earrings do not impair seal	May provide very little protection if not used carefully
Don't get in the way of other headgear	Problems if user gets hands dirty or wears gloves
Don't interfere with hair style	Can't be used if wearer has an ear infection
Don't get in the way in confined work spaces	Can be difficult for supervisor to see that they are being used properly
Cool, easy to carry around	

4. PROVIDE TRAINING ON USE AND CARE OF HEARING PROTECTORS

Arrange for the hearing protector supplier to provide training when hearing protectors are first bought. If the supplier cannot supply a training officer, ask for any available printed information about correct use and care of the protectors.

Appoint a suitable staff member (for example, the noise manager, nurse or health and safety officer) to become the local expert on hearing protectors. This person should obtain, study and retain, for future reference, all information about all hearing protectors purchased by the organisation.

Use the information provided with this control guide for training purposes. (This includes *Module 10: Fact Sheets* and material in *Module 11: Training and Information* and *Module 12: Personal Protection*.)

Provide new employees in noisy areas with hearing protectors and associated information and training as part of their introduction to the organisation.

5. ESTABLISH A MAINTENANCE PROGRAMME

Regular inspection and maintenance of protective equipment highlights the seriousness of the noise issue within the organisation and helps maintain wearer motivation. It also provides opportunities for refresher training in correct use of equipment.

Through the maintenance programme:

- Make regular inspections of all hearing protectors (at least monthly);
- Repair or replace defective protectors;
- Record all results for costing, budgeting and legal purposes.

STEP 5: MONITOR AND EVALUATE

INTRODUCTION

Evaluation is the careful appraisal of the planning, implementation, impact and outcomes of a programme against its goals and objectives.

Evaluation enables the following assessments to be made about the organisation's noise management programme:

- The extent to which the programme has met the targets, goals and objectives;
- Whether resources are being effectively allocated (supporting bids for necessary resources);
- The need for changes in the direction of the programme.

Evaluation can also be a useful consultative tool. Feeding back the findings to management and others who have participated in both the evaluation and the programmes will generate further awareness and involvement.

MONITORING PROGRAMME IMPLEMENTATION

The three sub-programmes of the noise management strategy, that is, the buy quiet programme, the noise control plan and the hearing protection programme can be monitored using the following checklist. It is a means of checking that the programme is being implemented as planned. The detail will need to be tailored to reflect the actual activities of your organisation's noise management programme.

EVALUATION

In addition to checking that all aspects of the programme have been implemented as planned, indicators need to be identified which will measure or gauge how well the planned measures have had their desired or planned effect. The details of such indicators need to reflect the specific, detailed goals and plans of each organisation. Possible indicators for some of the activities are listed below as examples.

MONITORING CHECKLIST

General Programme Yes No

Assessment

- | | | |
|--|--------------------------|--------------------------|
| 1. Noise manager nominated | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Walk-through survey completed | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Noise management proposal forwarded to management | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Current noise control and hearing protection activities audited | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Legal obligations established and met | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Simple noise control solutions are implemented immediately | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. Appropriate consultative arrangements established | <input type="checkbox"/> | <input type="checkbox"/> |

Goals and policies

- | | | |
|---|--------------------------|--------------------------|
| 8. Noise goals and policies developed | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. Policies circulated to all employees | <input type="checkbox"/> | <input type="checkbox"/> |

Noise Management Strategy

- | | | |
|--|--------------------------|--------------------------|
| 1. Noise management strategy prepared | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Budget and resources allocated | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Individuals advised of their their rights and obligations | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Employees informed about the noise levels to which they are exposed | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Training programmes established for key groups | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Noise addressed in induction and other relevant training programmes | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. Monitoring, reporting and evaluation processes established | <input type="checkbox"/> | <input type="checkbox"/> |

Noise Control Yes No

- | | | |
|--|--------------------------|--------------------------|
| 1. Noise control survey and report completed | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Major noise sources identified | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Solutions to noise problems documented | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. In-house maintenance and upgrading programmes address noise control | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Priorities set for noise control | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Budget and resources allocated | <input type="checkbox"/> | <input type="checkbox"/> |

Buy Quiet Procedures

- | | | |
|---|--------------------------|--------------------------|
| 1. Buy quiet policy and procedures developed | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Relevant staff informed and trained | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Sample purchasing specifications available | <input type="checkbox"/> | <input type="checkbox"/> |

Hearing Protection Programme (detailed checklist in *Module 12*)

- | | | |
|--|--------------------------|--------------------------|
| 1. Noisy areas and equipment identified and signposted/labelled | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Effective, wearer-acceptable hearing protectors issued to employees at risk | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Wearing of hearing protectors monitored and supported | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Training provided in fitting and correct use | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Hearing protectors maintained and replaced as necessary | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Reference point established for information and advice | <input type="checkbox"/> | <input type="checkbox"/> |

Noise Strategy (General)

How close has the implementation of the three key sub-programmes of the noise strategy come to achieving the noise exposure goal? Possible indicator:

- Monitor and check progress in reaching the noise exposure goal. Carry out a noise survey every two years and compare to evaluate progress.

Is noise control at source being given priority over the use of hearing protection? Possible indicators:

- Look at how much is being budgeted and spent on noise control measures compared with personal protection.
- List the noise control solutions which have been implemented.

Buy Quiet Programme

Are the buy quiet procedures being implemented?

Possible indicators:

- New equipment tenders include noise level specifications;
- Decisions taken to purchase specific items of equipment reflect consideration of noise levels;
- Requests to involve noise manager in equipment assessment procedures.

Noise Control

Have options for the control of noisy machinery been developed and implemented? Possible indicators:

- Priorities established for solving noise problems associated with specific work processes or equipment;
- Plans for equipment modifications developed;
- Equipment modifications installed.

Personal Protection

Are the hearing protectors being used effectively?

Possible indicators:

- Individuals are equipped with protectors suitable for them;
- Protectors are being worn correctly;
- Usage rates and condition of hearing protectors;
- Range of hearing protectors available.

**A NOTE ON
AUDIOMETRY**

Some organisations provide free hearing tests (audiometry) for their employees every year or two as a final check on the effectiveness of their noise control and personal protection programmes, and to try to detect individual cases of hearing loss at an early stage so that steps can be taken to prevent further damage.

Unless an organisation possesses both the necessary equipment and expertise, it would be best to subcontract hearing tests to an appropriate consultant.

Specifications for audiometric equipment and procedures are given in Australian Standard AS1269 (see *Appendix 3: Directory of Products and Services*).

Guidance in the assessment of audiograms is given in the National Acoustic Laboratories Report No. 80, *Criteria for Assessing Hearing Conservation Audiograms*, AGPS, Canberra, 1980.

APPENDIX 1: GLOSSARY OF TECHNICAL TERMS

Noise level: Technically called sound pressure level; the physical magnitude or strength of noise: experienced by people as loudness.

dB or decibel: The unit used to measure noise level. The pressure changes of the loudest sounds we can hear are about 10,000,000 times greater than those of the faintest sounds. Because a measurement scale ranging from 1 to 10,000,000 is awkward to work with, scientists instead use the logarithmic decibel (dB) scale for measuring the strength of sound.

By working with the logarithms of numbers rather than the numbers themselves, the decibel scale compresses a 1 to 10 million range of pressures into a range of 0 to 140 dB.

Because of the logarithmic nature of the decibel scale, a noise which is 3 dB higher in level than another has twice as much energy; a noise 3 dB lower in level has half as much. A 10 dB difference in level corresponds to an energy ratio of 10; 20 dB corresponds to a ratio of 100; 30 dB to 1,000; and so on.

dB(A): A-weighted decibel. The “A” indicates that the noise has been measured through a special acoustic filter which is used to assess how hazardous the noise is for individuals.

dB(C): C-weighted decibel. The “C” indicates that the noise has been measured through a special acoustic filter which gives results that are used for selecting hearing protectors in Australia.

Noise exposure: The overall amount of noise to which a person is exposed. Noise exposure depends on both the noise level and the exposure duration (the length of time spent in the noise).

As explained in *Appendix 2*, two alternative terms are used for expressing the amount of a person’s daily noise exposure at work: daily noise exposure level and daily noise exposure.

Personal hearing protection:

The protection of individuals from the harmful effects of noise by means of signposting noisy areas, arranging education, providing individuals with appropriate hearing protectors and monitoring their use. Many personal protection programmes also include regular hearing checks.

Attenuation:

The amount of noise reduction provided by a hearing protector.

APPENDIX 2: MEASURES OF NOISE EXPOSURE

At present in New Zealand two alternative terms are used for expressing the amount of a person's daily noise exposure at work: daily **noise exposure level** and daily **noise exposure**.

First of all, it is important to understand the difference between **noise level** and **noise exposure level**.

NOISE LEVEL

Noise level (symbol L_{Aeq}) is simply the strength or physical magnitude of noise, expressed in dB(A) (which stands for "A"-weighted decibels). For example the noise level of heavy traffic is about 85 dB(A).

NOISE EXPOSURE LEVEL ($L_{Aeq,8h}$)

Noise exposure level, on the other hand, is the total amount of noise energy a person is exposed to in the course of their working day, expressed as an 8-hour average (symbol $L_{Aeq,8h}$). It takes account of both the noise level and the length of time the person is exposed to it. To reach a noise exposure level of 85 dB(A), a person would have to be exposed to a noise level of 85 dB(A) for 8 hours (or to some other combination of noise level and exposure duration having the same total energy).

It is quite possible for the noise exposure level to be less than 85 dB(A) even though the noise level is greater than 85 dB(A). This would happen, for example, if the only noisy machine in a factory created a noise level of 90 dB(A) but people were exposed to it for only 2 hours a day. In this case the noise exposure level would be 84 dB(A).

A rule known as the 3 dB rule is worth noting. The rule is that when determining noise exposure level, halving the exposure duration is equivalent to decreasing the noise level by 3 dB(A) and doubling the exposure duration is equivalent to increasing the noise level by 3 dB(A). It follows from the 3 dB rule that the combinations of noise level and exposure duration shown below all produce the same noise exposure level of 85 dB(A):

82 dB(A) for 16 hours	91 dB(A) for 2 hours
85 dB(A) for 8 hours	94 dB(A) for 1 hour
88 dB(A) for 4 hours	. . . and so on.

**PARTIAL
NOISE
EXPOSURE**

An operator may work at several different tasks, each with a different noise level, in the course of a working day. A Partial Noise Exposure will be received from each task, depending on the amount of time spent on the task and the associated noise level. Adding the Partial Noise Exposures together will give the operator's Daily Noise Exposure.

The *Approved Code of Practice for Management of Noise in the Workplace* provides a table for determining the Partial Noise Exposure associated with any combination of noise level and exposure duration. This is duplicated below.

To determine an employee's *noise exposure level*, the following data are needed:

- (a) The different noise levels to which the employee is exposed;
- (b) The time that the employee is exposed to each of these noise levels.

Table 3 can be used to determine the $L_{Aeq,8h}$ using the following method:

- Convert each noise level to a Pascal-squared (Pa^2) value.
- Multiply each Pa^2 value by the respective exposure time in hours.
- Add these resulting fractional exposures together, to obtain the total exposure.
- Divide the total exposure by 8, to obtain the 8-hour average Pa^2
- Convert this value of Pa^2 using table 3 again to obtain the $L_{Aeq,8h}$

This is the employee's **Daily Noise Exposure Level** ($L_{Aeq,8h}$)

Table 3 can also be used to calculate any L_{Aeq} value, to convert dose or exposure measurements to L_{Aeq} and vice versa, or to simply add and subtract noise levels.

An Example: **Table 1: Typical Daily Noise Exposure Details for an Employee**

<i>Machine/Process</i>	<i>Measured noise level $L_{Aeq,T}$</i>	<i>Duration of Exposure, T (dB(A))</i>	<i>Pa² (Using Table 3) (Hours)</i>	<i>Partial Noise Exposure (Pa²h)</i>
Furnace	105	0.5	13	6.5
Chipping hammer	96	4.0	1.6	6.4
Power hacksaw	92	1.5	0.63	0.9
Welding	90	2.0	0.40	0.8
Daily Noise Exposure				14.6

The Daily Noise Exposure is thus 14.6 Pa²h, and the noise exposure level is determined by dividing this exposure by the 8 hours in a normal working day.

The average Pa² value of this exposure is therefore 14.6/8 = 1.8 Pa²

The noise exposure level or $L_{Aeq,8h}$ is obtained by looking up 1.8 in Table 3.

The noise exposure level or $L_{Aeq,8h}$ is therefore 96.5 dB(A), which is normally rounded to the nearest whole number (0.5 is normally rounded up).

So **$L_{Aeq,8h} = 97 \text{ dB(A)}$**

DAILY NOISE EXPOSURE (Pa²h)

Daily Noise Exposure is an alternative way to express the total amount of noise energy to which a person is exposed over their working day. Noise Exposure is normally expressed in “Pascal-squared hours” which has the symbol Pa²h.

A person’s Daily Noise Exposure is therefore simply the number of Pa²h that they are exposed to in a working day, however long the day is. The noise exposure is the combination of noise level and duration of exposure to that level.

The relationship between Noise Exposure and Noise Exposure Level is shown in table 2 below:

TABLE 2:
RELATIONSHIP
BETWEEN
NOISE
EXPOSURE AND
NOISE
EXPOSURE LEVEL

<i>Noise Exposure Level (dB(A))</i>	<i>Daily Noise Exposure (Pa²h)</i>	<i>Noise Exposure Level, (dB(A))</i>	<i>Daily Noise Exposure (Pa²h)</i>
80	0.32	98	20
81	0.40	99	25
82	0.51	100	32
83	0.64	101	40
84	0.80	102	51
85	1.0	103	64
86	1.3	104	80
87	1.6	105	100
88	2.0	106	130
89	2.5	107	160
90	3.2	108	200
91	4.0	109	250
92	5.1	110	320
93	6.4	111	400
94	8.0	112	510
95	10	113	640
96	13	114	800
97	16	115	1000

TABLE 3: DECIBEL TO PASCAL-SQUARED CONVERSION

<i>dB</i>	<i>Pa²</i>	<i>dB</i>	<i>Pa²</i>	<i>dB</i>	<i>Pa²</i>
75	0.013	95	1.3	115	130
75.5	0.014	95.5	1.4	115.5	140
76	0.016	96	1.6	116	160
76.5	0.018	96.5	1.8	116.5	180
77	0.020	97	2.0	117	200
77.5	0.023	97.5	2.3	117.5	230
78	0.025	98	2.5	118	250
78.5	0.028	98.5	2.8	118.5	280
79	0.032	99	3.2	119	320
79.5	0.036	99.5	3.6	119.5	360
80	0.040	100	4.0	120	400
80.5	0.045	100.5	4.5	120.5	450
81	0.050	101	5.0	121	500
81.5	0.057	101.5	5.7	121.5	570
82	0.063	102	6.3	122	630
82.5	0.071	102.5	7.1	122.5	710
83	0.080	103	8.0	123	800
83.5	0.090	103.5	9.0	123.5	900
84	0.10	104	10	124	1000
84.5	0.11	104.5	11	124.5	1100
85	0.13	105	13	125	1300
85.5	0.14	105.5	14	125.5	1400
86	0.16	106	16	126	1600
86.5	0.18	106.5	18	126.5	1800
87	0.20	107	20	127	2000
87.5	0.23	107.5	23	127.5	2300
88	0.25	108	25	128	2500
88.5	0.28	108.5	28	128.5	2800
89	0.32	109	32	129	3200
89.5	0.36	109.5	36	129.5	3600
90	0.40	110	40	130	4000
90.5	0.45	110.5	45	130.5	4500
91	0.50	111	50	131	5000
91.5	0.57	111.5	57	131.5	5700
92	0.63	112	63	132	6300
92.5	0.71	112.5	71	132.5	7100
93	0.80	113	80	133	8000
93.5	0.90	113.5	90	133.5	9000
94	1.0	114	100	134	10,000
94.5	1.1	114.5	110	134.5	11,000

The Pascal-squared values in the table above have been rounded to 2 significant figures. This will result in an accuracy of at least ±5% or ±0.2 dB.

APPENDIX 3: DIRECTORY OF PRODUCTS AND SERVICES

INTRODUCTION This appendix is a general directory designed to help users locate technical expertise and the necessary equipment and materials needed to implement an effective noise management programme in the workplace.

You should also check with your local Occupational Safety & Health Branch Office since some may have produced local directories.

CONTENTS Technical Expertise

This directory will assist you in finding the people with the following technical expertise you may need to implement an effective noise management programme in your workplace:

- Noise measurement and engineering noise control;
- Hearing tests.

Equipment and Materials

This directory will assist you in finding the following equipment and materials you may need to implement an effective noise management programme in your workplace:

- Noise control equipment and materials;
- Safety warning signs;
- Hearing protectors.

Legislation and Standards

This directory gives details of:

- Legislation on noise;
- Standards.

**NOISE
MEASUREMENT
AND
ENGINEERING
CONTROL**

How do I know if I have a noise problem and how do I get engineering advice about ways of reducing the noise?

It is not always possible for people in workplaces to judge correctly whether a certain noise, or noises, constitute(s) a long-term hazard to employees. Consultants can assist by carrying out a noise survey. The survey will establish whether a noise hazard exists. The consultant will generally offer advice on the results of the noise survey firstly by emphasising the most appropriate step, that is, engineering control of noise and vibration.

It is advisable to consult your relevant employer or employee organisations as they may be able to offer a service.

The Yellow Pages telephone directory is a good general source of information on consultants and services. The relevant sections are “Acoustic Consultants”, “Noise Control and Measurement” and “Occupational & Industrial Health & Safety”. “Vibration Analysis/Control” may also be relevant.

**HEARING
TESTS**

Where do I get information if I want hearing tests for my employees?

Audiologists are professionally qualified to test hearing. Audiometrists are able to do basic hearing tests but may need to refer their client to an audiologist or medical specialist if further assessment is necessary.

The Yellow Pages section “Audiologists” may be a source of information on audiometrists who would do screening hearing tests.

An additional source of information would be the union or employer association relevant to your industry.

**NOISE
CONTROL
EQUIPMENT
AND
MATERIALS**

How do I reduce the noise and where do I buy equipment, materials and services to reduce noise and vibration?

Many companies provide advice, services and special products for reducing noise. Some companies may be able to offer noise measuring services as well as supply and installation of controls. The following sources will

provide information on available engineering contractors and suppliers of equipment and materials to absorb, insulate, damp, muffle or isolate vibration and noise in the workplace:

- The Yellow Pages sections “Noise Control and Measurement”, “Acoustic Materials and Service”, “Vibration Analysis / Control”, “Insulating Materials-Retail” and “Insulating Materials-Wholesale or Manufacturers”.
- The Australian Engineering Directory 1989 which can be obtained from Technical Indexes Pty Ltd, in NSW, Victoria and Queensland, at a cost of A\$95.00. Libraries may also hold copies of this publication.
- Advertisers in *New Zealand Acoustics*, the journal of the New Zealand Acoustical Society, also provide a source of information. This publication can be obtained from: The Secretary, New Zealand Acoustical Society, PO Box 1181, AUCKLAND. University libraries may also have copies of the publication.

**SAFETY
WARNING
SIGNS**

How do I warn people that an area or machine is noisy?

The warning that hearing protectors are necessary in a specific area can be presented on a sign with words only (verbal), with a picture only (pictograph), or with words and picture (verbal pictograph). It is important to ensure that the sign can be understood by persons not familiar with written English.

The New Zealand/Australian Standard NZ/AS 1319 details rules for the design and use of safety signs. This can be obtained from Standards New Zealand, Wellington.

Convenient signs you can use are included in the *Management of Noise at Work Resource Kit*, available from the Occupational Safety & Health Service. These signs are in two sizes: A3 and A4, and are printed on a durable synthetic material. Write, in the spaces provided, the grade of hearing protector required and where people can get the protectors from (see facing page). Additional copies of these signs are available from OSH.

The signs are also supplied as a smaller self-adhesive label which may be attached to noisy machines.

The Yellow Pages section “Signs” lists companies which may supply safety signs complying with the Standard.



Write in the appropriate number

Write in where the protectors can be obtained e.g. Stores Dept Phil Smith

HEARING PROTECTORS

Reducing the noise level is preferable, but in the meantime how do I protect and educate my employees and where can I buy hearing protectors?

Reduction of the noise level is the best way of dealing with a noise problem. However, if noise reduction is delayed, it is essential to supply hearing protectors and training for everyone involved and/or reduce the amount of time individuals spend in noisy areas, for example, having staff alternate between quiet and noisy areas.

Consultants who advise on hearing protectors and education are listed in the Yellow Pages in the “Acoustic Consultants”, “Occupational & Industrial Health & Safety” and “Audiologists” sections.

The suppliers of hearing protectors are listed in the Yellow Pages under “Safety Equipment and Products” and “Clothing: Protective”. Some suppliers will give training sessions and advice on the choice and fit of hearing protectors.

It is also advisable to consult your relevant employer and employee organisations as they may be able to offer a service.

The Occupational Safety & Health Service has a publication entitled *List of Graded Hearing Protection Devices* (which is also included in the *Resource Kit*). Copies can be obtained from OSH branch offices.

**NOISE
LEGISLATION
AND
STANDARDS**

Where can I obtain information about noise legislation and standards?

Copies of the Health and Safety in Employment Act 1992 and the Health and Safety in Employment Regulations 1995 can be obtained from:

Your nearest OSH branch office or Bennetts
Government Books

Standards can be obtained from:

Standards New Zealand
Private Bag 2439
Standards House
155 The Terrace
WELLINGTON 6001
Tel: (04) 498 5990

Sales Orders (04) 498 5991
Standards Information Service 0900 50 550
Quality & Certification (04) 498 5993
Facsimile (04) 498 5994

Relevant Standards include:

IEC 651-1979 *Sound level meters*

IEC 225-1966 *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations*

IEC 804-1985 *Integrating-averaging sound level meters*

ISO 1999-1990 *Acoustics - Determination of occupational noise exposure and estimation of noise induced hearing impairment*

ISO 2631-1985 *Evaluation of human exposure to whole body vibration (Parts 1-3)*

ISO 4869-1990 *Acoustics - Hearing protectors*

ISO 5349-1986 *Mechanical vibration - Guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration*

BS 6841-1987 *Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*

AS 1081-1990 *Acoustics - Measurement of airborne noise emitted by rotating electrical machinery*

AS 1217-1985 *Acoustics - Determination of sound power levels of noise sources (Parts 1-7)*

AS 1259-1990 *Acoustics - Sound level meters*

AS 1269-1989 *Acoustics - Hearing Conservation*

AS 1276-1979 *Methods for determination of sound class and noise isolation class of building partitions*

NZ/AS 1319-1994 *Safety signs for the occupational environment*

AS 1359.51-1986 *Noise level limits (IEC 34-9)*

AS 1591-1987 *Acoustics - Instrumentation for audiometry (See also Z43)*

AS 1633-1985 *Acoustics - Glossary of terms and related symbols*

AS 1807.16-1989 *Determination of sound level in cleanrooms*

AS 1807.20-1989 *Determination of sound level at installed workstations and safety cabinets*

AS 1948-1987 *Acoustics - Measurement of airborne noise on board vessels and offshore platforms*

AS 2012-1990 *Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - stationary test condition*

AS 2107-1987 *Acoustics - Recommended design sound levels and reverberation times for building interiors*

AS 2221-1979 *Acoustics - Methods for measurements of airborne sound emitted by compressor units including primemovers and by pneumatic tools and machines*

AS 2253-1979 *Methods for field measurement of the reduction of airborne sound transmission in buildings*

AS 2254-1988 *Acoustics - Recommended noise levels for various areas of occupancy in vessels and offshore mobile platforms*

AS 2399-1980 *Acoustics - Personal noise dosimeters*

AS 2436-1981 *Guide to noise control on construction, maintenance and demolition sites*

AS 2586-1983 *Audiometers (IEC 645)*

AS 2659-1988 *Guide to the use of sound measuring equipment*

AS 2900.7-1986 *Quantities and units of acoustics*

AS 2991-1987 *Acoustics - Method for determination of*

airborne noise emitted by household and similar electrical appliances

AS 3534-1988 Acoustics - Methods for measurement of airborne noise emitted by powered lawnmowers, edge and brush cutters, and string trimmers

AS 3663-1989 Acoustics and mechanical vibration - Definitions of fundamental quantities and their expression as levels

AS 3713-1989 Acoustics - Industrial trucks - noise measurement

AS 3782-1990 Acoustics - Statistical methods for determining and verifying stated noise emission values of machinery and equipment

MODULE 1: CASE STUDIES

**THIS MODULE
IS FOR THE**

Noise manager
Chief executive officer
Production/engineering staff
Employee representatives
OHS committee

PURPOSE

These case studies demonstrate:

- the practical nature of noise management;
- effective, low-cost noise control solutions;
- policies and organisational arrangements supporting effective noise management programmes.

CONTENTS

CASE STUDY 1: WARATAH WIRE PRODUCTS
CASE STUDY 2: JOHNSON AND JOHNSON

CASE STUDY 1: WARATAH WIRE PRODUCTS

BACKGROUND Waratah Wire Products (Sydney Wiremill) is a subsidiary of the Broken Hill Proprietary Company Ltd. and produces wire fencing products, barbed wire, nails and steel reinforcing. The original factory was built over 100 years ago, although a large proportion of the operation has been modernised. The company has approximately 410 employees and is located in a residential area of Sydney.

THE HEARING CONSERVATION PROGRAMME The noise reduction programme began after complaints were received from nearby residents. Action was taken to quieten the main offending sources. This was the beginning of a noise reduction programme throughout the entire factory which has eventually benefited the work force and the company.

The main emphasis of the hearing conservation programme is on engineering noise control to bring noise levels to below 90 dB(A). The driving force behind this programme is an engineer who is specifically trained in noise control. He has applied the basic principles of noise control to great effect and is continually trying new ways to further reduce the noise levels in the factory.

The hearing conservation programme operates under a broad occupational health and safety policy which prescribes that “managers and supervisors provide resources, systems, facilities, procedures and methods of supervision to ensure the safety of employees”.

EMPLOYEE TRAINING Employees receive information on all occupational health and safety matters relevant to their particular job at an induction training course held at the commencement of their employment with the company. This includes advice on appropriate hearing protection. Supervisors attend regular refresher safety courses and are responsible for ensuring that hearing protectors are worn by employees in designated areas.

AUDIOMETRY Pre-placement audiometry is performed by the resident occupational health and safety nurse. Follow-up tests are made every two years. A computerised audiometric system, which provides reports for each of the employees tested, has recently been purchased. These reports are stored at the health centre on the premises.

NOISE SURVEYS Noise contour maps of the entire factory have been drawn. This has aided in the setting of priorities for noise control. The daily noise doses of employees are assessed about every two years. Noise levels are also measured when new equipment is purchased or existing machinery is modified or relocated.

**EXAMPLES OF
ENGINEERING
NOISE
CONTROL**

Numerous examples of engineering noise control solutions are to be found in the factory, and a selection of these are described below. In most of the cases described, hearing protectors were no longer required by the operators.

Wire is drawn to the required diameter on wire drawing machines and then recoiled. There were fifteen of these machines producing noise levels of between 103 dB(A) and 105 dB(A) in the area.

The drawing mechanism required the use of a large motor and a two-speed gear box. The original gear box was based on spur gears. After a few years, this gear box became very noisy due to wear.

The manufacturer in England was asked for a quotation on a new gear box. The price was \$6,000 and the noise level expected was 92 dB(A). The engineers then looked at the possibility of using a helical gear box bought locally. The cost of these machines was also unacceptable.

The gear box was eventually replaced by a belt drive which reduced the noise level considerably. Changing the belt to change the speed was accomplished by using a pneumatic lifter and a pivoting table to lift the motor and hence slacken the belts.

It was found that the maintenance-free life of the belt drive was far longer than that of the gear box.

After experimenting with this one machine the same noise control procedure was applied to all 15 machines.



Figure 1: Large wire drawing machine showing the pulley drive system which replaced the two-speed gear box

Noise reduction: from 105 dB(A) to 85 dB(A)

Cost: \$4,000 - \$5,000 per machine

SINGLE HOLE
WIRE DRAWING
MACHINES

Many modifications have been made on these machines in order to reduce the noise. These modifications include:

- Filling the wire guide rings with sand to dampen the impact vibration.
- Installing a pneumatic stopper for a swinging arm. This removed the impact noise which previously accompanied movement of the arm.
- Placing old conveyor belt on parts of the guide train where metal to metal contact was occurring.
- Supplying silencers with the pneumatic system to reduce the high-pitched sound of air release.
- Replacing spur gears with helical gears. This produced a considerable noise reduction.
- Eliminating metal to metal impact of the wire retainer hitting the base by simply placing a piece of rubber from an old flexible coupling under the retainer.

Noise reduction: from 98 dB(A) to 88 dB(A).

NAIL MAKING
MACHINES

Several nail making machines were purchased eight years ago. These machines produced noise levels up to 104 dB(A). The solution was to build full enclosures. An additional safety benefit was that the enclosures also served as guarding for the machines. When the door of the enclosure was opened, the machine automatically shut down. The enclosures were demountable which meant that maintenance could be easily carried out without the hindrance of the enclosure.

Noise levels were reduced to between 83 - 89 dB(A) depending on the measurement position. A great deal of noise was still escaping from the gap where the wire entered the enclosure so a small steel box was constructed around this inlet. The inside of the box was lined with 50 mm of sound absorbing foam. The foam



Figure 2: View of the nail making machine showing the total enclosure.



Figure 3: Silencing box fitted to the enclosure.

was covered with thin aluminium foil to prevent dust and grease accumulating. This treatment further reduced the noise level to 83 dB(A) from 89 dB(A) at that position.

Noise reduction: from 104 dB(A) to 83 dB(A).

GALVANISED NAIL RUMBLERS

Nails were tumbled in a rotating drum called a “rumbler” for polishing to the finished product. This process was very noisy and was the dominant noise source in an otherwise quiet part of the factory. The main sources of noise were the gear drive mechanism and the impact of the nails on the walls of the drum.



Figure 4: Nail rumbler with sound damping material painted onto the drum.

Noise control treatments consisted of:

- Painting sound damping material onto the outside of the drum reducing the noise level by about 3 dB(A);
- Overhauling the drive mechanism, replacing bearings and chains and replacing a steel gear with a nylon gear. The nylon gear was machined in the company's own workshop.

These treatments reduced the noise levels to an average of about 85 dB(A) as shown in the following table.

<i>Noise levels (dB(A)) at measuring positions</i>				
	1	2	3	4
Before treatment	95-100	90-96	88-94	90-97
With damping	91-94	88-91	88-91	85-87
With overhaul of drive mechanism	87-92	85-89	83-87	82-84

Noise reduction: approximately 5 - 8 dB(A) depending on measurement position.

STEEL NAIL
RUMBLERS

The company required three nail polishing machines. It was decided to build these machines in its own workshops.

The steel nails are polished in a rumbler. Finished nails are expelled from the machine via a chute and collected in a tray at the bottom. Previous experience with similar noisy machines allowed the engineers to anticipate where the major sources of noise would occur. Most noise would be produced by the impact of nails on the drum and their impact on the expulsion chute.

The following engineering noise controls were incorporated:

- The first step was to decrease the rotation speed of the drum to a point where the efficiency of the operation was not compromised.
 - The noise produced by the impact of the nails on the chute was diminished by covering the chute and the collecting tray with 1.6 mm rubber (Dunlop Flexide). This was in turn overlaid with a sheet of special hard wearing nylon material (4.5 mm Ralloy plastic).
 - A piece of old conveyor belt rubber was used as a baffle in front of the chute to collect stray nails.
 - Tico S, a cork based vibration damper, was used under the feet of the rumbler.
 - A silencer was fitted to a fabric dust collector.
- These treatments were successful in reducing the noise level to below 85 dB(A).

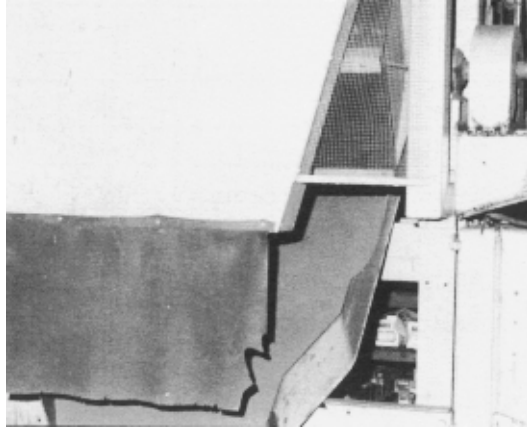


Figure 5: Nail rumpers. The machines were designed and constructed in-house with noise control treatments incorporated.

Figure 5 shows the rubber baffle and behind it the chute which was covered with rubber and hard wearing nylon.

Noise reduction: The noise level produced by the machines was 83 dB(A). It was estimated that without the noise control treatments the noise level would have been between 89 and 92 dB(A).

Cost: (in 1983) Chute insulation: 4.5 mm Ralloy sheet plastic (from Cadillac Plastics Australia bought in sheets 2 m x 1 m - \$126 per sheet). 1.6 mm rubber canvas insertion (Dunlop Flexide) - \$21 per metre. Silencer for dust collector, \$250.

BARBED WIRE
MAKING
MACHINE

The original barbed wire making machines produced noise levels of 98 dB(A). The newer machines were supplied with a complete enclosure and a sliding opening to allow full access to the working parts. The noise level was reduced to around 82 dB(A).

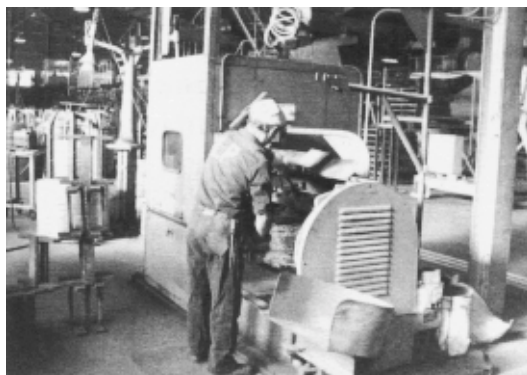


Figure 6: Barbed wire making machine with full enclosure.

Noise reduction: from 98 dB(A) to 82 dB(A).

Cost: The cost of enclosure was included in the total price of the machine as supplied by the manufacturer.

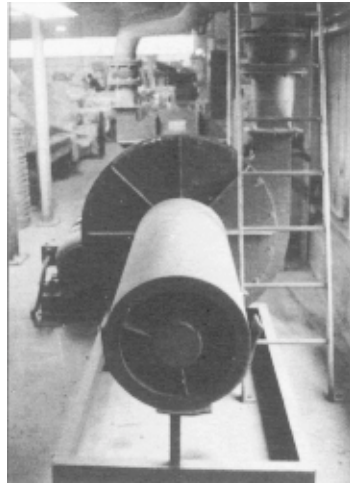


Figure 7: Furnace air fans showing intake silencer

FURNACE
AIR FANS

Large fans supplied air to furnaces. The noise control techniques included the installation of:

- anti-vibration mountings;
- silencers on air intake;
- rubber flexible connections;
- damping material on fan housing.

Noise reduction: 15 dB(A).

AIR
COMPRESSORS

Several air compressors are in use. The oldest of these has been fitted with a silencer on the air intake, flexible hose connections made from woven steel and neoprene anti-vibration mountings. These measures have brought the noise level down to 91 dB(A). Newer compressors came supplied with complete enclosures which reduced the noise level to about 81 dB(A). Operating controls were located on the outside of the enclosure.

Noise reduction: (due to enclosure) 20 dB(A)

Cost: The enclosure was included in the total price as supplied.

CASE STUDY 2: JOHNSON AND JOHNSON

BACKGROUND A very successful hearing conservation programme has been carried out by Johnson & Johnson Pty Ltd (J&J). The company has reduced noise to a level at which hearing protection is no longer necessary for the majority of the workforce. It has also eliminated compensation claims for hearing loss, and is very proud of its efforts.

J&J is an American multinational company which produces many familiar products such as Johnsons' Baby Powder, Shampoo, Carefree® Tampons, Cotton Buds, cotton balls, and disposable plastic gloves. The company employs about 1,000 people, most of whom have non-English speaking backgrounds.

Although being described as a light industry, J&J nevertheless used many noisy machines in its production lines. These included carding machines, filling and packing machines, presses and fork lift trucks. Before the hearing conservation programme, people working in these areas were receiving daily noise exposure levels which exceeded 90 dB(A).

In the period 1981-83, a complete safety audit was made on the company by a group under the acronym NATLSCO. This was a firm employed by the parent company in the United States of America to conduct safety audits on J&J companies around the world. The initial findings were disastrous and the commitment to health and safety of the parent company was so strong that it recommended the division be closed down if it could not lift its game!

With the necessary motivation behind them, this Australian subsidiary set about improving its performance in occupational health and safety.

THE NOISE MANAGEMENT PROGRAMME The Training Section of J&J decided that to successfully tackle the problem the management had to be convinced of the need for the programme. In 1984, educational materials were gathered from many

sources, but mostly from the suppliers of hearing protectors and other noise control devices. With this information, members of the Training Section produced a very comprehensive document on their hearing conservation programme. The hearing conservation programme gave guidelines on the following:

- company policy;
- the responsibilities of each department in regard to the programme;
- relevant legislation;
- noise and the concept of daily noise dose;
- noise exposure guidelines, exposure limits ($L_{eq(8h)} = 85 \text{ dB(A)}$), specifications for new plant, surveillance guidelines;
- noise monitoring programme;
- noise control (guidelines for engineering controls and personal hearing protection);
- audiometric testing programme (pre-employment for all employees and annually for those working in noisy areas);
- administrative responsibilities (consultation with employees, employee training and notification of test results, supervision and record keeping);
- in-house audit of the programme.

Training materials, including lecture notes, pamphlets, charts, videos, a model plastic ear and overhead transparencies, were prepared. Training sessions on the nature and effects of noise, assessment of exposure and basic noise control were held with both the supervisor group and the workers. Supervisors were issued with a manual on the hearing conservation programme and written safety objectives for their area of responsibility.

One particular technique was found to be successful in convincing the supervisors and workers of the effectiveness of hearing protectors. Sounds in the range 90 dB(A) to 100 dB(A) were played through loudspeakers to the participants, who were then asked to place earmuffs over their ears to notice the dramatic drop in loudness.

The educational programme was a success in the opinion of the training personnel, however a degree of

enforcement was still necessary to ensure compliance with rules for the wearing of hearing protection. It was important that top management was committed to the success of the programme.

The company encourages the workers to inform the management of any problems. Then the engineers must act on the problem within a week.

NOISE SURVEYS A noise survey of the plant is carried out yearly by a consultant to assess the daily noise doses of the employees and assess the company's progress in noise reduction.

NOISE CONTROL Through the purchase of quiet machinery and engineering noise control on other equipment, the reliance upon personal hearing protectors was gradually made unnecessary in most areas of the factory.

BUY QUIET POLICY The company has included a buy quiet policy into its purchasing guidelines for engineers. The stated policy is that a machine which exceeds 80 dB(A) at 1 metre must be fitted with noise-reducing panels. A major purchase of new machinery for the production of shampoo saw the policy work well: the manufacturer supplied equipment within the specified limits. Machinery guards, made of perspex, also served as partial noise enclosures.

EXAMPLES OF ENGINEERING NOISE CONTROL Machinery manufacturers are not always able to comply with the 80 dB(A) limit, necessitating post-installation noise control treatments. Details of such treatments are given below.

COTTON BUDS® MACHINES As supplied, machinery producing Cotton Buds® produced noise levels of 92 dB(A). The manufacturers suggested a complete enclosure. This option was rejected because access was needed for maintenance and product adjustment. The solution was to only enclose

the parts of the machine which produced noise. These partial enclosures also served as safety guards and access to the internal parts was still possible through interlocked hatches which when opened, shut the machine down. All construction was done in-house.

Noise reduction: from 92 dB(A) to 84 dB(A).

Cost: \$500 per machine.

Noisy parts of the machine were enclosed using stainless steel and brushed aluminium. The inner walls of the enclosure were lined with a special marine noise reducing material, FLS-20, obtained from a supplier of acoustic materials. The material consisted of a layer of loaded vinyl sandwiched between two layers of polyurethane foam. The foam was lined on the inner surface with thin aluminium foil to facilitate cleaning and prevent dust collecting on the foam. The foam was treated for fire resistance.

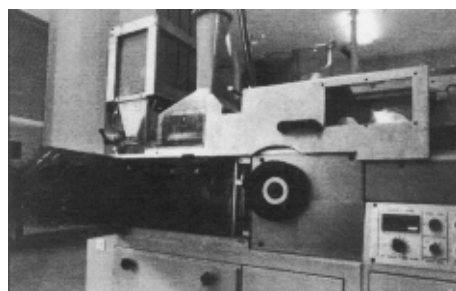
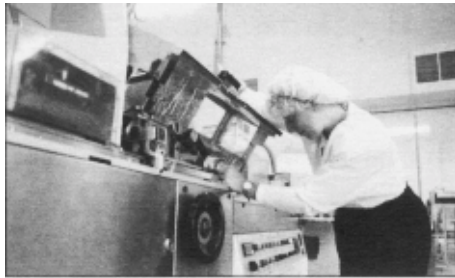


Figure 1: View of Cotton Buds[®] machine showing partial enclosures and ease of access.

The hopper/vibrator which supplied the plastic lids for the Cotton Buds[®] containers was also a major source of noise. This source was greatly reduced by covering the hopper cover with a perspex lid lined with FLS-20.

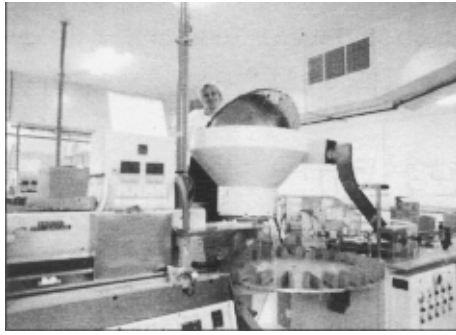


Figure 2: The vibrator was covered with a perspex lid lined with foam.

Noise reduction: from 88 dB(A) to 82 dB(A).

Cost: \$400 per machine.

OLD CARDING MACHINES

The newly purchased carding machines were supplied by the manufacturer with full enclosures. The old machines were initially open and unguarded. Partial enclosures were constructed for these machines by J&J's own personnel.

Simple enclosures were constructed around the drive mechanisms of the machines. Enclosures consisted of aluminium sheet with small perspex windows. These partial enclosures served as safety guards as well as noise insulators.

An important feature of the partial enclosures was their ease of removal for maintenance. To aid removal, wheels were fitted to each enclosure.

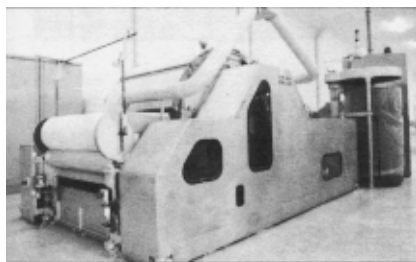
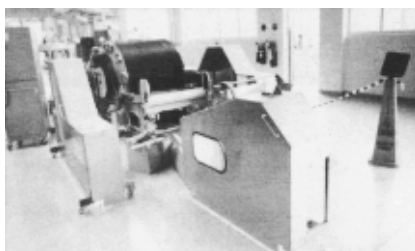


Figure 3: View of old carding machine with partial enclosure along sides. The enclosure is built in sections and is on wheels for removal during maintenance.



PLASTIC GLOVE
MAKING
MACHINE

A machine which made disposable plastic gloves produced noise levels up to 94 dB(A). Noise levels at the operator's position were reduced to 82 dB(A).

The glove making machine was to be relocated, so thought was given to reducing the operator's noise exposure and at the same time improve the efficiency of the process. The old machine was totally refurbished; the mechanical drive unit and all bearings were replaced. A vibration packing unit was also replaced with a quieter process. Metal to metal contacts were eliminated where possible by using rubber inserts.

The waste plastic was drawn off through an exhaust duct. The fans which powered this Venturi system were originally located just above the machine. This method of waste removal was considered to be efficient, so it was retained, but the fans were relocated to a nearby plant room and silencers placed in the ducts.

Finally, the sides of the machine were enclosed using steel sheet with glass viewing panels. Reflected noise was controlled by placing sound-absorbing panels above the machine. The whole machine was isolated in its own room so that its noise would not intrude on other quieter areas in the factory.



Figure 4: The glove making machine showing enclosed sides, the Venturi exhaust ducting above and the windows (in the background) of the enclosing room.

Noise reduction: from 94 dB(A) to 82 dB(A).

Cost: \$7,000 (4 per cent of total machine replacement cost.)

CAREFREE®
TAMPONS
MACHINE

The machine which formed Carefree® Tampons from cotton/ rayon sliver produced a noise level of 88 dB(A) at the operator's position. A transparent enclosure (perspex, 6 mm), which included access doors, was constructed around the sides of the machine. This achieved a noise reduction of 5 dB(A) to 83 dB(A). The noise level at the operator's position was slightly higher (85 dB(A)) because several of these machines were operating simultaneously in the room.

The noise control treatment was not fully efficient because noise still leaked from a few gaps between the perspex panels and out through the top, which was still open. The next step will be to seal the existing gaps, cover the top, and place sound-absorbing material within the enclosure. These additional measures should further reduce the noise level by up to 10 dB(A).

As a safety feature, the machine guards were interlocked to automatically switch the machine off when an enclosure door was opened.

Noise reduction: from 88 dB(A) to 83 dB(A).

COTTON BALL
MAKING MACHINE

Noisy parts of the machine, mainly the drive mechanisms, were enclosed, reducing the noise level from 86 dB(A) to 83 dB(A).

FORK LIFT TRUCKS

Noisy diesel fork lift trucks were replaced by quiet electric models.

CONCLUSION

Johnson & Johnson are justly proud of their achievements in the control of noise. They have a buy quiet policy which seems to be working in most, but not all, cases. The need for personal hearing protectors has almost been eliminated and worker morale is high.

MODULE 2: WALK-THROUGH AUDIT

THIS MODULE IS FOR Noise manager
Production/engineering staff
Maintenance staff
Employee representatives
OHS committee

PURPOSE A walk-through assessment can help to define the noise problem and provide the basis for a noise control plan. It is an informal audit of noise sources, possible noise controls and management measures to reduce noise exposure.

OUTCOMES The expected outcomes are that the noise manager should be able to:

- Identify problem noise areas/machines;
- Identify obvious noise control methods;
- Evaluate effects of major changes expected in the workplace;
- Identify the need for a detailed noise control study or design;
- Identify the need for revision of the personal hearing protection and education programme.

CONTENTS SETTING IT UP
ASSESSMENT PROCEDURE

A WALK-THROUGH ASSESSMENT OF YOUR WORKPLACE

SETTING UP You may wish to arrange for the assessment to include the entire workplace (if small) or only part of it. Choose an area that can be covered in about half a day.

It is crucial that you are accompanied by the right people. You are likely to need people who understand the work process and the machinery (engineering/production); operators of particular machines, health and safety representatives or employee representatives; and people who control decision-making, planning and budgets (management). Try and keep the group to a workable size (say three to six people), since it may be hard for larger groups to hold discussions in noisy areas!

If you have a sound level meter, it is useful to take this along to show the group indicative sound levels (if you are confident to do so). Measure noise levels at operator ear positions wherever possible. Pay particular attention to areas where operators use powered hand tools such as pneumatic nut-runners and screwdrivers. Noise levels at operator ear positions in these situations are usually much greater than those a few metres away in the passageways and may surprise managers and engineers who believed there were no noise problems in these areas.

Prior to embarking on your “walk”, assemble all the relevant information you can find relating to noise in the area to be assessed. This may include:

- Previous noise survey reports;
- Manufacturers’ data on particular items of plant;
- Your own previous “walk-through” measurements and observations;
- Previous comments by employees or others.

You may also find it useful to draw up an assessment sheet for each small work area or machine, as a means of logging the results /ideas /solutions /options put forward. Sample blank and completed noise assessment report forms are included at the end of this module. The forms follow the format of the four-step procedure for a walk-through assessment, given below.

**ASSESSMENT
PROCEDURE**

The following four-step procedure is aimed at developing an engineering noise control strategy. Each step is discussed in terms of the “sources”, “paths”, and “receivers” (employees). You should cover all four steps for each work area as a whole as well as for the primary noise sources or machines in the area.

1. IDENTIFY THE
PROBLEMS

Sources

- What type of noise sources are evident?
 - Mechanical sources: Impact? Out of balance? Transmission system (gears, chains, belts, etc.)?
 - Hydraulic systems: Pump noise? Flow noise? Noise from moving load?
 - Aerodynamic noise: Compressed air jet? Pneumatic exhaust? Fan? Fan noise in duct?
 - Thermodynamic noise: Noise from burners?
- Which of these noise sources or mechanisms appear to be most important?

Paths

- What type of noise paths are present?
 - Mechanical coupling to a radiating surface? Structure-borne?
 - Airborne? Direct line of sight in a reverberant building? Over a barrier?
 - Duct-borne? Fan noise coming down a duct?
- Which paths are most important? (noise may be arriving at the receiver via several paths).

Receivers

- How many employees are affected? (See *Module 5: Using Surveys*).
- Where are they?
- Why are they there? Are they on any kind of job rotation?
- What protection do they have? Are they wearing it? Is it appropriate? Do they know what noise level they are exposed to? When did they last have a noise education programme? (See *Module 12: Personal Protection*.)

Example -John's Story

As I walked towards the plant I could hear a distinctive tone. "You can't do anything about those centrifuges" he said "they run at 15,000 rpm".

Interesting, 15,000 revs per minute is $15,000/60 = 250$ revs per second. The source of the tone I could hear was probably an imbalance in the centrifuge, causing a tone at the frequency corresponding to the rotational speed. I already knew something useful before putting my foot in the door! I knew the type of source and the noise-generating mechanism.

Up on the centrifuge floor, my suspicions about the quality of the installation were confirmed. The six centrifuges were bolted rigidly to the concrete floor and the loud noise dominated everywhere. It was conducted into the floor slab via the mountings and rigid pipe connections (the path). It was conducted into the walls and other panels via electrical cable trays and other pipes. I asked myself why don't people stop and think before doing this sort of installation?

The operators (the receivers) were on the centrifuge floor all day, either in the plant area, laboratory or lunchroom . All complained about the loud noise. Was the primary path into these rooms structural (through the slab) or air-borne (from the centrifuges themselves)? I stood in one of the rooms with the door closed, then opened it. A bit more high frequency noise but no difference to the tone. I could feel the floor, walls and windows vibrating and this tended to confirm that the noise was structure-borne. With proper isolation of the mountings and pipework, we should be able to improve this situation no end but we'll leave that to the experts. "You can't do anything about those centrifuges". Who says?

2. IDENTIFY OBVIOUS TREATMENTS

Sources

- Do we have to do it this way? Can we change the process and eliminate or minimise the source?
- Can we reduce forces? Impacts? Reduce air pressure? Speed?
- Is it a routine maintenance matter? (See *Module 3: In-house Control*).

- Can we isolate coupled components to reduce transmission of vibration to noise radiating surfaces?
- Can we introduce vibration damping on surfaces to reduce their response to impacts?
- Are there mufflers/silencers readily available for these aerodynamic sources?

Paths

- Can we increase the distance between source and receiver?
- Can we introduce a localised cover or guard over a noise radiating surface or noise source?
- Is a simple enclosure of the source possible?
- Can we introduce simple screens or barriers between sources and receivers?
- Can we simply introduce sound absorption in the space?

Receivers

- Can some employees be located in booths or shelters?
- Can we easily change the layout to better separate employees from machines?
- Is it possible to remove some employees to quieter areas?
- Can we make changes to routines to reduce employees exposure time in the noisy area?

Before implementing extensive changes following the assessment above, you will need to consider whether any major changes, likely to affect the work areas, are about to occur. Consider changes to sources, paths and receivers.

3. EVALUATE
EFFECTS OF
MAJOR CHANGES
EXPECTED

Sources

- Is this machine to be replaced soon?
- Is a new work process to be implemented? New machines added?
- Is the machinery to be upgraded or modified?
- Is a new plant to be built?

- Is there a purchase policy or noise specification for the new plant/machine? (See *Module 8: Buy Quiet*).

Paths

- Is the layout of the work area to be altered?
- Are architectural changes planned? Partitions?
- Are you moving to new premises?

Receivers

- Are personnel to be moved?
- Are the above changes in sources and paths likely to result in relocation of employees?
- Will retraining be needed (thus providing an opportunity for a noise education program)?

You can use these changes as an opportunity to integrate aspects of your noise control plan into your overall workplace planning. This may mean bringing some changes forward for noise control reasons, or deferring some treatments identified in Step 2. Your aims must be to ensure that the changes result in a **quieter** workplace and that this occurs within a reasonable time frame.

Example - Plastics Recycling Company

A plastics recycling company had three granulators which generated noise levels typically 95-110 dB(A) at the operator's position, while grinding. The company identified a low-cost treatment in the form of an absorptive lining in the feed chute (operator's position) and acoustic shrouding around the discharge point.

At the same time, however, it was apparent that the oldest (and noisiest) of the granulators was almost due for replacement. Information from an Australian manufacturer of plastics granulators indicated that a new granulator would emit a noise level of about 85 dB(A) at the operator's position while grinding, that is, some 25 dB(A) quieter than the old unit!

Accordingly the new unit was budgeted for, and the other two units were earmarked for later replacement. As a result of the time lag in obtaining budget approval and completing purchase and commissioning of the new machine, it was decided that the old machine

(along with the other two machines) should be provided with the low-cost treatment. This reduced noise levels to about 100 dB(A) on the oldest machine and about 90 dB(A) on the other two.

4. IDENTIFY THE
NEED FOR
DETAILED
CONTROL STUDY
OR DESIGN

A walk-through assessment will highlight lots of areas where reductions in noise can be achieved with minimal or moderate expenditure. However, you are also likely to find machines, or even whole work areas where the reduction of noise is likely to involve considerable expenditure and technical complexity. Before embarking on such a costly exercise, it may be wise to seek the assistance of an acoustical consultant. This person can introduce the expertise needed to identify the options for noise control, evaluate costs and benefits, and carry out detailed design work. A contractor would then be engaged to carry out the work. *Module 4: Consultants* deals with the roles of consultants and contractors and how to brief them.

You may require external expertise if, when faced with the following questions, you cannot answer them:

- We feel it best to enclose this machine, but how do we do it in the most cost-effective way, still allowing for cooling and access? Would it be better to reconsider treating the source?
- How do we design the new control room so that it is effectively isolated from the surrounding noise and vibration?
- How do we design the new plant to minimise noise?
- We have a fixed budget for noise control work. How do we best spend it?
- Is it more cost-effective to enclose this machine (with still the noise of other machines) or to apply absorptive material to the work area to achieve an overall reduction in noise level?
- If we treat the airborne noise path, will the structure-borne noise path still be significant? How do we then treat the structure-borne path?

NOISE ASSESSMENT REPORT FORM

Work Area:	Sheet: of	Date:
Location:	Assessment Team:	
Machines:	Background Data:	

Task/Item	Identify Problem	Obvious Treatment	Major Changes	Detailed Study
SOURCES: Mechanical: <ul style="list-style-type: none"> • Impact • Vibration • Rotation Aerodynamic: <ul style="list-style-type: none"> • Pneumatic • Fan Turbulent flow: <ul style="list-style-type: none"> • Duct • Pipe Other:				
PATHS: Airborne: <ul style="list-style-type: none"> • Open air • Reverberant space • Barrier Structure-borne: <ul style="list-style-type: none"> • Building • Coupling to surface Duct-borne: Other:				
RECEIVERS: No. affected: <ul style="list-style-type: none"> • Operator • Bystander • Other Location: <ul style="list-style-type: none"> • Operator • Bystander • Other HPD Worn: <ul style="list-style-type: none"> • Operator • Bystander • Other Other Comments:				

MODULE 3: IN-HOUSE CONTROL

THIS MODULE IS FOR Noise manager
Production/engineering staff.

PURPOSE One of the best ways of reducing workplace noise “at the source” is via a program which ensures that noise is considered as part of the maintenance, modification and upgrading of the plant. This module sets out a “practical diagnosis” procedure which can be carried out by maintenance personnel to tackle noise problems. This module follows on from *Module 2: Walk-Through Audit* in which the main noise sources, paths and receivers were identified.

OUTCOMES By using this module, you should be able to:

- conduct a “practical diagnosis” on each machine of interest;
- develop a maintenance program to minimise noise from existing plant, including specific noise control items which need maintenance;
- identify and set priorities for modifications to the plant to reduce noise, for integration into the company noise control plan;
- establish a process for considering noise in minor plant upgrades;
- minimise noise from maintenance work itself.

CONTENTS WHAT YOU WILL NEED
OVERVIEW OF MAINTENANCE AND MODIFICATION
PRACTICAL DIAGNOSIS
DIAGNOSTIC TESTS
MAINTENANCE OR MODIFICATION?
UPGRADING THE PLANT
MINIMISING MAINTENANCE NOISE
CONCLUSION
REFERENCED DOCUMENTS
APPENDIX

REDUCING NOISE THROUGH “IN-HOUSE” MAINTENANCE, MODIFICATION AND UPGRADING OF PLANT

WHAT YOU WILL NEED

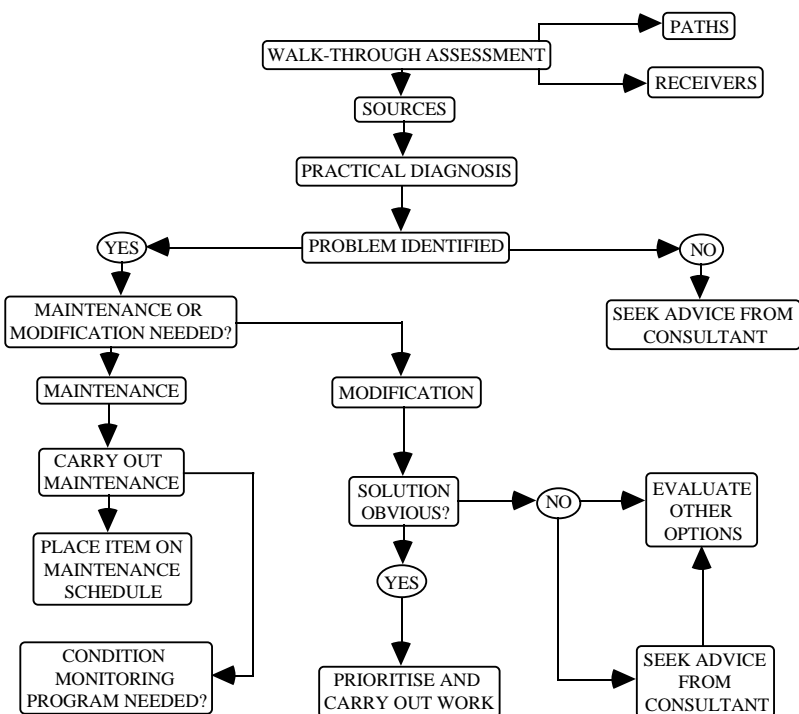
To use this module, you will need the results of previous walk-through assessments (see *Module 2: Walk-through Audit*) and any previous noise survey reports. You may wish to obtain a copy of the references listed at the end of this module.

The result of the initial walk-through assessments should have highlighted:

- machines requiring basic maintenance or modification (involving you and your staff);
- areas or machines requiring a noise control study using an external consultant;
- any changes about to take place which may replace the need for either of the above;
- any broad options available for noise control.

OVERVIEW OF MAINTENANCE AND MODIFICATION

The figure below presents an overview of the procedures involved in maintenance and modification of existing plant to minimise noise.



**PRACTICAL
DIAGNOSIS**

This section presents a series of diagnostic steps which can be carried out by an engineer or maintenance supervisor with a thorough understanding of the machines and a basic knowledge of noise. No sound measuring instruments are needed for this procedure, which is based on the work of S A Worley⁽¹⁾, at Lucas Diesel Systems, London. In cases which are beyond the scope of this procedure, the assistance of a consultant with sophisticated measurement and analysis equipment may be needed.

The procedure, summarised in Table 1, consists of a structured series of listening tests based on four questions:

Q1. What kind of noise is this machine producing?

Q2. What is it in this machine which might be causing this noise?

Q3. What tests can I do to eliminate some of the possibilities?

Q4. What are the answers and solutions I am looking for?

Even if you had started to answer some of these questions in your initial “walk-through” assessment, it is advisable to start from Q1 and work through to Q4 with each machine.

The work you do now will not be wasted even if a consultant is eventually called in, since your knowledge will save the consultant time and the company money.

**DIAGNOSTIC
TESTS**

Table 1 on the following pages lists a series of tests which should be followed systematically during practical diagnosis. Each test is designed to identify a particular noise generating mechanism. The tests are described in detail on pages 5 to 8. They should only be carried out by competent staff and where tests can be done safely.

Table 1: Practical Diagnosis Procedure

Follow Q1 down until you find the right description then move to Q2 and so on:

<i>Q1</i> <i>Type of noise</i>	<i>Q2</i> <i>Possible causes</i>	<i>Q3</i> <i>Tests</i>	<i>Q4</i> <i>Examples of Treatments</i>
1. VARIES WITH TIME			
Impact (e.g. thump, bang, crash)	Impact of machine parts		Reduce impact velocity and rate of change of working forces (e.g. shear on press tool, soft face on hammer). Cushion impact with resilient material. Buffer at end of actuation travel. Damp resonant response of structure with self-adhesive damping sheet. Reduce backlash in drives, mass of moving parts.
	<ul style="list-style-type: none"> • guards 1,2 • working forces 1,3 • clutch 1,2,3 • indexing 1,3 • punch break-through 1,3 • other 		
	Component or scrap handling		Reduce drop height, cushion impact as above, damp resonant response as above, fit stock tube liner, reduce mass of moving parts.
	<ul style="list-style-type: none"> • chute 1,3 • bin 1,2,3 • scrap on scrap 1,3 • other 		
Cyclic (e.g. varying repeatably with each cycle of a process)	Load-related		Reduce noise of sources related to load condition. Reduce noise of sources which are independent of load.
	<ul style="list-style-type: none"> • louder on load 2,6,14 • louder off load 2,6,14 		
	Hydraulics		Check control system to ensure not pumping into closed volume. Fit hydraulic silencer or accumulator if strong pressure fluctuations in fluid. Isolate valves, pipes and load from structure.
	<ul style="list-style-type: none"> • pipework 5,6 • pump 5,6 • valves 5,6 • other 		
2. FREQUENCY CHARACTER			
Tonal	Mechanical transmission		Replace toothed belts, with V-belts, if synchronisation not vital, otherwise with half-cylinder tooth profile. Replace belt tensioning mechanism, replace worn, stretched belts. Replace worn gears with nylon gears, if possible check shafts for bending. Check gear box oil level and thicken if needed. Replace worn bearings.
	<ul style="list-style-type: none"> • toothed belt drives 6,9 • slipping flat belts 6,9 • slipping V-belt 6,9 • flapping drive belt 6,9 • gear box 6,7,9 • worn bearings 8 • other 		
	Cutting action		Ensure correct tool clamping, geometry, position and sharpness. Ensure workpiece is adequately clamped with damping on vibrating surfaces. Ensure sawblades are sharp. Use damping collars and plugs in expansion slots. Remove or provide air relief in solid obstructions near rotating cutters. Isolate machine frame.
	<ul style="list-style-type: none"> • tool chatter 2,5,10 • saw blade 2,10 • workpiece vibration 3,5 • solid obstruction near rotating cutter 9 • tool vibration 10 • vibration in machine frame 5,11 • other 		

<i>Q1</i> <i>Type of noise</i>	<i>Q2</i> <i>Possible causes</i>	<i>Q3</i> <i>Tests</i>	<i>Q4</i> <i>Examples of Treatments</i>
	Hydraulics		
	• pump or support	5,6	As above, plus use quieter pump, fit flexible pipe to pump inlet and outlet and smooth entry and exit. Ensure pump supply pipe is large enough in diameter so that pump fills correctly and no air leaks on pump inlet.
	• pipework	5,6	
	• valve	5,6	
	• load	5,6,14	
	• other		
	Air flow		
	• fan noise	2,5,12	Check fan for build-up of dirt, defects in impeller blades, imbalance, obstructions, abrupt bends or changes of section, missing silencers. Check if fan duty is appropriate. Isolate direct-drive motors from frame. Check for rattling or whistling dampers, valves or grilles.
	• whistling air	13	
	• other		
Distinctive non-tonal noise (e.g. reciprocating compressor, air jet, gears)	Compressed air exhaust		Reduce air pressure, fix leaks, use proprietary quiet nozzle or quiet hand-held blow gun, preferably with regulator. Fit porous pneumatic exhaust silencers to all ports, using a long pipe if rapid release needed. Use fluid wash for swarf removal, and chemical or thermal method for drying.
	• component ejection	1,2	
	• swarf removal	1,2	
• component drying	1,2		
• air powered	2		
	Reciprocating compressor		Fit proprietary intake silencers, check valve seating plate, reduce piston slap with crankcase oil additive. Relocate to remote area, or replace with new silenced unit.
	• intake	2,5	
	• valve seating	2,5	
	• piston slap	2,5	
	• other		

TEST 1 Location of sources of impacts

Listen to the machine and identify the events which occur or the parts of the machine (or components) which make contact, running the machine at reduced speed if possible, or running automatic machines under manual control.

TEST 2 Isolation of suspected noise sources

Operate parts of a machine which are suspected noise sources in isolation. If this is not possible, disable suspected parts and operate the remainder. Disabling the most significant source will cause the greatest noise reduction.

TEST 3 Identification of resonant structures and panels

Excite the parts which are suspected to resonate (ring) in response to impacts, by striking each in turn with a

ball-peen hammer. Compare the tones generated to those heard when the machine is running. Ringing of thin panels can sometimes be identified by applying light manual pressure. Resonance can sometimes be identified by changing the forcing frequency (by changing the drive speed) in which case there will be a sudden drop in noise level when the drive speed changes away from the panel resonant frequency.

TEST 4 **Sources with unusual time variations**

Look for a source of noise generation which undergoes change while conditions elsewhere remain the same (for example, the rattle of bar stock on an automatic lathe may change as bar length changes).

TEST 5 **Location of radiating surfaces**

The loudest sound radiation is usually located near the point of highest sound level around the machine (though if distant from the operator it may not be significant). You may be able to temporarily suppress this radiation by covering it with a limp heavy loaded vinyl sheet to assess the difference. Feeling vibrating surfaces by hand does not give a good indication. It is better to use a stethoscope or place the ear close to a surface (where safe to do so).

TEST 6 **Characteristic sources within a machine**

The covers may be removed, one at a time, (taking all safety precautions) to reveal sources within the machine. Look for sources with noticeable characteristics.

TEST 7 **Location of transmission eccentricities**

Noise which is modulated (that is has a noticeable rapid fluctuation in level, for example, throbbing) is often caused by bent shafts or eccentrically mounted gears and pulleys. The rate at which the noise fluctuates is determined by the rotational speed of the defective component. Change the speed of each inspected item and listen for a change in modulation, or try and count the number of modulations per minute and relate this to components which run at that speed.

- TEST 8 **Location of worn bearings**
- If the noise level increases markedly as the rotational speed of the shaft is increased, then it may be due to worn bearings. Noise will be radiated from the bearing casing and may be detected by measuring excessive shaft run-out.
- TEST 9 **Location of sources of tones**
- Change the speed of the different machine components in turn and note which change most affects the level and frequency of this tone.
- TEST 10 **Test of tool or sawblade errors**
- Check the quality of the machined surface or cut to indicate tool chatter, clamping or positioning problems and blade or tool wear.
- TEST 11 **Location of loose panels or components**
- Look for rattles, checking these by hand in light structures (where safe) or by restraining with clamps or stops in larger structures (in which case the strength and stiffness must match that of the structure).
- TEST 12 **Test for fan noise**
- Switch off each fan in turn to identify any noisy units. Excessive low frequency noise may be due to a fan imbalance or running near stall condition, while a tonal noise may indicate an obstruction, a blade defect, poor mounting or running at higher than rated speed.
- TEST 13 **Test for flow-generated noise**
- Remove in turn all sharp edges and constrictions from the flow.
- TEST 14 **Effect of load on system**
- Compare the noise level at idle with that when under load. Identify noise-generating mechanisms which are only active, or which change, under load. If noisier when under load, these mechanisms dominate. If

noise is the same or less under load, look at the mechanisms which do not change with load.

There are many other tests which you can develop for your workplace. It is good practice to document these and put them into a checklist or questionnaire format for others to use.

The treatments listed in Table 1 are only a sample of the many techniques available. A good practical reference is *Noise Control - Principles and Practice* (2). There are also courses run in most Australian States and Territories on engineering noise control.

**MAINTENANCE
OR
MODIFICATION**

Having undertaken the “practical diagnosis” step, you will have identified a number of problems and solutions, some of which you will have acted on immediately. Many solutions, however, will need to be scheduled for future implementation.

For the noise control plan, you need to advise management on what needs to be done, what can be achieved in-house and with external assistance and what resources will be required.

The treatments you need to carry out as a result of your practical diagnosis fall into two categories:

- maintenance (repairing/refurbishing an item to its proper state);
- modification (modifying or adding to the machine for the specific purpose of reducing noise).

MAINTENANCE

Develop a program for maintenance which anticipates noise problems occurring and which enables noise problems to be picked up during routine work, as well as addressing the existing problems above. When examining any noisy machine the first question to resolve is “Was this machine quieter in the past?” If so, what has changed: is it the job or process, the material, the tooling, the machine operating conditions, or is the extra noise due to wear and tear in the machine?

In the case of expensive or critical items of plant, you should consider introducing a “machine condition

monitoring” procedure. This is based on the monitoring of vibration levels on the machine and comparison with baseline vibration levels to follow trends which may lead to failure of the machine. There are a number of reasonably priced measuring systems available to achieve this. While noise and vibration are powerful tools for predictive maintenance, Norton ⁽³⁾ highlights several questions which need to be asked when costs and benefits are considered:

- Do noise and vibration measurements suit the particular maintenance system and the machines being used?
- What instrumentation is needed to provide the most economical system?
- Are specialised personnel essential or can personnel already available perform this task?
- Can the use of noise and vibration measurements reduce operation or maintenance costs to give an improvement in plant economy?

Other considerations include whether an intermittent (manual) system is sufficient or a permanent system is needed, what measuring points to use, and how the information is to be analysed and used. Norton ⁽³⁾ gives a good overview of this topic and illustrates some of the faults which can be detected by this procedure (see *Appendix* to this module).

NOTE Your maintenance program should also include existing noise control equipment. For example, check for poor sealing of enclosure doors, degradation of acoustic linings, clogging of silencer lining perforations, missing silencers, vibration isolators which have “bottomed” and degradation of impact-absorbing surfaces.

MODIFICATION The solutions or treatments which you identify as modifications to the machinery need to be prioritised and programmed in your work program as well as within the company’s noise control plan.

Where there is more than one possible solution, you may need to do a cost/benefit analysis of the options in cooperation with the noise manager (see *Module 9: Evaluating Options*).

Where there is significant expenditure involved and you feel the problem is beyond your level of expertise, recommend that a consultant be called in for further evaluation or confirmation.

UPGRADING THE PLANT

We have looked at practical diagnosis on existing plant, and you have developed a maintenance and modification program. But what about the situation where you are asked to upgrade the plant in some minor way (for example, fit an air nozzle to clean dust off a conveyor, install a ventilation fan or design a component collection system)?

These minor additions can easily add significantly to the noise in the workplace unless proper measures are taken in their design and installation.

Firstly, you need to be aware of the company's noise exposure goal for the area, so your upgrade will not equal or exceed this level, making it difficult to maintain the goal in future upgrades.

The following process is suggested:

- Consider what the upgrade needs to achieve, and what is the quietest, effective way of doing so. A process which produces lots of noise is unlikely to be cost-efficient anyway.
- Select quiet components. These may or may not be covered by your buy quiet policy (see *Module 8: Buy Quiet*).
- Design for minimum impacts or vibrating forces.
- Isolate impacting or vibrating parts from the surrounding structure. NOTE: A common mistake is to install an isolating layer then proceed to bolt directly through it, thus short circuiting the isolator! Isolating grommets are available for this purpose.
- Consider future maintenance needs. Training of maintenance staff is important if this process is to be carried through.

Maintenance work can itself be very noisy and the employees in your section need to gain the benefits of an effective noise control program.

**MINIMISING
MAINTENANCE
NOISE**

This means looking for the quietest way to do the job effectively, whether in the workshop or on site. The principles established in your practical diagnosis procedure should be a useful guide in minimising noise of your own operations.

Here are a few additional pointers:

- Use quiet air nozzles, for example, for cleaning.
- Use “dead-blow” hammers where possible instead of hard hammers.
- Avoid dropping tools or machine parts onto hard surfaces (use a mat).
- Use pressure rather than impact to move or shape metal where possible.
- Use limp damping mats when working on resonant surfaces or panels.

The use of personal hearing protection will be essential in many instances and your management of this is important. The staff need to know in what areas of the plant they will need personal hearing protection, and how to fit and maintain their protectors. The noise manager can assist with this.

CONCLUSION

Two elements are crucial to your success with this module:

- Your own level of commitment to reduction of noise in the workplace;
- The training of your staff in specific aspects of noise control.

The noise reductions you do achieve are likely to be the most cost-effective your company will manage.

REFERENCED DOCUMENTS

1. Worley, S. A. *A Practical Diagnostic Procedure Leading to Noise Control by Engineering Means*. Institute of Mechanical Engineers Publication C406/016, London, 1990.
2. Bruel and Kjaer. *Noise Control - Principles and Practice*. Bruel and Kjaer Pty Ltd, Denmark, 1986, available from David Reid Technology Ltd, PO Box 1898, Auckland.
3. Norton, M.P. *Fundamentals of Noise and Vibration Analysis for Engineers*. Cambridge University Press, Cambridge, 1989.

ADDITIONAL RESOURCE

The SHARE registry may be able to help you find an existing solution used by another company with a similar problem. SHARE (Safety and Health Accumulated Research Experience) aims to identify successful solutions to common health and safety problems and promote widespread application of these solutions in workplaces.

Copies of SHARE solutions on noise are available from:

Occupational Safety & Health Service General Manager's Office	Victorian Department of Labour Public Relations and Information Branch
62 The Terrace PO Box 3705 WELLINGTON 6001 New Zealand	Level 22, Nauru House 80 Collins Street MELBOURNE Victoria 3000 Australia
Telephone (04) 471 2937	Telephone (61 3) 655 6332

APPENDIX

Some typical faults and defects that can be detected with noise and vibration analysis (Norton⁽³⁾)

Item	Fault
Gears	Tooth meshing faults Misalignment Cracked and/or worn teeth Eccentric gears
Rotors and shafts	Unbalance Bent shafts Misalignment Eccentric journals Loose components Rubs Critical speeds Cracked shafts Blade loss Blade resonance
Rolling element bearings	Pitting of race and ball/roller Spalling Other rolling element defects
Journal bearings	Oil whirl Oval or barrelled journal Journal/bearing rub
Flexible couplings	Misalignment Unbalance
Electrical machines	Unbalanced magnetic pulls Broken/damaged rotor bars Air gap geometry variations
Miscellaneous	Structural and foundation faults Structural resonances Piping resonances Vortex shedding

MODULE 4: CONSULTANTS

THIS MODULE IS FOR Noise manager
Production/engineering staff.

PURPOSE When using external noise and vibration consultants and contractors, you need some idea of their roles and limitations in order to make the best use of their services.

OUTCOMES With the help of this module you should be able to:

- identify and define the project which the consultant or contractor is to undertake;
- select a consultant or contractor capable of providing the services you need;
- brief the consultant or contractor on what is needed and what services they will provide;
- liaise with or supervise them during the work.

CONTENTS CONSULTANT OR CONTRACTOR?
USING A CONSULTANT OR CONTRACTOR
SUMMARY

GETTING THE BEST FROM CONSULTANTS AND CONTRACTORS

CONSULTANT OR CONTRACTOR?

A *consultant* may provide a range of services including:

- conducting a noise survey;
- noise training;
- noise control (measurements analysis and design);
- legal technical services;
- liaising with statutory authorities.

The rationale for calling in a consultant is that by retaining the services of an independent expert, the organisation can identify the most cost-effective noise control solutions while satisfying statutory and other technical requirements. When used effectively, consultants can save the organisation their fees many times over.

A consultant however, is only a provider of expertise, and does not *install* any noise reduction treatments. This is the task of the *contractor*. A contractor is needed when your own tradespeople don't have the time or the required detailed knowledge of the properties of materials and proper installation methods.

You can, in some cases, go directly to a contractor without involving a consultant, that is, if the job is simple and straightforward, if the cost to the organisation is not high or if you have sufficient in-house expertise to be sure you have the best option. In such cases, contractors usually have effective off-the-shelf solutions which they can offer at reasonable cost (for example, absorptive linings for vehicle cabs and modular enclosure systems).

Where there is significant cost involved (say more than \$10,000), technical complexity, a legal requirement or a range of options to be evaluated, it is likely to be beneficial to use a consultant.

ROLES AND
LIMITATIONS

The following table summarises the roles and limitations of consultants and contractors.

<i>Consultant</i>	<i>Contractor</i>
Provider of expertise	Provider of skill
Able to carry out detailed acoustic/vibration measurements for identifying noise sources	Carries out only very limited noise or vibration measurement
Analyses noise sources to determine ranking in order of noise emission and likely overall noise reduction if given sources are treated	Limited noise analysis only
Can provide detailed analysis of benefits of noise control options	Can provide detailed analysis of costs of some noise control options
Can specify noise control treatments in detail, not specific to a proprietary brand	Can specify noise control treatments in detail, normally specific to their own product or service
May sometimes provide working drawings	Normally provides working drawings
May arrange quotes from a range of contractors	Provides quotes for specified work and may arrange for a consultant to be called in if needed
Does not carry out the installation work	Carries out the installation work
May provide site or workshop supervision of contractor	May be supervised directly by client
May conduct verification tests (that is, that specified noise levels are achieved)	May conduct verification tests

EXAMPLE: PAINT
MANUFACTURER

A paint manufacturer had an area where the noise appeared to be dominated by a large ball mill, though there was ancillary plant also generating noise. The company called in a consultant to assist with the design of an enclosure. The company's concept was of a large structure enclosing the whole mill, including the drive, with an opening in the roof for cooling and a series of baffles to reduce noise through the roof. The consultant immediately recommended against this approach, since to open the roof would aggravate an existing neighbourhood noise problem. The company stressed that the enclosure must not cause the mill to overheat as this may affect the product

The consultant's first task was to verify that treatment of the mill was in fact the best option. What residual noise would the ancillary plant cause? What if the mill were to be enclosed, but not the mill drive? Various tests were conducted to show that the noise of the

ancillary plant and mill drive were well below that of the mill.

The consultant was then able to design a temperature-controlled enclosure which excluded the drive motor, but provided a reduction of about 17 dB(A) in mill noise. The overall noise reduction was about 10dBA and the cost was much less than that of the company's enclosure concept.

**USING A
CONSULTANT
OR
CONTRACTOR**

The following four-stage process emphasises the use of a consultant or contractor for engineering noise control work. However, it may also apply to other noise management tasks or even non-noise work, for which external assistance is required.

1. IDENTIFY
AND DEFINE
THE PROJECT

To identify and define the project which the consultant or contractor is to undertake, you should first have conducted a noise audit of the workplace (see *Module 2: Walk-through Audit*), or have had a noise survey done (see *Module 5: Using Surveys*). These steps will provide information on which work areas or machines require priority treatment.

Decisions need to be made concerning:

- the work area(s) or machine(s) which need noise control work;
- the desired final noise level, for example:
 - noise reduced to a specified policy limit;
 - noise reduced “as far as workable”;
 - noise reduced to comply with the statutory limit or a notice;
- any technical or operational constraints, for example:
 - minimal restriction on production during noise control work and none after this;
 - minimal restriction on maintenance access;
 - general safety requirements;
 - any airflow, thermal or other technical requirements;
- budgetary constraints.

These points need not be “set in concrete”, but at least form a basis for your initial discussions with the consultant or contractor. Ultimately, they may form part of the brief for the contract.

2. SELECTION OF CONSULTANT OR CONTRACTOR

Acoustical consultants and contractors are listed under “Acoustic Consultants” in the Yellow Pages (see Appendix 3 in Core). The information contained there may help you establish a short list. The following information may assist you in your choice.

Qualifications/Affiliations

Consultants should have an engineering or related tertiary qualification and/or be members of the Australian Acoustical Society, the Association of Acoustical Consultants Australia, the Association of Consulting Engineers Australia or equivalent New Zealand qualifications. Contractors may or may not have tertiary qualifications, but should be affiliated with trade or industry organisations which impose a code of ethics. In Victoria, Australia there is an Association of Noise Control Engineering (contactable via PO Box 14, Moorabbin, Victoria 3189) which has established codes of ethics for acoustical contractors in that State.

Experience

The consultant and contractor should have experience in noise control work in similar industrial situations to yours. There is nothing like a recommendation from one of your colleagues in the industry! Be wary of contractors who have not carried out acoustical treatments before because they may be unaware of the acoustical properties of the materials involved.

Range of services available

Use the list of services in the table above under the subsection “Roles and Limitations”, as a checklist when assessing what the prospective company may offer you.

Capability

In the case of a consultant, what noise measuring and diagnostic equipment is to be used? A consultant who has only a basic sound level meter cannot get as much information as one who can carry out detailed frequency analysis, vibration analysis, sound intensity

analysis and other services. For a contractor, the question of capability centres on the workshop facilities and personnel available. The job may be too large, too small or too specialised.

Fees and availability

Most consultants would charge an hourly rate, up to an agreed ceiling beyond which further agreement needs to be made. You need to check whether the hourly rate includes measuring equipment as well as time, and any other charges which may accrue. Note that the hourly rate will vary depending on the status of the person carrying out the work. Contractors normally charge on an agreed lump sum basis, with variations as in standard building practice.

3 BRIEFING CONSULTANT OR CONTRACTOR

Having selected your consultant or contractor, you will need to give them a clear brief, so that both of you understand exactly what services will be provided and what outcome you expect. The points listed under Stage 1 will form the basis of the brief. However, the consultant or contractor may have further thoughts on how the brief should be structured, so you may finalise the brief only after an initial meeting with the consultant or contractor.

The brief may be incorporated into a formal contract or may be in the form of a letter on which the contractual arrangements are based. It is quite common for consultants to write their own brief as part of a proposal, or for contractors to write their own brief as part of a quotation. As always, it is important to have the brief in writing.

4. LIAISON AND SUPERVISION

Constant liaison/supervision is one of the keys to getting the best from your consultant or contractor. If you can be “on the spot” with information about the organisation and work processes, establish contacts and help with access arrangements, the consultant or contractor can make more efficient use of the time and create less disturbance in the organisation.

As the consultant’s or contractor’s work progresses, new options may emerge, requiring consultation within your organisation. In particular, keep the consultant

and contractor well-informed on the likely operational status of the plant. They may, for example, be keen to look at the plant during shutdown as well as when operational. Try to provide the most up-to-date advice on likely timing of any special process for which their presence on site is needed.

SUMMARY By following this four-stage process in the use of consultants and contractors when undertaking noise control work, you should be able to achieve the most cost-effective solutions in your workplace. It is wise to consult external expertise prior to spending a lot of time and money doing-it-yourself, since the old adage, “there is never enough money to do it properly, but always enough to do it twice” is still true!

MODULE 5: USING SURVEYS

THIS MODULE IS FOR Noise managers
Production/engineering staff
Employee representatives
OHS committees.

OUTCOMES Once a noise survey report has been prepared for a workplace, the noise manager should be able to:

- define which parts of the workplace and workforce have been surveyed;
- identify which employees are likely to be exposed to noise above the exposure limits;
- describe the conditions under which the plant was operating at the time of the survey, comment on whether or not this was typical, and estimate the likely effects of other normal operating conditions;
- assess the level of risk of employees suffering a noise-induced hearing loss;
- identify in which areas, during which operations, or at which machines the employees are receiving the most significant noise exposures;
- provide relevant information to both management and employees as to noise in the workplace, as part of a noise education programme;
- select appropriate personal hearing protection for employees in noisy areas;
- define any remaining legal obligations which the employer (or employees), may have to fulfil.

CONTENTS PURPOSE OF A NOISE SURVEY
WHAT YOU NEED TO USE A SURVEY
DEFINE SCOPE OF SURVEY
IDENTIFY EXPOSED EMPLOYEES
DESCRIBE PLANT OPERATING CONDITIONS
ASSESS RISK TO EMPLOYEES
IDENTIFY AREAS OF HIGHEST EXPOSURE
SELECT HEARING PROTECTORS
PROVIDE INFORMATION
DEFINE LEGAL OBLIGATIONS
SUMMARY

UNDERSTANDING AND USING NOISE SURVEY REPORTS

PURPOSE OF A NOISE SURVEY

A noise survey report is first and foremost a springboard for action. It provides the basic technical information about the workplace to enable you to take the actions listed under OUTCOMES on the previous page. The noise survey report contains measurements of the noise levels (especially the A-weighted noise levels) to which operators are exposed and estimates of their typical daily noise exposure levels. The report may cover the whole workplace or only part of it (for example, the machine shop or a new vehicle).

It may have been prepared in response to the need to comply with the law or in response to a request from the employees for information on noise levels.

A noise survey report is not a noise control plan (see Step 4 of the Core) or a noise policy (see Step 3 of the Core and *Module 7: Noise Policy*) for your workplace. These need to be developed from the information in the noise survey report.

Above all, the noise survey report should not be seen as a menu for personal hearing protectors as though this were the end point of your noise management planning.

A noise survey report is unlikely to be written in a form suitable for presentation “as is” to management and employees. Relevant information will need to be extracted and presented in a different format. For example, the noise level results may need to be transferred onto a wall chart to show noise levels in various areas, with a “temperature scale” to show what the noise levels mean.

WHAT YOU NEED TO USE A SURVEY

Firstly, you need a basic grasp of noise terminology and how noise surveys are carried out. Appendices 1 and 2 of the Core list some of the terms you should know. For further reading on noise measurement, see Bruel and Kjaer Ltd.’s booklet *Measuring Sound* (Denmark, 1984) available from Reid Technology Ltd, PO Box 1898, Auckland. The methods of noise measurement and the basis of calculations used in noise survey reports are

detailed in Australian Standard AS1269 *Acoustics - Hearing Conservation*, available from Standards New Zealand.

Secondly, you need a grasp of the regulation on occupational noise. Approach the Occupational Safety and Health Service to find out their requirements. They may have booklets or run short seminars explaining the legislation.

**DEFINE SCOPE
OF SURVEY**

The noise survey report should clearly set out, at the beginning, which parts of the workplace or workforce have been surveyed. For example:

This noise survey report on XYZ Bakery covers the main baking hall and adjoining preparation areas. There are approximately 80 staff employed in this area, including plant operators, packers and supervisors. The survey did not include the following people who are to be the subject of a later survey:

- laboratory and technical staff;
- workshop and maintenance staff;
- drivers and vendors;
- office staff.

**IDENTIFY
EXPOSED
EMPLOYEES**

Employees likely to be exposed to noise above the exposure limit should be identified.

In small workplaces, the noise survey report may list all employees likely to be exposed above the exposure limit. In medium to larger workplaces, this may have to be estimated from the results in the report. For example, if the report contains an assessment of two plant operators, both of whom are exposed to noise above the exposure limit, then it can be assumed that the other eight operators performing similar tasks may also be exposed to noise above the exposure limit.

If noise exposures vary a lot over the day, or from day to day, it is often possible to estimate an employee's typical 8-hour average exposure from the results in the report.

<i>Machine/Process</i>	<i>Noise Level at Operator's Ear</i> $L_{Aeq,T}$ (dB(A))
Angle grinder	104
Power hacksaw	88
Chipping hammer	98
Welding	93
Ambient noise	85

You now estimate the typical duration for which the employee is likely to operate those items in a typical “worst case” day, that is, angle grinder 1 hour, hacksaw 1.5 hours, hammer 0.5 hour, welding 2 hours and ambient noise for remainder of day (3 hours). As described in Appendix 2 of the Core of this Control Guide, use Table 3 to assign a PNE to each of the above combinations of noise levels and durations as demonstrated in the following table:

<i>Machine/process</i>	<i>Noise level</i> $L_{Aeq,T}$ (dB(A))	<i>Duration</i> (hrs)	<i>Partial noise exposure</i> (Pa ² h)
Angle grinder	104	1.0	10.0
Power hacksaw	88	1.5	0.4
Chipping hammer	98	0.5	1.3
Welding	93	2.0	1.6
Ambient noise	85	3.0	0.4
Daily Noise Exposure = sum of partial noise exposures =			13.7

The daily noise exposure is simply converted to the equivalent 8-hour noise exposure level using the same process in reverse.

$$L_{Aeq,8h} = 96 \text{ dB(A)}$$

This value is then compared with the exposure limit.

The above example shows that it is possible to estimate an employee’s noise exposure for a given day’s duties, knowing the noise levels and duration of the various tasks.

Sometimes, however, an employee’s exposure is likely to be so variable that a typical duration for each task

cannot be assigned. In this case, it is often possible to assess the likelihood that the noise exposure exceeds the exposure limit. This can be done by taking the noise level results in the report and calculating the duration for which one operation would need to be carried out to cause the exposure limit to be exceeded. To do this, use Table 3 in Appendix 2 of the Core in the following way:

- look up the Pa^2 value for the noise level, (X);
- divide 1 by this value (1/X);
- the result is the time in hours beyond which the exposure limit will be exceeded.

Example (the exposure limit is $L_{Aeq,8h}$ 85 dB(A))

<i>Machine/process</i>	<i>Noise level</i> $L_{Aeq,T}$ (dB(A))	<i>Time for exposure limit</i> <i>to be exceeded</i>
Angle grinder	104	6 mins
Power hacksaw	88	4 hrs
Chipping hammer	98	24 mins
Welding	92	1.6 hrs
Ambient noise	85	8 hrs

Knowing that the employee is likely to spend at least 6 minutes per day on the angle grinder, apart from other noise exposure during the day, indicates that the employee’s exposure is likely to be above the exposure limit.

Note that there may be employees who spend time in the area without operating the machines (for example, other staff and cleaners). You could assume that these employees are exposed to the “ambient level” given in the example.

Remember that exposure limits are also expressed in terms of a peak noise level for impulsive/impactive sounds, as well as an 8-hour exposure level. In this case, any employee exposed to such a high level of sound, even once in a day, should be counted as being exposed above the exposure limit.

Using the results in the noise survey report in this way, you should be able to construct a picture of those employees likely to be exposed to noise above the exposure limit. You could use this procedure for

identifying priorities for noise control and personal hearing protection and to establish which employees are to be given audiometric testing.

**DESCRIBE
PLANT
OPERATING
CONDITIONS**

A well-written noise survey report should describe the plant operating conditions at the time of the survey, indicate whether the conditions are typical and, if relevant, note the effects of other conditions.

A well-written noise survey report should include most of this information. If you return to the above example, the noise level results in full should read thus:

<i>Machine/process</i>	<i>Noise level $L_{Aeq,T}$ (dB(A))</i>
Angle grinder (100 mm Hitachi, grinding 2 m length of 25 x 25 mm steel tubing)	104
Power hacksaw (cutting 6 m lengths of 25 x 25 mm steel tubing)	88

Now look at these results critically. Consult others in the workplace. Are these typical of the noisiest operations that would take place? If not, you may need to have measurements carried out on the noisiest typical operation. The factors you need to consider include:

- the size and type of material being worked on (larger hollow workpieces may radiate more noise);
- the rate at which work is being done (for example, blows per minute or motor speed);
- the number of machines operating together;
- presence or absence of extraneous noises (for example, noisy equipment due for repairs or contractor on site);
- the amount of time employees would normally spend in that area.

Look carefully at the situation of employees whose noise exposure was found to be marginal, or just below the exposure limit in the survey report. Could any of the above factors cause their exposure to exceed the exposure limit?

In some cases you can estimate the effect of a change in operating conditions. For example, a doubling in the number of blows from 60 to 120 per minute would normally increase the $L_{Aeq,T}$ by 3 dB(A). However, you will probably need to consult an expert in most instances, as these calculations can be very complex. In general, concentrate on the larger factors and don't get distracted by small differences in operating conditions. Keep in mind that you are trying to estimate the employee's noise exposure on a typical "worst-case" day, not under every possible set of conditions!

**ASSESS RISK
TO
EMPLOYEES**

It may be useful to go further than just estimating the number of employees exposed above the exposure limit. Knowing that the risk of hearing loss exists even below the exposure limit and that it increases as the level increases, you may wish to estimate the likely extent of hearing loss for a given level of noise exposure over a nominated period of years. Appendix D of AS1269-1989 gives a method for this type of assessment.

**IDENTIFY
AREAS OF
HIGHEST
EXPOSURES**

In developing a noise control plan, you will need to know where the noise problems are. You can build up this information by studying the workplace and the noise survey report, (although you may not have to have a noise survey done before developing a noise control plan).

A thorough noise survey report might give a list of some noise control treatments required, especially any straightforward items. If not, you can glean a lot of information from the results by working through the following steps.

Step 1

Look at the noise levels themselves and identify items of plant or areas which are potentially:

- extremely hazardous (greater than 105 dB(A));
- hazardous (90 - 105 dB(A));
- marginally hazardous (80 - 90 dB(A)).

Step 2

Look at the period of time over which each source is likely to operate, or the period of time the employee is likely to be exposed to that noise source. Use the noise level and exposure duration data to calculate partial noise exposures, following the procedure outlined above (see the section “*Identify Exposed Employees*” above).

The higher the PNE, the more significant is the risk associated with the operation. In the example the angle grinder represented the greatest level of risk (PNE = 10.0), followed by the welding operation (PNE = 1.6) and the chipping hammer (PNE = 1.3). Note that although the welding operation was less noisy (93 dB(A)) than the chipping hammer (98 dB(A)) the PNE, and therefore the associated risk, was greater because of the longer operating time. So, if the noise survey report gives you results in terms of Partial Noise Exposures, use these to identify high-risk areas.

Step 3

Look at the number of employees involved in each high risk area or operation. In general the greater the numbers of employees at high risk, the higher the priority in the noise control plan.

Some techniques for looking at these issues in greater detail and for comparing the effectiveness of various noise control options are discussed in *Module 9: Evaluating Options*.

SELECT HEARING PROTECTORS

The noise survey report should contain information on the grading of areas or machines/processes and the appropriate personal hearing protectors required (see *Module 12: Personal Protection*).

A noise survey report may give a list of personal hearing protectors and the noise levels to which wearers would be exposed. While this makes selection easy, remember that the “appropriateness” of any protector will depend on other factors as well, such as weight and clamping force of earmuffs, compatibility with other headgear and comfort. This is dealt with in more detail in *Module 12: Personal Protection*.

Finally, keep in mind that personal hearing protection is no substitute for engineering noise control, since:

- the hazard is still there in the workplace;
- you can't be sure exactly how much the risk has been reduced;
- you are placing all the responsibility on the employee.

**PROVIDE
INFORMATION**

A noise survey report is likely to be in too technical a form to be useful to most managers and employees, although this information forms a crucial part of the noise education programme. Here are a few ideas for presenting the information in a more accessible form:

- erect warning signs (standard warning signs are mandatory where personal hearing protection is required);
- summarise results on charts or wall posters;
- publish results in “in-house” newsletters or circulars;
- use results for in-house training sessions;
- fix noise labels to machines where appropriate.

Copies of the noise survey report should always be available at the workplace for any employee, employee representative, manager or health and safety inspector.

**DEFINE LEGAL
OBLIGATIONS**

Having received a noise survey report you should make yourself aware of any legal obligations relating to the report itself. Apart from carrying out noise control work and providing personal hearing protection, there may be requirements to:

- make copies available at the workplace;
- communicate the results to the health and safety inspector;
- communicate the results to employees;
- repeat the noise survey after a period of 5 years.

In some cases, these requirements may be stated in the report. You can check with your local branch of Occupational Safety and Health for current requirements.

SUMMARY Your noise survey report is a working document, a springboard for achieving change in the workplace. The way it is understood and used will have a significant bearing on the effectiveness of your noise management programme.

A word of warning on the selection of personal hearing protectors. It is tempting to go straight to the highest-performance protector, that is the one that reduces noise the most, “to give employees the best protection”. There is a danger in over-protection since workers may not hear warning sounds, they will remove their protectors when not exposed to the loudest noise and the devices may be uncomfortable due to their weight and clamping force. In general, choose appropriately graded devices, that is, a device that has the same grading as (or one grade higher than) the noise in question.

MODULE 6: COSTS/BENEFITS

THIS MODULE IS FOR Chief executive officer
Noise manager
Other managers
Employee representatives
OHS committee.

OUTCOMES A consideration of the contents of this module should result in:

- raised awareness of the costs of workplace noise;
- raised awareness of the benefits of workplace noise reduction;
- calculation of estimated annual financial loss suffered by the organisation as a result of noise;
- consideration given to including expenditure on noise reduction as a permanent item in the organisation's annual budget until noise has been reduced to acceptable levels;
- inclusion of this decision in the organisation's noise policy.

CONTENTS OVERVIEW
INTRODUCTION
COSTS OF NOISE TO ORGANISATIONS
COSTS OF NOISE TO EXPOSED PERSONNEL
BENEFITS OF NOISE CONTROL FOR THE ORGANISATION
BENEFITS OF NOISE CONTROL FOR EXPOSED PERSONNEL
REFERENCED DOCUMENTS

COSTS OF NOISE AND BENEFITS OF NOISE CONTROL

OVERVIEW The costs of noise have usually been thought of only in terms of compensation costs for noise-induced hearing loss (NIHL). This can make it difficult to justify expenditure on noise control because the benefits seem a long way off. It is argued that people will keep coming forward with compensation claims for NIHL that was actually caused years ago, so the benefits of noise control expenditure won't be realised for years. This is incorrect. Compensation costs are probably less than 10 percent of the total costs of noise (see the table on page 9 of this module). The benefits of noise control can be realised immediately in relation to absenteeism, morale, productivity, noise-related accidents and corporate image; and in the short-term in relation to turnover and employee quality.

INTRODUCTION The material in this module is based on an analysis of Australian data using approaches developed in the USA and Sweden.

The USA approach is detailed in Richard K. Miller's *Handbook of Industrial Noise Management* ⁽¹⁾ and the Swedish approach in the Swedish Joint Industrial Safety Council publication *Working Environment and Economy* ⁽²⁾.

The following extracts from these references summarise the overall approach:

There is an obvious trend in industry to improve the working environment. With the increased quality of life brought about in recent years, workers are becoming more reluctant to work in poor environments. Some industries are finding that they are losing top workers to nearby plants with air conditioned or sound-controlled facilities. Decreased productivity is currently a problem of national concern, and it must be recognised that decreased morale due to dissatisfaction with environmental conditions is a major contributor to the problem. It is not a coincidence that many of the

largest, most productive, and most profitable industries in the country are also the quietest, and possess the most pleasant overall working environments.⁽¹⁾

A well engineered working environment pays off. An investment which leads to efficient production with high product quality, a good working environment and interesting work tasks is also the basis for higher profitability. The reverse is also true, as a poor working environment reduces the company's profitability through increased absenteeism, higher personnel turnover, lower product quality and increased production costs. Questions about the working environment should not be seen as an isolated issue, but as an integral part of an organisation's operations.⁽²⁾

COSTS OF NOISE TO ORGANISATIONS

What follows is an estimate of the financial costs to industry of untreated workplace noise. New Zealand and Australian data are used where available but conservative estimates are based on USA data where New Zealand or Australian data are unavailable.

A number of hidden costs are associated with noise. In addition to compensation claims for industrial deafness, noise generates costs by means of its detrimental effects on work attendance, staff turnover, employee quality and productivity. The data suggest these factors are of greater economic significance than compensation costs alone.

The role of noise in causing accidents is also considered. It is concluded that there are several ways in which noise can contribute to workplace accidents but that insufficient data are available to quantify the resulting economic losses.

Other non-quantifiable factors considered are the negative effects on morale and the corporate image of operating an excessively noisy working environment.

ACC LEVIES/
INSURANCE
PREMIUMS

New Zealand-wide, the estimated annual payout by ACC for compensation claims for noise-induced hearing loss is \$38,000,000. In Australia, the estimated annual payout for compensation claims is \$35,000,000.⁽³⁾

The actual cost to the community is estimated to be twice this, that is, \$76,000,000, once account is taken of all the other costs involved in rehabilitation.⁽⁴⁾ It follows that the compensation system as a whole requires an input of this magnitude to cover the costs of claims payouts and associated overheads. This input comes, of course, from the ACC levies levied on industry.

Manufacturing industry accounts for approximately 50 per cent of compensation claims for noise-induced hearing loss.⁽⁵⁾ It is a reasonable assumption that it also accounts for 50 per cent of the \$76,000,000 compensation burden, that is, \$38,000,000.

There were 242,000 employees in the manufacturing sector in New Zealand in 1993,⁽⁶⁾ (1,042,400 in Australia).⁽⁷⁾ It is estimated that 26 per cent of employees in the manufacturing sector are at risk of NIHL (by which is meant exposure to daily noise exposure levels of 90 dB(A) or more)⁽⁸⁾. This means that 26 per cent of 242,000, or 62,900 manufacturing employees were at risk.

Each employee at risk of NIHL represents a compensation insurance burden for the employer of \$38,000,000/62,900, that is \$604.

In Australia a further, indirect, cost burden is created by retired workers with occupational NIHL who do not claim compensation for their condition but who instead, as pensioners, obtain free hearing aids and audiological services through the Commonwealth Government's Hearing Services Programme. In 1988-89, the total cost of this programme was approximately \$29 million and pensioners comprised 72 per cent of its clientele.⁽⁹⁾ No data are available to indicate the proportion of pensioners using this service who do so basically as a result of occupational NIHL, but it is possibly quite large. Even at 25 per cent, the annual cost would be over \$7 million. This burden is passed on to the community generally through the Australian taxation system.

ABSENTEEISM

Loud noise has long been recognised as a source of stress in the working environment. Noise exposure is correlated with workers' reports of difficulties in

communication in the workplace, failure to hear important events, such as warning sounds, and annoyance.⁽¹⁰⁾ In workplace surveys noise is often the chief complaint made about working conditions.⁽¹¹⁾

Suppose, then, an employee feels unwell and is contemplating whether to come to work or to take a sick day. The prospect of having to spend the day in high levels of noise, with its associated stresses, could occasionally be the deciding factor in the employee's decision to take the day off.

There appears to be no published New Zealand or Australian data comparing absenteeism in noisy and quiet working environments. In the USA, a National Institute of Occupational Safety and Health (NIOSH) study⁽¹²⁾ of 866 employees found that median absence rates for quiet (<80 dB(A)) and noisy (approximately 95 dB(A)) areas were respectively 5 and 19 days a year.

Following introduction of a personal hearing protection programme for the high noise group, their absences dropped to a median of 9 days a year, a great improvement but still 4 days an employee per year above the median for the quiet group.

If the USA results are accepted as a guide, noise is responsible for at least four extra days' absence per year per noise-exposed employee. This means that noise causes the loss of four days' production per year from each noise-exposed employee. The value of this lost production will, of course, vary from plant to plant and employee to employee, but an average figure can be estimated as follows:

- There are approximately 235 actual working days per year (250 less 15 days' annual leave).
- Suppose the average salary per noise-exposed shop floor employee is \$22,000, then the average daily salary is $\$22,000/235 = \93.60 per actual working day.
- To allow for overheads and a profit margin, the value of an employee's production must be greater than the employee's salary. Suppose it is 1.5 times salary. Then each lost employee-day represents a loss of $1.5 \times \$93.60 = \140.40 .
- The annual loss per noise-exposed employee is four times this amount, that is \$561.60.

STAFF TURNOVER As pointed out above, noise is a significant cause of employee dissatisfaction with workplace conditions. Unless the labour market is very depressed, noise must therefore have some influence on staff turnover rates.

Turnover is a well-recognised drain on productivity, as the following analysis of resulting non-productive activities and costs shows.

Recruitment expenses include:

- costs of advertising vacancy;
- time spent interviewing applicants and selecting new employee;
- costs of medical examination (if required);
- time spent introducing new employee to workplace, issuing tools, protective clothing;
- costs of audiometry;
- time spent training new employee.

Lost production costs include:

- lost production, or extra overtime costs, in the period between the departing employee leaving and a new employee starting;
- reduced output, or extra overtime costs, during a new employee's training and learning period;
- any losses associated with increased number of defective or low-quality products produced during the new employee's training and learning period;
- increased risk of accidents during learning period.

Although relevant field data are again unavailable, it is estimated that the total cost of losing one employee and replacing them with another could approximate \$1,000.

Suppose that noise is the determining factor in one staff turnover event per noise-exposed employee per ten year period. Then, on the above reckoning, it would account for a loss of \$1,000 for each noise-exposed employee once every 10 years, or \$100 per noise-exposed employee a year.

EMPLOYEE QUALITY Because of their worth to employers, good-quality employees can to some extent pick and choose their

employment. Better employees tend to seek and hold jobs in organisations with superior working conditions.

This means that, all other things being equal, the noisier the workplace the poorer the chances of attracting the best employees. This too must have some effect on productivity.

Even if the difference is as low as 1 per cent (that is the quality of employees in noisy workplaces is 99 per cent that of employees in quieter workplaces) it is worth considering. Assuming, as before, that the value of an employee's production is 1.5 times the employee's wages, a 1 per cent decrement in productivity equals 1 per cent of $(1.5 \times \$22,000) = \330 per employee per year.

PRODUCTIVITY Noise can directly influence productivity, though not always consistently. Noise can heighten alertness and speed up performance on some tasks, but it can slow performance and increase error rates on others.⁽¹³⁾ Most studies in the area have investigated the effects of reproduced or artificial noises on specific tasks in laboratory settings. It is usually impossible to deduce what the results imply for multiple and complex tasks in actual working conditions. A number of field studies have claimed productivity improvements between 3.5 and 30 per cent due to noise reduction. However, field studies are seldom well-controlled in the scientific sense and it is difficult to know how much of the observed improvement is due to noise reduction and how much to other causes such as improved morale. The links between noise and productivity are complex but the weight of evidence tends to support the industry experience quoted above that “. . . many of the largest, most productive, and most profitable industries in the country are also the quietest . . .”⁽¹⁾

Making the probably modest assumption that workers in excessive noise levels are 2 per cent less productive than those who are not, it can be calculated (as in the subsection “Employee Quality” above) that each noise-exposed worker represents a wastage of \$660 per year.

RISK OF
ACCIDENTS

Noise can be a significant factor in accident causation.⁽¹⁴⁾ Wherever safe working practices depend on voice communication, noise will be a threat to safety. People have been killed or injured as a result of failure to hear warning shouts.⁽¹⁵⁾

Noise can also make the consequences of an accident worse than they otherwise might have been. A worker whose hand was caught in manufacturing equipment screamed for help but was not heard because of the surrounding noise. As a result he lost his hand.⁽¹⁶⁾

A review of noise and accidents by staff of the Institute of Sound and Vibration Research in the UK concluded that:

There is suggestive, although not conclusive, evidence that noise is at least a contributory factor in the occurrence of some accidents . . . the possible link between noise and accidents provides a strong argument for the reduction of occupational noise levels in addition to that required to prevent hearing damage.⁽¹⁷⁾

Unfortunately, there are no data on either the number or likely costs of noise-related industrial accidents in New Zealand or Australia. Nonetheless, the potential for such costs is obvious and must be kept in mind when considering the probable costs of excessive noise in the workplace.

PERSONAL
PROTECTION
PROGRAMME

Until noise hazards are removed from the workplace a personal protection programme will be necessary. While personal hearing protectors may control the risk of hearing damage to some extent, depending principally on usage rates, they do not remove the noise hazard. In addition, they may make only a marginal or no improvement in communication, may introduce discomfort, will almost certainly be less acceptable to employees than noise controls and may provoke employee resistance and complaints. It is therefore legitimate to treat the cost of personal protection programmes as a cost of untreated noise.

It is estimated that, on average, the cost of a personal protection programme is about \$110 per worker per year. This represents the sum of the estimated annual

costs of warning signs and labels (\$10), hearing protectors (\$20), maintenance (\$10), information and training (\$20), supervision and management (\$20) and periodic hearing checks (\$30).

SUMMARY OF COSTS

<i>Source of loss</i>	<i>Estimated annual loss per noise-exposed employee</i>
	(\$)
NIHL insurance (through levies)	604
Absenteeism	560
Staff turnover	100
Employee quality	330
Productivity	660
Personal protection programme	110
Total annual loss per noise-exposed employee	\$2,364

The average number of noise-exposed employees per manufacturing establishment is 7.6.⁽⁶⁾ The average annual loss per manufacturing establishment caused by noise is therefore $7.6 \times \$2,364 = \$17,966$.

To estimate the probable annual noise costs in your own organisation:

$$\text{Number of noise-exposed employee} \times \$2,364 = \$ \text{_____} \text{ per annum}$$

This sum is a minimum estimate, since quite cautious assumptions have been involved in its derivation and no financial cost has been placed on some factors, especially costs arising from noise-related accidents.

COSTS OF NOISE TO EXPOSED PERSONNEL

The main costs borne by noise-exposed personnel have been summarised in step 1 of the Core and explained in detail in *Module 10: Fact Sheets*. In summary, noise-exposed personnel risk:

- permanent hearing loss and its personal and social consequences;
- permanent tinnitus (“ringing in the ears”);
- possible safety hazards;

- communication problems in the workplace;
- annoyance, stress and fatigue.

**BENEFITS OF
NOISE CONTROL
FOR THE
ORGANISATION**

ECONOMIC
BENEFITS

Reduced risk of compensation claims

A reduction in the number of hearing loss compensation claims should ultimately reduce ACC levies.

Reduced risk of penalties

There will be a reduced risk of prosecution and penalties in relation to:

- prosecution under the Health and Safety in Employment Act 1992 for failing to provide a safe place of work and for breaches of the noise regulation.

Reduced reliance on personal protection

Fewer people will need hearing protectors and those who still do may be equipped with lighter, more comfortable hearing protectors which will improve acceptance and wearing rates. Even if protector performance is impaired as a result of poor fitting or poor maintenance, the likelihood of hearing damage will be less. If hearing protectors are removed for short periods, or even if not worn at all, there will be less risk of hearing damage.

Productivity improvements

Productivity will improve because of:

- reductions in absenteeism, personnel turnover and accidents;
- an ability to attract higher quality employees;
- improvements directly related to a quieter working environment.

NON-ECONOMIC
BENEFITS

Catalysing effect on other OHS programmes

A well managed noise reduction programme creates a climate supportive of other health and safety initiatives and strengthens an organisation's overall health and safety programme. Much of the experience gained in planning and implementing the noise programme will be transferable to other health and safety issues.

Industrial relations

By providing concrete evidence of an organisation's commitment to OHS, a good noise management programme will contribute to improved industrial relations.

Corporate image

Noise is a high-priority OHS issue (it is one of the Occupational Safety and Health Service's priority hazards) and a commitment to noise control gives credibility to an organisation's health and safety image.

BENEFITS OF NOISE CONTROL FOR EXPOSED PERSONNEL

Exposed personnel will benefit because of:

- a reduced risk of hearing loss and tinnitus;
- the reassurance that their health and welfare is important to an organisation;
- improved communications in the workplace;
- less stress, annoyance and fatigue.

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MODULE 7: NOISE POLICY

THIS MODULE IS FOR Chief executive officer
Noise manager
Other managers
Production/engineering staff
Employee representatives
OHS committee.

PURPOSE The purposes of this module are to:

- encourage the organisation to develop a written noise policy;
- suggest points the policy should address;
- suggest ways of developing the policy.

OUTCOMES With the help of this module, the organisation should be able to develop a written comprehensive noise policy.

CONTENTS WHAT IS A NOISE POLICY?
PURPOSES OF A NOISE POLICY
BENEFITS OF A NOISE POLICY
FACTORS TO TAKE INTO ACCOUNT
SPECIFIC ISSUES THAT MAY BE DEALT WITH
DEVELOPING THE ORGANISATION'S NOISE POLICY
USING THE POLICY
FURTHER READING

DEVELOPING A NOISE POLICY FOR YOUR WORKPLACE

WHAT IS A NOISE POLICY?

A noise policy is a document laying down the general rules the organisation intends to follow in dealing with its noise problems. The most serious of these problems is the presence of hazardous noise (sufficient to cause hearing damage) in working areas. Noise can, of course, cause problems even when it does not pose a threat to hearing (for example, it can create difficulties in communication or concentration in office areas or provoke complaints from the organisation's neighbours) but these problems are outside the scope of this module.

The preparation of this module was facilitated by reference to the noise control policy developed by the Noise Management Team at BP Refinery (Kwinana) Pty Ltd., Western Australia.

PURPOSES OF A NOISE POLICY

The organisation's noise control goals should be specified, for example:

SPECIFY GOALS

- to ensure that no employee's 8-hour average noise exposure level ($L_{Aeq,8h}$) exceeds 90 dB(A) in 1997 and 85 dB(A) by 2000; and
- to ensure that no employee is exposed to impulse noise with a level exceeding 140 dB (Unweighted) Peak.

SPECIFY PREFERRED CONTROL METHODS

Preferred methods of controlling risk should be specified, for example:

- Wherever workable, noise levels of existing plant will be reduced by engineering means to achieve the above goals.
- Where it is not immediately possible to reach goals by engineering means, exposure duration will be restricted.

- The wearing of personal hearing protectors may be necessary as an interim measure.
- Noise limits will be specified for new plant and equipment so that noise levels in working areas are progressively reduced to the point where hearing protectors are unnecessary.

DETAIL
ADMINISTRATIVE
ARRANGEMENTS

Arrangements for achieving the specified goals should be detailed, for example:

- A member of management will be appointed noise manager to oversee and coordinate the noise management programme.
- A noise working group, including employee and/or employee representatives, will be set up to help develop the noise control programme.
- An ongoing information and training programme about noise and its effects, noise control and personal hearing protection will be organised for managers, supervisors and workers.
- Following a preliminary noise audit, a noise consultant will be called in to advise on noise control options.

DEFINE
RESPONSIBILITIES

The responsibilities of managers, supervisors and employees should be stated, for example:

- Managers are responsible for organising the noise programme in areas under their control, preparing budget estimates for noise control and ensuring that their staff receive adequate information and training.
- Supervisors are responsible for monitoring the day-to-day operation of the noise programme, ensuring that purchase requests for equipment and power tools specify the quietest workable item, monitoring the use and condition of noise control devices and hearing protectors and maintaining relevant records.
- Employees are responsible for attending noise information and training sessions, using noise control equipment and personal hearing protectors

where necessary and reporting equipment defects and problems to supervisors. Employees are invited to nominate for membership of the noise committee and to participate in the development of the noise control programme.

BENEFITS OF A NOISE POLICY

In addition to the major points listed above, a well thought out noise policy can serve a number of other purposes, including the following:

- Noise has been a feature of the industrial scene for so long that it tends to be accepted as an inevitable part of many jobs. This attitude needs to be challenged. A noise policy that sets definite noise control goals will create such a challenge and put noise “on the agenda” of relevant groups in the organisation.
- A noise policy helps integrate the noise programme with the rest of the organisation’s operations. If noise is made a specialised area, it is in danger of being regarded as the province only of specialists. On the other hand, if “think quiet” and “buy quiet” are fully integrated into the organisation’s operations, they stand a better chance of success.
- The process of working out a noise policy can help identify areas where arrangements need to be made for coordination (for example, budgeting for noise control needs to be integrated with overall budgeting; a system is needed to keep the noise manager informed of proposed equipment purchases).
- A forward-looking policy, especially one that gives clear priority to workable engineering controls, provides the strongest support for the introduction of personal hearing protection. Employees are more likely to cooperate in a personal protection programme if they can see there are plans to progressively reduce noise to non-hazardous levels.
- The declaration of management commitment, embodied in a noise policy, helps create a positive health and safety climate in the organisation.
- It is a basic reference point for planning and for noise information and training programmes within the organisation.

- It promotes good industrial relations by acknowledging the value of employee participation and ideas.

FACTORS TO TAKE INTO ACCOUNT

The major factors that need to be considered in developing a noise policy are:

- the organisation’s legal obligations under the Health and Safety in Employment Act and Health and Safety in Employment Regulations;
- the resources (for example, technical expertise and finances) at the organisation’s disposal;
- any occupational health and safety policies and/or agreements with employees or their representatives already in place in the organisation;
- the costs, benefits and effectiveness of various options (see *Modules 6: Costs/Benefits* and *Module 9: Evaluating Options*).

SPECIFIC ISSUES THAT MAY BE DEALT WITH

Some key issues, such as setting a noise exposure standard and adopting a “buy quiet” purchasing policy, were mentioned above. Other points that may need to be covered, again with examples of possible policy statements, are given below.

Noise control in temporary work sites

Any temporary work site shall be suitably located or screened to ensure that noise levels generated do not adversely affect employees’ hearing. If necessary, entry to such sites shall be restricted to personnel wearing appropriate graded hearing protectors.

Design of new work areas

New work areas shall be designed and laid out so that employee noise exposure is maintained at the lowest workable level.

Purchasing of new plant and equipment

Noise emission will in future be an important factor in the selection of new plant and equipment. So far as is workable, the quietest available item shall be favoured for purchase.

Warning signs

Working areas and equipment requiring the use of hearing protectors shall be clearly identified by appropriate signs or labels.

Maintenance

All noise control fixtures (for example, seals, vibration mounts and silencers) will be regularly inspected and maintained to ensure that noise emission is kept to a minimum. Training sessions in basic noise control will be organised for maintenance staff.

Work procedures to reduce exposure

Work procedures will be designed to minimise noise emission and ensure that as few people as possible are exposed to high levels of noise.

Protection of contractors and visitors

Contractors and visitors to the organisation shall comply with the noise control and personal hearing protection procedures prescribed for employees.

Employees visiting elsewhere

Employees working at other employers' premises (for example, carrying out maintenance work) shall comply with noise control procedures in operation there and use hearing protectors if necessary.

Audiometry

Audiometric (hearing) testing shall be offered to employees according to the requirements of the Health and Safety in Employment Act. Each employee shall be provided with a record of his or her test results. Release of the test results to other persons shall be in accordance with the legal requirements.

Budgeting

Estimates of the amount of funds necessary for the implementation of this policy shall be included in the organisation's budget each year with a view to ensuring progressive reduction and, where possible, ultimate elimination of noise hazards.

Regular review of policy

This policy shall be reviewed annually, at which time suggestions for improvement will be invited from all interested persons.

DEVELOPING THE ORGANISATION'S NOISE POLICY

It is essential that senior management is involved in the development of the organisation's noise policy and is committed to seeing it put into effect. The reasons are that:

MANAGEMENT

- top management controls the working environment and is legally responsible for controlling any hazards it contains;
- top management has the final say in the allocation of funds and other resources and therefore effectively controls the extent to which the policy is put into practice;
- experience and research shows that top management support is vital to the success of noise control programmes.

EMPLOYEES

Requirements that employees be consulted in the development of health and safety policies and systems are now part of the Health and Safety in Employment Act. The reasons for this are:

- a policy is much more likely to be accepted and followed if the people it affects have a say in developing it;
- it is likely to be more relevant and effective because of the direct input of those affected.

There are other reasons for consulting employees and involving them in the development of an organisation's noise policy. They have an intimate knowledge of the machines and work practices that create noise, and are usually an excellent source of ideas for possible control methods. Even when solutions are proposed by others, such as noise consultants or contractors, it is important to seek the views of employees before installation to check that work flow and maintenance access will not be adversely affected.

USING THE POLICY

Once the noise policy is completed, don't file it away, but:

- post it on notice boards to inform those concerned and demonstrate the organisation's commitment to employees' health and safety;

- use it in training new managers, supervisors and operators in their responsibilities;
- use it to promote the organisation's image;
- mention it when job vacancies are being advertised to attract good-quality staff;
- use it as a reference when developing other OHS policies;
- have it on hand when a health and safety inspector calls to show what the organisation is doing to meet its legal obligations.

**FURTHER
READING**

Occupational Health, Safety and Welfare Commission of Western Australia, *A Code of Practice for Noise Control in the Workplace*, Occupational Health, Safety and Welfare Commission of Western Australia, Perth, 1989.

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MODULE 8: BUY QUIET

THIS MODULE IS FOR Noise manager
Production/engineering staff
Purchasing staff.

PURPOSE The purpose of this module is to:

- illustrate a typical buy quiet purchasing procedure;
- provide guidelines for the preparation of noise specifications;
- show how to calculate the maximum acceptable noise level for new equipment;
- show how to interpret noise information provided by suppliers;
- discuss key policy and procedural issues.

CONTENTS INTRODUCTION
BASIC BUY QUIET RULES
PURCHASING PROCEDURE OVERVIEW
POLICY AND PROCEDURAL ISSUES
FURTHER READING

BUY QUIET PURCHASING POLICY AND PROCEDURES

INTRODUCTION Increasingly, New Zealand and overseas occupational health and safety legislation requires designers, manufacturers and suppliers of industrial plant and equipment to minimise hazards, such as excessive noise, associated with their products, and to provide information about potential hazards to prospective purchasers. In addition, complementary legal obligations have been imposed on employers to ensure that any plant they purchase is as free as possible from hazards to employees. There is thus strong legislative backing for buy quiet programmes.

Even so, noise is still often overlooked when new machinery is purchased, with the result that the working environment is needlessly noisy. Ignoring noise at the purchasing stage also indicates inefficient management, since the manufacturer can, in most cases, reduce the noise level of a machine more cheaply and effectively during manufacture than the purchaser can afterwards, as illustrated in the following example.

EXAMPLE: SAVINGS FROM NOISE CONTROL AT DESIGN STAGE

A manufacturer of plastic bottles required two new blow moulding machines. A type of moulder was chosen as suitable and two were ordered. While the company gave no thought to noise, it was the supplier's practice to provide information on sound levels produced by their machines. A value of 85 dB(A) was quoted as the noise level one metre from the moulder.

The supplier also offered optional noise control equipment on the machine which would reduce the noise level to 79 dB(A) at extra cost. The plastics company considered this an unnecessary expense because the 85 dB(A) noise level seemed low enough to comply with the noise legislation.

The new moulders were installed side by side along a wall but, as soon as they commenced operation, the packers nearby complained about the high level of noise and the fact that they were no longer able to hear the radio. They were given hearing protectors but these were not always worn.

Noise levels were measured around the moulders and at the packing table, with the following results:

<i>Position</i>	<i>Noise level</i>
Between moulders (at 1.0 m)	91 dB(A)
At packing table (2.5 m)	89 dB(A)

The end result was that the company had to fit noise control treatments to the moulders, which proved to be much more expensive than if the supplier had been allowed to incorporate the noise control features in the first place.

Note that noise levels measured after the machines were installed were greater than those which the supplier quoted. Some of the reasons why this might occur include:

- installation (for example, mountings) not according to supplier's specifications;
- there were different loads, materials, speed or other operating conditions;
- non-standard noise measuring techniques were used.

In the example of the manufacturer of plastic bottles however, the reasons were more straightforward, as indicated below.

Reverberation

The noise levels quoted by the supplier had been measured in a room which had very little reverberation, unlike the factory environment. In the factory, sound reflections from the back walls, ceiling and other equipment increased the overall noise level created by each machine from 85 to 88 dB(A).

Two machines were placed side by side

When two equally loud noise sources are added together, the result is an increase of 3 dB(A). Two adjacent 88 dB(A) sources would be expected to produce an overall noise level of 91 dB(A), just as the measurement showed.

**BASIC BUY
QUIET RULES**

Properly handled, the purchase of new plant is an opportunity for cost-effective noise control. To capitalise on this opportunity, two basic rules need to be followed:

- invitations to tender for the supply of new plant should specify a maximum acceptable noise level;
- if plant is to be purchased without tender, noise emission data should first be obtained from potential suppliers.

**PURCHASING
PROCEDURE
OVERVIEW**

The aim in both cases is to enable competing products to be compared with one another and assessed in relation to the organisation's noise goals. The remainder of this module explains how to apply these rules in practice.

Flow chart 1 provides an overview of a typical procedure for purchasing an item of industrial equipment, taking account of its noise emission in the process. The following explanations and comments relate to the lettered points on the flow chart.

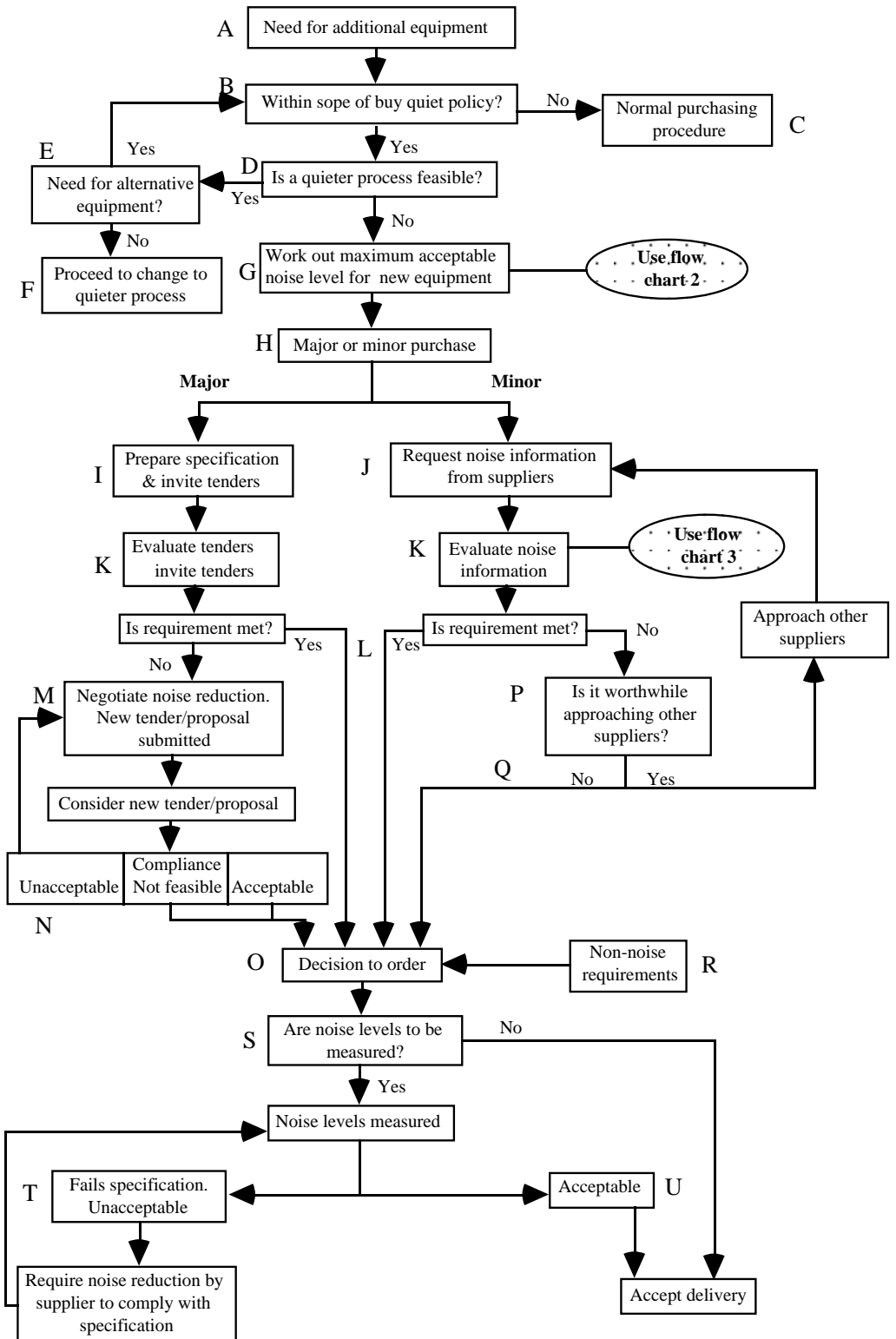
- (A) The chart commences at the point where the need for a new item of equipment becomes apparent.
- (B) The first question is whether the item falls within the scope of the buy quiet policy.
- (C) If it does not, normal purchasing action can proceed.
- (D) If it does, this is a good time to consider whether there is scope for changing the process for which the machine is required to an intrinsically quieter process (for example, changing from nailing to gluing). A review of the exact nature of the need and of the possibility of substituting a quieter process is therefore suggested at this point.
- (E) If process substitution is feasible the purchase of different equipment may be necessary, leading back to the question whether the new equipment falls within the scope of the buy quiet policy.

- (F)** It sometimes happens that a thorough examination of the need for new equipment reveals an unexpected and better solution. For example, a foundry had a severe noise problem arising from a finishing process applied to castings. Critical examination of the need for this process led to the discovery that the purchaser of the castings was prepared to accept them unfinished for a slightly lower price. The solution removed the need for the process, was cost-effective for both companies and eliminated a severe noise problem at the foundry.
- (G)** If substituting a quieter process is not feasible, the next step is to calculate the maximum acceptable noise level that the new machine can be allowed to introduce into the workplace. A method for making this calculation is explained below (see “4 Maximum acceptable noise levels” in the next section and Flow chart 2).
- (H)** The next steps depend on the significance of the purchase in relation to the organisation’s overall noise problems. As explained in Step 4 of the Core Module, the classification of the purchase as major or minor is based on the number of items to be purchased, their cost, estimated daily usage and likely effect on workplace noise levels.
- (I)** For major purchases, such as significant items to be purchased by tender, a noise specification will be necessary. If the organisation possesses sufficient in-house expertise, a specification may be prepared internally. See “3 Noise specification” in the next section for the main issues to be covered. Organisations lacking the necessary expertise would be well advised to enlist the aid of a consultant. This is particularly important if it is proposed to undertake noise emission verification tests following installation, since the supplier will need to be informed in advance of the technical details of the tests to be conducted.
- (J)** For relatively minor items for which a formal specification would be inappropriate, potential suppliers can be contacted directly and re-

quested to include noise details in the product noise information, and asked specifically about noise control options and accessories, which are becoming more common as equipment manufacturers respond to the increasing demand for quieter products.

- (K)** Noise information provided by suppliers must be evaluated carefully. The supplier's noise measurements may have been made in a different type of acoustical environment and under different operating conditions from those of the proposed installation. In addition, noise levels may be reported in terms of sound power levels or sound pressure levels. Flow chart 3 shows how to take account of these factors when estimating, from noise data provided by a prospective supplier, the workplace noise level likely to result from installation of a particular item of equipment.
- (L)** For items which, according to information provided by tenderers/suppliers, meet the noise limit requirement, the next issue to consider is whether to place a purchasing order.
- (M)** If no tendered item meets the requirement, tenderers can be requested to estimate the cost of appropriate noise control measures and submit new proposals.
- (N)** Consideration of these proposals and, if necessary, further negotiation, will finally lead to the point where an acceptable proposal is received or it becomes clear that the specified noise limit cannot be met, in which case consideration will need to be given to post-installation site control measures (for example, acoustical absorption or barriers), job rotation and personal protection.
- (O)** If there is no option but to order an item that fails the original specification, it is advisable to purchase whatever noise controls/accessories can be afforded so that the supplied item has the lowest possible noise emission. This will make the design of site noise controls easier, minimise their cost and minimise reliance on personal protection.

FLOW CHART 1: BUY QUIET PURCHASING PROCEDURE



- (P) If the suppliers originally approached are unable to offer equipment meeting the specification, consider approaching others. There can be wide variations in the noise output of competing machines and it pays to shop around.
- (Q) As with tenders, the point will sooner or later be reached where a machine meeting the requirement is found or it is apparent that no available machine is likely to meet the requirement.
- (R) The decision to order will, of course, be based not only on noise emission but on significant non-noise factors such as productivity, cost and other occupational health and safety issues.
- (S) For major purchases, it is common to arrange for the noise levels of the equipment to be measured to verify the supplier's claims.
- (T) If the measured noise levels fail to meet the agreed specification, the supplier should be required to rectify the problem and the noise levels should be re-measured to verify that the result is acceptable. In cases of this type, the assistance of a consultant, especially if the consultant was involved in preparation of the specification, will be highly valued.
- (U) Once an acceptable result is achieved, formal acceptance of delivery can go ahead.

POLICY AND PROCEDURAL ISSUES

Decisions that have to be made at various points in the purchasing procedure raise policy and procedural issues for an organisation. These issues are discussed below.

1. ROLES

What are the respective roles of the production engineer, noise manager and purchasing officer? Naturally these will vary from organisation to organisation but typical roles are described below:

Production engineer

The production engineer should:

- establish the need for new equipment;
- question whether a quieter process could be substituted;

- participate in the ultimate decision to order equipment.

Production engineer in association with noise manager

The production engineer should, in association with the noise manager:

- specify the maximum acceptable noise level;
- assist with the preparation of specification and tender documents;
- evaluate noise information provided with tenders/quotes;
- participate in the decision to order equipment;
- negotiate with suppliers for additional noise control as necessary;
- where required, arrange for noise measurements for evaluation and acceptance purposes;
- participate in the decision to formally accept delivery of equipment.

Noise manager

The noise manager should coordinate the implementation of the buy quiet programme with overall budget planning and with other parts of an organisation's noise management programme, especially the plant maintenance and replacement programme.

Purchasing officer

The purchasing officer should:

- check whether the item to be purchased is within the scope of the buy quiet policy;
- ensure that buy quiet procedures are followed where appropriate.

2. BUY QUIET

Which items fall within the scope of the buy quiet policy?

While the specific items will vary from industry to industry, buy quiet procedures should apply to all potentially noisy equipment. Even powered hand tools are important because they are a significant source of

excessive noise in many workplaces. If the size of the organisation warrants it, consider compiling a specific list of the potentially noisy items in your industry/enterprise to simplify the purchasing officer's job.

3. NOISE SPECIFICATION

What should be provided in a noise specification?

Specify the maximum acceptable noise level at a specified position (or positions) when the machine is operating under specified operating and acoustical conditions.

Noise level

The basic noise level to specify is the equivalent continuous A weighted sound pressure level ($L_{Aeq,T}$) measured over a complete operating cycle (or the average of several cycles).

NOTE: For equipment which is likely to emit high-level impulse noise (explosive-powered tools, impact devices such as presses) it may also be necessary to specify a maximum value of linear (unweighted) peak sound pressure level. The Health and Safety in Employment Regulations specify a maximum linear (unweighted) peak sound pressure level of 140 dB for occupational exposure. This is an area where expert advice may be needed.

Position

The position usually specified for noise measurements is the operator's position. However, for some machines (such as a machine for which there is no fixed operator position or a machine with a built-in operator's enclosure) it may be important to know the noise levels at other points around the machine so that exposure of the operator, and the effects on others in the workplace, can be properly assessed. In these cases, specify that noise should be measured at points around the machine at a height of 1.5 metres above the floor and/or access platform(s) and 1.0 metre from the machine itself, ignoring small projections.

Operating conditions

The operating conditions to be specified depend on the nature of the machine and its intended use and include

such factors as speed, load, tooling, material being processed and feed rate. Specify whatever conditions are likely to result in the highest noise emission.

If it is not known what these might be, specify a range of typical operating conditions and base decisions on the highest level.

Acoustical conditions

The acoustical conditions may be specified in three ways:

- The first option is to specify that the noise of the machine is to be measured under agreed conditions in an environment similar to the proposed installation site. In practice, the manufacturer's or supplier's workplace will often meet this requirement.
- A second option, appropriate for major purchases by tender, is to specify that the maximum acceptable noise level is not to be exceeded when the machine is installed and operating in your workplace. This puts the onus on the manufacturer to take the acoustical characteristics of your workplace into account when responding to the tender invitation. In order to do this, the tenderer should inspect the installation site. If unable to do so, the tenderer would need to ask for relevant details such as the dimensions of the installation site, the size and placement of nearby machines, benches and other fittings and the nature of floor, wall and ceiling materials. If a tenderer neither inspects nor requests details, treat the tender with caution.
- A third option is to specify that the noise of the machine is to be measured in a standard acoustical environment, such as one of those defined in a relevant New Zealand, Australian or International Standard for machine noise measurement. Unless you are knowledgeable and experienced, you will need expert help to select an appropriate standard and to interpret the results.

4. MAXIMUM
ACCEPTABLE
NOISE LEVEL

How do we work out the maximum acceptable noise level to include in a specification?

Fundamentally, this will be determined by the noise exposure level the organisation sets as its goal for working areas. As the case study in the “Introduction” shows, however, in order to keep workplace noise below a certain limit, the noise output of individual pieces of machinery will usually need to be well below that limit.

Flow chart 2 outlines a step-by-step procedure for calculating the maximum acceptable noise level for a given installation site. The following comments refer to the lettered points on Flow chart 2.

- (A) In Box 1 enter the noise exposure goal [$L_{Aeq,8h}$] that the organisation has set for working areas.
- (B) In Box 2 enter the present noise exposure level [$L_{Aeq,8h}$] at what will be the operator position of the new machine, measured when the machine it is to replace is not running.
- (C) If the value in Box 1 exceeds the value in Box 2 (which means the present noise in the area is below the goal), use the “Subtracting Decibels Table” on the flow chart to subtract the level in Box 2 from the level in Box 1 and enter the result in Box 4.

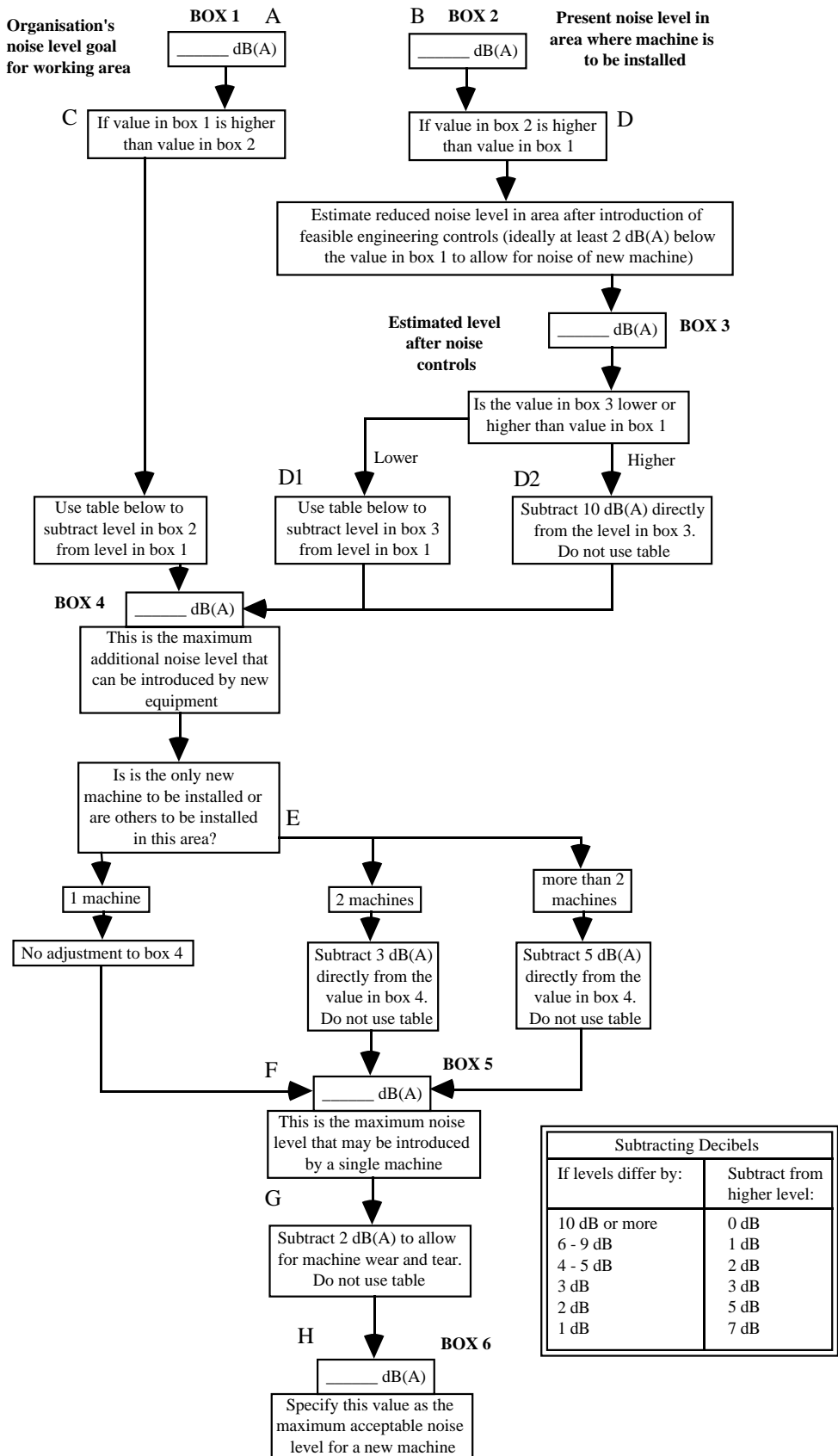
For example, if the level in Box 1 is 85 dB(A) and the level in Box 2 is 80 dB(A), by using the “Subtracting Decibels Table” the level to be entered in box 4 is 83 dB(A).

- (D) If the value in Box 2 exceeds the value in Box 1, the present noise in the area is above the goal and therefore needs to be reduced. Estimate the level that will exist in the area after feasible engineering controls have been installed and enter it in Box 3.
- (D1) If the value in Box 3 is lower than the value in Box 1 (that is, anticipated engineering controls will reduce the noise in the area below the goal), use the “Subtracting Decibels Table” to subtract the value in Box 3 from the value in Box

1 and enter the result in Box 4. The result is the maximum noise exposure level that can be introduced into the treated noise environment without causing the noise goal to be exceeded.

- (D2)** If the value in Box 3 is higher than the value in Box 1 (that is, after the installation of feasible controls the noise in the area will still exceed the goal), reduce the value in Box 3 by 10 dB(A) and enter the result in Box 4. This will ensure that after feasible controls have been introduced, installation of new equipment will have a minimal effect (the increase will be less than 0.5 dB(A)) on the noise exposure level in the area.
- (E)** Subtract 0, 3 or 5 dB(A) from the value in Box 4, depending on whether 1, 2, or 3 or more machines respectively will be installed either now or in the future, and enter the result in Box 5. This correction allows for the additive effects of noise from adjacent sources.
- (F)** The value in Box 5 is the maximum level that can be tolerated from an individual machine over its working lifetime.
- (G)** Since the noise emitted by a machine normally increases with wear and tear, it is desirable to specify for a new machine a somewhat lower limit than the calculated maximum acceptable value. A correction of 2 dB(A) allows a small margin for wear and tear and produces the final result in Box 6.
- (H)** This is the maximum acceptable noise level to specify for a new machine.

FLOW CHART 2: CALCULATING THE MAXIMUM ACCEPTABLE NOISE LEVEL FOR A NEW MACHINE



NOTE 1: The calculation method in flow chart 2 ensures that the new machine can be used for up to 8 hours per day without causing the noise exposure goal to be exceeded. If it is certain that the machine will be used for fewer hours every day, higher noise levels, calculated according to the 3 dB rule mentioned in Appendix 2 of the Core, could be tolerated without infringing the noise exposure goal. For example, if the machine will never be used for more than 2 hours a day, a maximum acceptable noise level 6 dB(A) higher than the value calculated in Box 6 (for 8 hours) would be tolerable.

Generally, in cases where a machine will be used (or people will be exposed to its noise) for less than 8 hours a day, consider specifying a range of acceptable noise levels encompassing its expected actual use and its potential daily use. If the value in Box 6 is 78 dB(A) but the machine will probably never be used more than 2 hours a day, specify 78 dB(A) as the maximum preferred level, thus allowing for increased use/exposure at some time in the future, say as a result of expansion, and 84 dB(A) as the maximum acceptable level.

NOTE 2: When comparing noise emission levels quoted by suppliers with your maximum acceptable noise level, check the conditions under which the supplier's noise measurements have been obtained. Noise levels appearing in a supplier's data sheet may have been measured under non-representative conditions (for example, a light to medium load on a machine installed in non-reverberant surroundings). At your workplace it is more likely that the surroundings will be reverberant and that the machine will be run at full load. To allow for these effects, add 4 dB(A) to the supplier's noise measurements unless it is clear that they were made under typical working conditions.

5. USING SUPPLIERS' NOISE INFORMATION

How can we work out from a supplier's noise information sheet how much noise their machine would introduce into our workplace?

Both International and Australian standard methods are now available for measuring and describing the noise emission of industrial machines. It is best if suppliers'

noise data have been measured according to one of these standards. Measurements made according to other procedures may, however, be acceptable if performed by a competent person according to a clearly defined procedure.

Flow chart 3 presents a method for using a supplier's noise information to estimate the amount of noise a given machine will introduce into the workplace:

- (A)** Enter the supplier's noise measurement result in Box 1.
- (B)** Refer to the supplier's noise information sheet to determine whether the noise was measured as a sound pressure level or a sound power level.
- (C)** If measured as a sound pressure level, make no adjustment. However, if supplier's sound pressure level data are for positions at larger distances than the operator's location, seek expert advice.
- (D)** If measured as a sound power level, subtract 8 dB(A) from the value in Box 1 and enter the result in Box 2.
- (E)** Refer to the supplier's noise information sheet for a description of the conditions under which the noise measurement was made.
- (F)** If the test conditions appear to have been representative of typical working conditions (for example, machines are installed in reverberant surroundings, have suffered some wear and tear and are run fully loaded), no adjustment is necessary.
- (G)** If the test conditions are not representative (for example, the test machine is in new condition and is run on less than full load in non-reverberant surroundings) add a 6 dB(A) correction to the value in Box 2 and enter the result in Box 3.

If the test conditions are partially, but not fully, representative of your working conditions, select an appropriate correction between 0 and 6 dB(A).

- (H)** The value in Box 3 is the estimated noise level the machine will introduce into the area in which it is installed. Remember that this value is an estimate and that variations of ± 5 dB(A) are possible.
- (I)** The noise introduced by the new machine will combine with the noise already present in the area. To calculate the new noise level in the area, enter the present noise level in the installation area in Box 4, then use the “Adding Decibels Table” to combine the levels in Boxes 3 and 4.

For example, if a machine with a noise level of 78 dB(A) is introduced into an area where the existing noise level is 80 dB(A), by using the “Adding Decibels Table” the new noise level in the area will be 82 dB(A).

6. LACK OF
SUPPLIER
INFORMATION

What if the supplier is unable to provide noise information?

It may be possible to arrange for noise measurements to be made of the same model of machine already installed elsewhere or of a machine set up in the suppliers workshop. The supplier may be prepared to meet or at least share the cost of having the measurements made since the information would be useful in relation to future product promotion and sales.

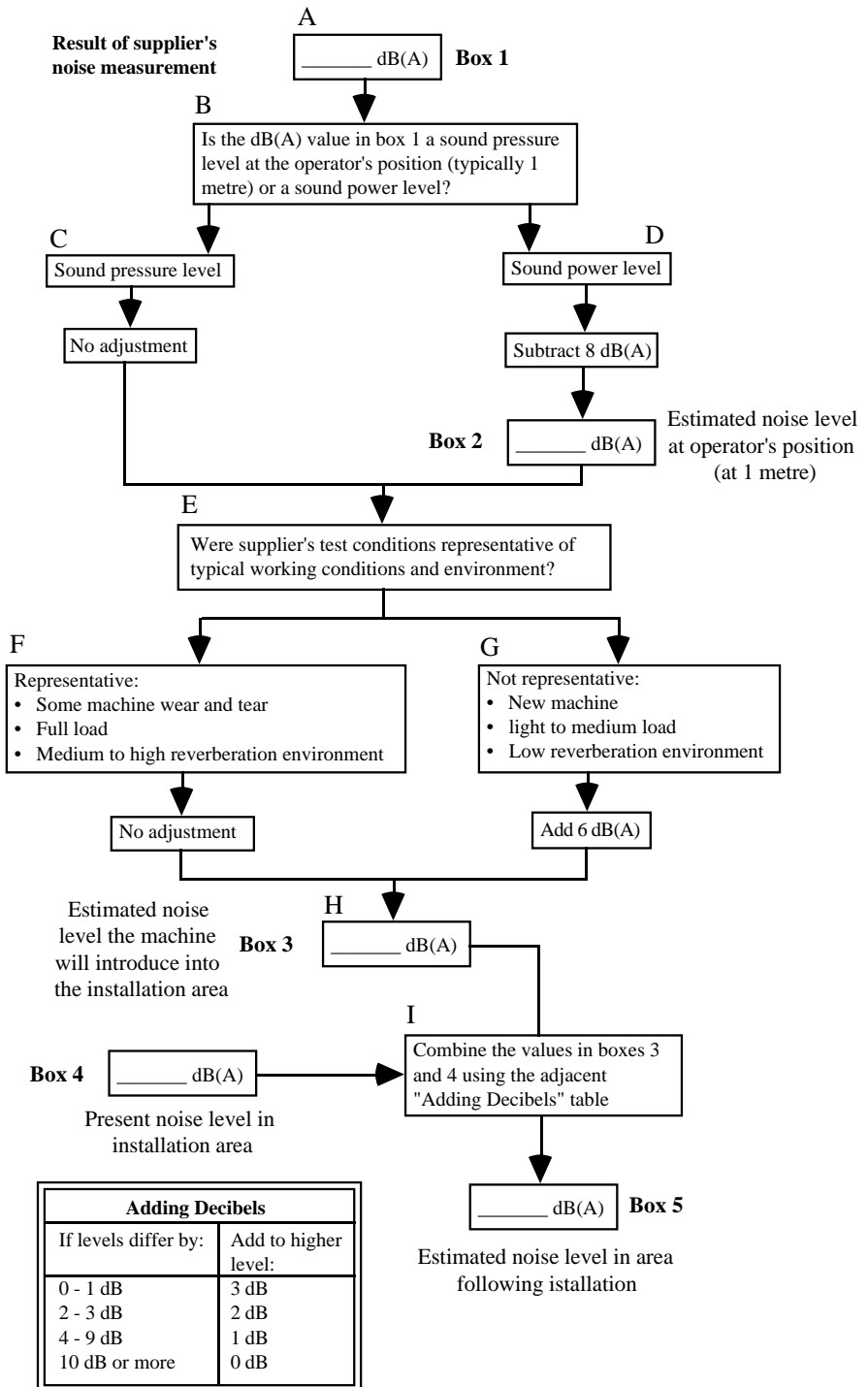
7. PRIORITY FOR
NOISE

How much weight should be given to noise when assessing competing products?

This will depend mainly on the magnitude of the organisation’s noise problem and the availability of funds.

As an example of a general policy on this issue, the policy of federal government agencies in the USA is to purchase noise-suppressed items automatically if their price is no more than 25 per cent greater than the price of the cheapest otherwise acceptable item. If the price is more than 25 per cent greater, purchase of the noise-suppressed item may still go ahead but is subject to justification.

FLOW CHART 3: ESTIMATING THE AMOUNT OF NOISE A GIVEN MACHINE WILL INTRODUCE INTO THE WORKPLACE



8. FAILURE TO
MEET NOISE
SPECIFICATIONS

What if no tender meets the noise specification?

As a matter of policy, plant which fails to meet the noise specification should be accepted only with the written approval of a senior manager who should check that:

- efforts have been made to locate alternative suppliers;
- negotiations have been held with tenderers to determine the feasibility of additional noise control work on their products and the availability of noise-reducing accessories;
- the equipment is to be supplied with the maximum affordable amount of noise reduction treatment in order to minimise noise emission in the workplace;
- consideration has been given to the design of the area in which the new equipment is to be installed to ensure that operator exposure levels will be as low as workable.

**FURTHER
READING**

Bruce, R.D. and Toothman, E.H., "Engineering Controls", in Berger, EH et al. (Eds), *Noise and Hearing Conservation Manual*, 4th edition, American Industrial Hygiene Association, Ohio, 1986.

Middleton, A., "How to specify quieter machinery", *Works Management*, vol. 37, no. 1, pp. 28-9, 1984.

Pinder, J.N., "Noise specifications for industrial plant and equipment - avoiding shortcomings", *Noise and Vibration Control Worldwide*, pp. 292-5, October, 1982.

Bruel and Kjaer Ltd, *Noise Control - Principles and Practice*, Bruel and Kjaer Ltd, Denmark, 1986. (Text on pages 20-5 "Noise control of new projects" is especially useful). This publication is available from Reid Technology Ltd, PO Box 1898, Auckland.

MODULE 9: EVALUATING OPTIONS

THIS MODULE IS FOR	Noise manager Production/engineering staff.
PURPOSE	To outline a method for assigning priorities to noise control treatments on the basis of cost-effectiveness.
OUTCOMES	The relevant manager(s) should be able to: <ul style="list-style-type: none">• identify which machines or tasks contribute most to the overall noise exposure of operators;• estimate how much noise reduction is required;• compare the effectiveness and cost of various treatment options;• select the most cost-effective treatment, taking account of significant non-noise factors such as other health and safety considerations and productivity.
CONTENTS	IDENTIFYING NOISE CONTROL OPTIONS ESTIMATING THE EFFECTIVENESS OF OPTIONS SELECTING THE MOST EFFECTIVE TREATMENT OPTION COSTING THE OPTIONS EXAMPLE: STAMPING NUMBERS ON STEEL GAS CYLINDERS IMPLEMENTING THE CHOSEN SOLUTION BASIC NOISE CONTROL FURTHER READING

EVALUATING NOISE CONTROL OPTIONS

IDENTIFYING NOISE CONTROL OPTIONS

A walk-through audit of your workplace (as pointed out in *Module 2: Walk-through Audit*) is a good source of ideas for practical noise control options.

Noise measurements taken in the course of a more formal noise survey are also a useful source of ideas for noise control. As shown below, such measurements also enable the likely effectiveness of various options to be estimated.

The most basic information to start with is a list of the tasks which each operator works, the associated noise levels and how long each operator spends at each task during a typical working day. For a single operator, this information can be summarised in a simple table:

TABLE 1: BASIC
NOISE EXPOSURE
DATA FOR A
SINGLE OPERATOR

<i>Task number</i>	<i>Noise level dB(A)</i>	<i>Duration (Hours)</i>
1	84	4
2	89	3
4	88	1

By using the Table 3 in Appendix 2 of the Core, the data in Table 1 above can be used to calculate the Partial Noise Exposure (PNE) associated with each task:

TABLE 2:
CALCULATION OF
PNEs FROM
NOISE LEVEL AND
EXPOSURE
DURATION

<i>Task</i>	<i>Noise level dB(A)</i>	<i>Duration (Hours)</i>	<i>PNE (Pa²h)</i>
1	84	4	0.4
2	89	3	0.95
4	88	1	0.25
TOTAL		8	1.6

The sum of the PNEs for the 8 hours of the working day is the Daily Noise Exposure (DNE), which in this case is 1.6 Pa²h.

The above procedure — listing tasks and the amount of time spent on them in a typical workday, then using the Pascal-squared conversion table to calculate PNEs — can be repeated for each employee. The data for all the employees in a given area can then be put together in a

summary table. The following example shows partial noise exposures (PNEs) for seven operators, each of whom works on one or more of the five tasks in an individual pattern. The data could be for a small establishment or a section of a larger one.

TABLE 3: PARTIAL NOISE EXPOSURES FOR SEVEN OPERATORS SHARING FIVE TASKS

Task	Noise level (dB(A))	Partial Noise Exposure of operator(Pa ² h)							Total for task
		A	B	C	D	E	F	G	
1	84	0.40	0.50	0.30		0.10			1.30
2	89	0.95		0.95					1.90
3	86		0.48	0.32	0.64				1.44
4	88	0.25			1.01	1.76	1.26		4.28
5	83						0.24	0.64	0.88
TOTAL (DNE)		1.60	0.98	1.57	1.65	1.86	1.50	0.64	9.80

The sum of the PNEs in each column is the daily noise exposure (DNE) for the operator concerned. Operator G has the lowest DNE (0.64 Pa²h) and operator E the highest (1.86 Pa²h).

The sum of the PNEs in each row indicates the contribution made to the total exposure by the associated task. Note that task 4 contributes most to the total exposure, even though task 2 has a higher dB(A) level.

It can be seen from this summary table that:

- noise exposure reductions are clearly necessary, since five of the seven operators are exposed to DNEs above 1.0 Pa²h (the current legal limit, equivalent to a noise exposure level ($L_{Aeq,8h}$) of 85 dB(A);
- task 4 is the major single contributor (4.28 Pa²h) to the total noise exposure;
- task 4 is responsible for 3 operators (D, E and F) exceeding the exposure limit.

On this analysis, reducing the 88 dB(A) noise level associated with task 4 presents itself as an obvious noise reduction option to consider.

ESTIMATING THE EFFECTIVENESS OF OPTIONS

To get some feel for the effectiveness of this option, we can ask what would happen if the noise level of task 4 was reduced by, say, 10 dB(A)? A reduction of 10 dB(A) is easy to work with because it means that each associated exposure would be reduced to one tenth of its existing value. However, it is not difficult to consider the effect of any desired reduction, as shown later.

To continue with the present example, if the noise level of task 4 is reduced by 10 dB(A) to 78 dB(A), each exposure for task 4 is reduced to a tenth of its present value and the table looks like this:

TABLE 4:
ESTIMATING THE EFFECTIVENESS OF A 10 DB(A) REDUCTION OF TASK 4

Task	Noise level (dB(A))	Partial Noise Exposure of operator (Pa ² h)						Total for task	
		A	B	C	D	E	F		G
1	84	0.40	0.50	0.30		0.10		1.30	
2	89	0.95		0.95				1.90	
3	86		0.48	0.32	0.64			1.44	
4	78	0.03			0.10	0.18	0.13	0.44	
5	83						0.24	0.64	0.88
TOTAL (DNE)		1.38	0.98	1.57	0.74	0.28	0.37	0.64	5.96

The main result is that the number of operators exposed to exposures above 1.0 Pa²h has dropped from five (with operator B marginal) to two (with operator B marginal).

Task 2 now emerges as the highest contributor to the total exposure and to the individual exposures received by operators A and C, indicating that treatment of the noise source for task 2, as well as the noise source for task 4, may bring all operators below the current maximum permissible DNE of 1.0 Pa²h.

As before, we can estimate the effectiveness of this additional reduction by recalculating exposures on the assumption that the noise level associated with task 2, as well as that of task 4, has been reduced by 10 dB(A). This leads to the following table, in which the exposures associated with both tasks 2 and 4 have been reduced to a tenth of their original values.

TABLE 5:
ESTIMATING THE
EFFECTIVENESS
OF A 10 DB(A)
REDUCTION OF
TASKS 2 AND 4

Task	Noise Level (dB(A))	Partial Noise Exposure of operator (Pa ² h)							Total for task
		A	B	C	D	E	F	G	
1	84	0.40	0.50	0.30		0.10			1.30
2	79	0.10		0.10					0.20
3	86		0.48	0.32	0.64				1.44
4	78	0.03			0.10	0.18	0.13		0.44
5	83						0.24	0.64	0.88
TOTAL (DNE)		0.53	0.98	0.72	0.74	0.28	0.37	0.64	4.26

The combined effect of both reductions is that all operators are now exposed to DNEs less than 1.0 Pa²h (though the DNE for operator B remains marginal), and are therefore below the current legal exposure limit.

The approach outlined above may be used to estimate the effects of various noise reduction treatments and combinations of such treatments. While reductions of 10 dB(A) in source noise levels have been used for convenience in the above examples, it is of course possible to consider other values of reduction. Using a calculator, the following table of exposure reduction factors may be applied directly to the PNE values in Table 3 above.

TABLE 6:
EXPOSURE
REDUCTION
FACTORS

<i>If noise level is reduced by the following number of decibels (dB(A))</i>	<i>Divide the original PNE or DNE by</i>
1	1.3
2	1.6
3	2.0
4	2.5
5	3.2
6	4.0
7	5.0
8	6.3
9	8.0
10	10
11	13
12	16
13	20
14	25
15	32
16	40
17	50
18	63
19	80
20	100

To consider the effect of a noise level reduction of 5 dB(A) rather than 10 dB(A), the associated exposures would be divided by 3.2 rather than 10.

In conjunction with a task-by-operator table of PNE values of the kind we began with (Table 3), Table 6 can be used to estimate the individual and overall effects of any proposed reduction in noise levels.

By exploring such options in advance, it is possible to get an overall “feel” for the machines or processes where a given noise level reduction will have the biggest effects and, conversely, to avoid spending money on treatments that will have only a limited effect. As an example of the latter, a 10 dB(A) reduction in the noise level of task 1 in our original example would leave unchanged the number of operators exposed above the permissible limit. Again, it can be seen that the benefit of reducing the noise level of task 2 is fully realised only if task 4 is dealt with first.

WARNING In practice, it often happens that an operator’s exposure is determined by the noise of several machines running together, so reducing the noise of a particular machine may or may not result in as large a reduction of the noise level at the operator’s position. One way to find out is to measure the noise level at the operator’s position and note the reduction when the machine in question is switched off. Consultants use this technique to determine the dominant sources of noise at each operator’s position, systematically turning machines on and off and noting the effects. If machines cannot be switched off for production or other reasons, consultants have special noise measurement techniques that take longer but enable the contribution of individual machines to be determined even when they are all running at once.

As a further example of the use of Table 6, consider an entirely different approach, that is a uniform reduction of all noise levels by a relatively small amount, say 3 dB(A). An overall noise reduction of this magnitude is sometimes achievable by means of sound-absorptive treatments to walls and ceilings.

A uniform reduction in noise levels of 3 dB(A) in Table 3 would have the effect of halving all exposures (Table 6),

producing the following result shown in Table 7.

It can be seen that an across-the-board reduction of 3 dB(A) would bring all operators below the DNE 1.0 Pa²h limit. On paper at least, this approach has roughly the same effect as reducing the noise levels of tasks 2 and 4 by 10 dB(A).

TABLE 7:
ESTIMATING THE
EFFECTIVENESS OF
A 3 DB(A)
REDUCTION IN ALL
NOISE LEVELS

Task	Noise Level (dB(A))	Partial Noise Exposure of operator (Pa ² h)						Total for task	
		A	B	C	D	E	F		
1	81	0.20	0.25	0.15		0.05		0.65	
2	86	0.48		0.48				0.96	
3	83		0.24	0.16	0.32			0.72	
4	85	0.13			0.50	0.88	0.63	2.14	
5	80						0.12	0.32	
TOTAL (DNE)		0.81	0.49	0.79	0.82	0.93	0.75	0.32	4.91

WARNING

Another word of warning is in order here. Acoustical absorption is an expensive treatment that may not change sound levels close to machinery, exactly where many operators are required to work. It should certainly not be applied without first seeking advice from an acoustics expert.

**SELECTING
THE MOST
EFFECTIVE
TREATMENT
OPTION**

For illustrative purposes, however, let us suppose that an acoustical consultant has confirmed that absorptive treatment of walls and ceiling is a feasible option in the example we are considering. The three treatment options we have examined can now be ranked as follows in terms of relative effectiveness and contrasted with existing conditions.

TABLE 8:
COMPARISON OF
NOISE CONTROL
OPTIONS WITH
EXISTING
CONDITIONS

Conditions	Total Exposure (Pa ² h)	No. of Operators whose DNE ≥ 1 Pa ² h
Existing conditions	9.80	7
Option 1- reduce noise level of source 4 by 10 dB(A)	5.96	2
Option 2 - reduce noise levels of sources 4 and 2 by 10 dB(A)	4.26	0
Option 3 - absorption treatment to walls and ceilings	4.91	0

On this analysis, options 2 and 3 would be equally acceptable. Although they are quite different approaches they are about equally effective, in that each would roughly halve the total exposure and ensure that no operator would be exposed above the legal limit.

COSTING THE OPTIONS

Having determined the relative effectiveness of various options, the next step is to cost them.

The first step in the costing process is to consider how the required noise reductions can actually be brought about. A short list of basic noise control techniques is listed at the end of this module, together with references to some useful publications.

ACOUSTICAL TREATMENT OF THE WORKPLACE

Acoustical treatment of the workplace, which includes installing screens and barriers, applying sound-absorbing treatment to surfaces such as walls and ceilings, and enclosing machines operators, should be discussed with a consultant or contractor before proceeding, especially concerning possible limits to their effectiveness in your particular workplace. The consultant or contractor should be able to provide cost estimates at the same time. As noted above, treatment generally provides low reductions in noise level for all employees. On the other hand, it involves little disruption or machine down-time and has the advantage of improving the acoustical comfort of the environment by reducing reverberation.

TREATMENT OF THE NOISE SOURCE

Treatment of the noise source usually results in larger noise level reductions than acoustical treatment of the workplace itself, though at potentially greater cost in terms of machine down-time and interference with production (unless modifications can be carried out during scheduled maintenance down-time or outside normal operating hours). Source treatment presents three main sub-options, that is, substitution, modification or replacement.

Substitution

Ideas for substitution can be gained from industry journals and advice from equipment designers and manufacturers, relevant industry associations or government departments.

Modifications

For modifications, refer to the supplier of the machinery or equipment concerned because they may know of successful solutions already developed. Noise control options are becoming more common on new equipment as the demand for quieter equipment grows.

Replacement

Replacement of an existing machine with a quieter one that does the same job involves seeking information from equipment suppliers, industry and trade associations and relevant government departments. For advice on how to request noise information and specify noise limits when purchasing equipment, see *Module 8: Buy Quiet*.

EXAMPLE: STAMPING NUMBERS ON STEEL GAS CYLINDERS

The following example gives an overview of the main factors to be considered when comparing alternative solutions to a given noise problem.

In a factory manufacturing steel gas cylinders, each cylinder was numbered by an operator using a hammer and a set of number punches. The empty cylinder rang loudly at each hammer blow, causing the operators' noise exposure to exceed the permissible limit and placing their hearing at risk.

The following noise control options were considered:

- Substituting a different process, that is, to “hand-write” numbers with an arc welder instead of stamping them.
- Modifying the existing machine or process so that before stamping, the cylinder was placed on a tough sound-absorbing mat and draped with a flexible acoustical damping sheet.
- Replacing the existing machine with a quieter one by using a hydraulic press to impress the numbers slowly under high pressure.

Table 9 lists the main factors taken into account in evaluating the three options. The replacement option was chosen.

TABLE 9:
COMPARISON OF
COSTS AND
BENEFITS OF
OPTIONS FOR
REDUCING NOISE
OF NUMBER-
STAMPING
OPERATION

	<i>Substitution</i>	<i>Modification</i>	<i>Replacement</i>
Noise Control Options	“hand-write” numbers with arc welder instead of stamping	place cylinder on rope mat; drape with lead-vinyl damping sheet before stamping	replace manual stamping with hydraulic press
Effects:			
• Noise	moderate reduction	moderate reduction	substantial reduction
• Productivity	mod. reduction	slight reduction	substantial increase
• Health/safety	fumes, visual hazard	unchanged	unchanged
• Cost	low	low	moderate

IMPLEMENTING THE CHOSEN SOLUTION
VALUE OF EXPERT ADVICE

Unless your organisation has in-house expertise or previous relevant experience, it is wise to get expert advice on the feasibility, likely effectiveness and estimated costs of any noise solution you are considering, especially if significant expense is involved.

However, systematic analysis of various options along the lines mentioned above will have put you in a position to work with a consultant most effectively. You will be able to discuss your organisation’s noise problems intelligently and make an informed appraisal of the consultant’s or contractor’s recommendations.

ARRANGING FOR WORK TO BE CARRIED OUT

This is basically a matter of deciding whether to hire a contractor or to use your organisation’s resources. The decision depends on how specialised the job is and on the expertise and availability of the organisation’s staff. The major options are:

- design and install the noise control solution entirely in-house, a solution not recommended for complex problems;
- design a solution and have it checked by an expert before installing it yourself;
- hire an expert to design the solution, then install it yourself;

- hire an expert to design the solution and have a contractor install it.

IMPLEMENTATION
TIMETABLE

The timetable for introducing noise controls will be determined mainly by the availability of funds and whether installation of noise controls can be integrated with other planned changes such as equipment upgrading, alterations to processes or movement to new premises. Other factors, such as a health and safety inspector's improvement notice or complaints from employees, employee representatives or nearby residents, can also be important at times.

Planning for the introduction of noise controls should therefore be integrated with the organisation's overall production and financial planning, and consideration should be given to including noise control as a permanent item in the organisation's budget until noise hazards are eliminated. Remember, noise is estimated to cost the "average" manufacturing enterprise over \$17,000 a year.

**BASIC NOISE
CONTROL**

The basic techniques for reducing noise at source are to:

- Substitute quieter processes, for example: compression riveting for impact riveting, welding for riveting, or hydraulic pressing for impact forging.
- Substitute quieter machines, for example: presses for hammers, hydraulic presses for mechanical presses, belt drives for gears, nylon for metal gears, or conveyor belts for rollers.
- Reduce impacts, for example: minimise loose play in gears, cams or chains, apply tough rubber or plastics to impacting surfaces, or minimise height of fall.
- Reduce vibration, for example: balance rotating parts, mount vibrating items on resilient mountings, reduce area of vibrating surfaces, or coat vibrating surfaces with damping material.
- Reduce transmission of sound through structures, for example: mount large vibrating machines on

vibration isolators or separate foundations, or use flexible shaft couplings, hoses, pipe and duct connectors.

- Reduce noise produced by air or gas flows, for example: prefer low-velocity large-diameter pipe and duct systems over high-velocity small-diameter systems, or fit silencers on intakes and exhausts or streamline flows.

**FURTHER
READING**

Bruce, R.D. and Toothman, E.H., “Engineering Controls”, in Berger, E.H. et al. (Eds.) *Noise and Hearing Conservation Manual*, 4th Edition, American Industrial Hygiene Association, Ohio, 1986.

Bruel and Kjaer Ltd., *Noise Control - Principles and Practice*, Bruel and Kjaer Ltd, Denmark, 1986, available from Reid Technology Ltd, PO Box 1898, Auckland.

Health and Safety Executive, *100 Practical Applications of Noise Reduction Methods*, HMSO, London, 1983.

SHARE *Solutions on Noise*, available from Victorian Department of Labour, Level 22, Nauru House, 80 Collins Street, MELBOURNE, VIC 3000, or the local branch of Occupational Safety and Health.

MODULE 10: FACT SHEETS

THIS MODULE IS FOR Chief executive officer
Production/engineering staff
Maintenance staff
Nurse/medical staff
Purchasing staff
Employee representatives
OHS committee

INTENDED OUTCOMES The fact sheets are intended to raise awareness about:

- the effects of noise and the value of good hearing;
- noise and noise control;
- ways of reducing noise exposure;
- personal hearing protectors.

CONTENTS FACT SHEET 1: EFFECTS OF NOISE AND VALUE OF GOOD HEARING

FACT SHEET 2: QUESTIONS AND ANSWERS ON NOISE AND NOISE CONTROL

FACT SHEET 3: WAYS OF AVOIDING HEARING DAMAGE

FACT SHEET 4: HEARING PROTECTORS

FACT SHEET 1: EFFECTS OF NOISE AND VALUE OF GOOD HEARING

GOOD HEARING IS IMPORTANT

You depend on your hearing:

- to communicate;
- to socialise;
- to learn;
- to keep in touch with the world around you;
- to be warned of impending danger;
- to be entertained;
- to enjoy music and the sounds of nature.

Taking care of your hearing makes sense.

NOISE IN NEW ZEALAND WORKPLACES

Up to half a million New Zealanders work in noisy jobs. Noise is a leading cause of hearing loss in adults. Many workers in the State of Victoria in Australia have had their hearing tested as part of a Victorian government programme.

Some key findings were:

- over 80,000 workers were found to have damaged hearing, with many more workers yet to be tested;
- in some factories, more than half the workers had impaired hearing.

Though there are no data available for the situation in New Zealand, it is likely to be similar. The population of New Zealand (3.5 million) is about 80% of that of the State of Victoria (4.4 million).

Noise problems are not confined to large organisations. There are a large number of workers exposed to excessive noise in small manufacturing enterprises.

WHAT DOES NOISE DO TO THE EAR?

Noise destroys delicate nerve cells in the inner ear that transmit sound messages to the brain. The nerve cells are replaced by scar tissue which does not respond to sound.

The damage is painless but is also permanent and there is no cure. Hearing aids can be of some help but fall far short of restoring normal hearing.

**HOW DOES
INNER EAR
DAMAGE
AFFECT
HEARING?**

Noise-induced hearing loss (NIHL) does not result in total deafness. Those parts of the ear which process high-frequency sound are more affected than other parts of the ear. The ability to hear low-frequency sounds can remain almost normal. This partial hearing loss can have a number of strange effects, including the following:

- In quiet surroundings, such as the countryside, you may hear far away thunder or a distant car (both faint low-frequency sounds) as well as anyone else. At the same time, you may fail to hear closer sounds which are clearly audible to others, such as the song of a bird or a cicada or the rustle of a small animal in the grass (faint high-frequency sounds). Such apparent inconsistencies in your behaviour can make people think you are a dreamer or that you sometimes just pretend not to hear.
- Inconsistencies may also occur when listening to speech. The loudness of speech is determined by its low-frequency content, so it sounds as loud to a person with NIHL as it does to most people; on the other hand the intelligibility of speech is determined by its high-frequency content. To a person with NIHL, many words sound the same and speech sounds jumbled. The typical complaints of a person with NIHL are, “Don’t shout, I’m not deaf” and, “I can hear but I can’t understand”. It’s easy to see why someone unaware of the nature of NIHL can mistake this hearing difficulty for low intelligence and misinterpret requests to repeat what is said as a deliberate tactic to annoy or make conversation difficult.

**EFFECTS OF
HEARING
IMPAIRMENT**

If your hearing is impaired it can affect many areas of your life.

Talking with people

If you have NIHL, everyone seems to mumble, so it is

hard to have relaxed conversations, use the telephone, deal with people in shops and follow what's going on at meetings.

Social life

You may find yourself avoiding people because you are embarrassed about not being able to hear properly. Your family and social life may suffer. At work, you may be passed over for promotion.

Quality of life

Being hard of hearing takes pleasure away from things like music, television, films and the sounds of nature.

ringing in the ears

As well as impaired hearing, you may also suffer from “ringing in the ears”. This can be very distressing, especially if you are trying to sleep.

Safety/emergencies

If you have NIHL, you don't always hear what's going on around you. You could miss a warning sound or a cry for help, or misunderstand an important message. In an emergency you could be a danger to yourself or others.

WARNING SOUNDS

Because enemy troops are usually detected by the sounds they make, the US Army studied the effects of hearing loss on enemy troop detection.

They found that a sentry with normal hearing would have almost two minutes warning of an approaching enemy soldier walking on leaves.

A sentry with poor hearing — about the same as moderate industrial deafness — would not hear the approach until the enemy was five steps away.

The same sentry with an additional temporary hearing loss, such as could be experienced after a day's work in a noisy factory, *would not hear the enemy approach at all.*

OTHER EFFECTS OF NOISE

Noise exposure which is high enough to cause permanent damage will usually cause temporary

hearing problems by the end of the working day. Hearing may be poor for some hours after work just at the time when it is needed for relaxing with family or friends, enjoying television or participating in other leisure activities. Hearing will usually recover overnight but if noise exposure continues, less and less recovery occurs and the temporary changes gradually become permanent.

Noise can be a safety hazard. It can distract attention, drown out the sound of a malfunctioning machine, an alarm signal, a warning shout or a cry for help. Many people find high workplace noise levels irritating and stressful. Communicating in noisy areas requires extra effort and concentration and there is a risk that messages or instructions will be misunderstood, leading to mistakes, frustration and possible safety problems.

FACT SHEET 2: QUESTIONS AND ANSWERS ON NOISE AND NOISE CONTROL

WHAT'S A BIT OF HEARING LOSS

It is often incorrectly said that hearing loss is not as bad as losing a finger or being injured in an accident.

Many hearing impaired people would gladly trade a finger to have normal hearing again.

Recent research at the University of Montreal highlights a number of consequences of noise-induced hearing loss (Hetu R., Riverin L., Lalande L., Getty C. and St Cyr C. "Qualitative analysis of the handicap associated with occupational hearing loss", *British Journal of Audiology*, vol. 22, pp. 251-64, 1988). The research, which was based on reports from industrial workers, revealed that workers have to expend extra effort to overcome their hearing loss, suffer from anxiety, stress and fatigue and feel isolated in groups.

EFFORTS

Extra effort is required by the workers because:

- they must be more attentive in communicating with others;
- they must concentrate more in conversations;
- it is annoying to ask others to repeat themselves;
- adjustments demand a great deal of effort.

ANXIETY AND STRESS

Anxiety and stress were caused because:

- noise at home is bothersome;
- ringing in the ears is very annoying;
- workers worry about the condition of their hearing and the noise level at work;
- noise at work led to aggressive behaviour; and
- of the inability to hear the telephone ringing.

FATIGUE

Workers reported that:

- after work it is very annoying to feel the sensation that their ears are blocked;

- they have headaches;
- they need peace and quiet;
- they feel too tired for normal activities.

EFFECTS ON
GROUP ACTIVITIES

Workers said that their hearing problems had led to changes in their social activities because:

- they are less communicative in groups;
- they are more and more isolated in groups;
- they participate less and less in group discussions;
- their inability to follow group discussions is annoying.

Therefore the real question is, “If it’s entirely preventable, what’s the point of having the ears of a 70-year-old when you’re only 20?”

**I’M YOUNG,
WHAT DOES
IT MATTER?**

“I’m young, I’ll worry about it later. It’s mostly the older ones who are hard of hearing”, is sometimes said.

However, most older workers with noise-induced hearing loss have had it since they were young. The reason it is more noticeable among older workers is that the additional hearing loss that comes with age makes it impossible for them to hide their difficulties.

The time to prevent noise-induced hearing loss is from the first day in a noisy environment. You may have thought, “I’ll notice if noise is affecting my hearing and I’ll do something about it then”.

Unfortunately, however, you probably won’t notice. Noise-induced hearing loss develops gradually over a period of months to years, depending on the degree of exposure. The process is slow and painless and very few people notice it happening until quite a lot of hearing has been lost.

There is no cure for noise-induced hearing loss, so all you will be able to do is learn how to live with a permanent hearing impairment.

**WHAT MAKES
A NOISE
HARMFUL?**

The two main aspects of noise which determine whether it is harmful are:

- how loud the noise is;
- how long you are exposed to it each day.

Noise starts to be a risk to hearing when it is about as loud as heavy city traffic, that is about 85 decibels (85 dB(A)). You can work all day in noise levels below 85 decibels with little risk of hearing damage.

Above 85 decibels, the risk increases rapidly as the noise gets louder. At 100 decibels, for example, exposure should be no more than 15 minutes a day.

Although the best way of judging if a noise is harmful is for a trained person to measure it, there are also some simple indicators. Some of the indicators that a noise is likely to be harmful are:

- the noise is as loud or louder than heavy city traffic;
- you have to raise your voice to speak to someone a metre away;
- people who have worked in the noise for a while seem to be a bit deaf;
- things sound different after exposure to the noise;
- you hear ringing or other noises in your ears after exposure to the noise;
- you often have to strain to catch what people are saying;
- you have to turn the radio or TV higher than you used to;
- members of your family say you seem to be having problems with your hearing.

**CAN LOUD
MUSIC HARM
MY HEARING?**

Yes, it certainly can. One exposure is unlikely to cause permanent harm, although you may notice some temporary effects like muffled hearing. However, the risk of permanent hearing damage increases:

- the more often you are exposed;
- the louder the music;
- if you have already been exposed to loud noise that day, for example in a noisy job.

The safe way to listen to your favourite music is to:

- alternate between loud and quiet music;
- give your ears a complete rest for ten minutes every half hour;
- be alert for effects such as ringing in your ears or muffled hearing.

If you experience such effects, take them as a warning that you are over-loading your ears and change your listening habits. Be particularly careful if you work in a noisy job, because noise exposures add up.

**EMPLOYER:
WHY SHOULD
I HAVE TO
WORRY?**

An employer has said, “Why should I have to worry about the noise in my factory when young people can go to a disco after work and blast their ears off?”

Our ears are able to cope with exposure to loud noise provided it doesn’t last too long and is not repeated too often.

Although disco and other amplified music can be very loud, exposures are typically brief and infrequent compared with exposures at work. Therefore, much less hearing damage is caused.

In a survey of over a thousand young people in Sydney, many of whom had often attended concerts and discos, researchers from the National Acoustic Laboratories (the Commonwealth Government scientific laboratory that specialises in the study of noise and hearing) failed to find any clear cases of music-induced hearing loss. (Carter N., Waugh R., Keen K., Murray N. and Bulteau V., “Amplified music and young people’s hearing”, *Medical Journal of Australia*, vol. 2, pp. 125-8, August 7, 1982.)

This is not to say that no one has ever suffered hearing damage as a result of loud music, but it does indicate that significant damage is rare. By contrast, there are now about 9,000 cases of occupational hearing loss every year in New Zealand.

Another point to bear in mind is that employers are under a legal obligation to control noise exposure in the workplace. Government takes the view that, just as the existence of non-occupational risks of injury does not

relieve employers of the responsibility to guard dangerous machines, the existence of non-occupational noise hazards does not relieve employers of the responsibility to control noise hazards in the workplace.

**ISN'T NOISE
CONTROL
EXPENSIVE?**

It is often assumed that noise control is very expensive and that in most cases it is probably impossible to do anything about the noise anyway.

It's true that some noise controls are expensive, especially if equipment has to be modified after installation. This is why it makes sense to buy quiet. Even if it is more expensive, it is better to buy quiet equipment at the outset than to make costly modifications later.

To help break down the myth that noise control work always costs a fortune, consider the following examples of really inexpensive noise solutions:

- A noise consulting firm achieved a 50 decibel reduction (that's a lot) in the noise made by cyclone separators by inserting a small metal plate that broke up a resonant airflow that was causing a high-pitched whistle. The cost was \$1 per machine.
- After advice from a noise consultant, one of the maintenance staff of a small company built sound-proof enclosures around several noisy machines. The machine operators helped with the design to ensure that access and production were not affected. The enclosures were made of plywood and ceiling insulation material enclosed in plastic garbage bags and chicken wire. The material cost was about \$440 per enclosure. The enclosures were effective and removed the need for the operators to wear hearing protectors.
- A French company has developed an "intelligent" rock breaker that senses the nature of the rock and then adjusts the strength and direction of the impacts to break it up as efficiently as possible. Operation is claimed to be virtually vibration-free, with no overheating and little noise.

A lot of noise control work is neither expensive nor complicated once some basic principles are understood. An excellent guide to noise control principles, written

in simple language and clearly illustrated, is now available from Bruel and Kjaer. Details are at the end of this fact sheet.

Another useful publication (also listed at the end) is *100 Practical Applications of Noise Reduction Methods*, from which the following examples are drawn. They show noise levels at the operator's position of various machines before and after simple, inexpensive treatments. In most cases, the noise level has been reduced to the point where the operator would not need to wear hearing protectors.

<i>Problem Machine</i>	<i>Noise Control</i>	<i>Noise level (dB(A))</i>		<i>Cost (\$)</i>
		<i>Before</i>	<i>After</i>	
paper reeler	replace steel with with bronze gears	99	86	825
paper cutter	replace steel with plastic gear	93	85	275
plastic grinder	redesign feed hopper	95	83	110
book binder	line case guard with polyurethane	95	85	45
grinder	replace steel with plastic chute	92	82	50% less
band saw	enclose in acoustic curtains	101	91	2,500

The expense of noise control work has to be weighed against the existing costs of noise. *Module 6: Costs/ Benefits* explores this question and concludes that untreated noise costs the average manufacturing enterprise over \$17,000 per year, to say nothing of the effects on the employees' hearing and health.

Inexpensive noise controls like those listed above are a profitable investment for an organisation and they have very positive health, safety and comfort benefits for employees.

PUBLICATIONS

Bruel and Kjaer Ltd., *Noise Control - Principles and Practice*, Bruel and Kjaer Ltd., Denmark 1986, available from Reid Technology Ltd, PO Box 1898, Auckland.

Health and Safety Executive, *100 Practical Applications of Noise Reduction Methods*, HMSO, London, 1983.

FACT SHEET 3: WAYS OF AVOIDING HEARING DAMAGE

HOW CAN HEARING DAMAGE BE AVOIDED?

The best way to avoid hearing damage is to cut down the noise that people are exposed to. The main ways to do this are by:

Controlling the source of noise

A great deal of noise control is just common sense. Large noise reductions were made in one factory simply by lining metal chutes and bins with scrap conveyor belting.

Stopping the noise from reaching people

This may be done by moving a noisy machine away from people, by building a soundproof enclosure around it or by putting up a barrier between the machine and people.

Reducing the time people are exposed

Quiet work, like packing or inspecting, should be done in a quiet place. Where possible, people should swap between noisy and quiet jobs so that nobody gets exposed for too long.

While it is up to the employer to approve such changes, employees may be able to contribute ideas and help with trialing changes. If you can see ways your workplace might be made quieter, suggest them to your supervisor, safety committee or employer.

If exposure is still excessive after all possible control measures have been taken, individual protection is available from earmuffs or earplugs. *Fact Sheet 4: Hearing Protectors* has detailed information about personal hearing protectors.

DUTIES AND RESPONSIBILITIES

Employees' health and safety at work is protected by law. Employers have a duty to protect employees and to keep them informed about health and safety matters. Employees have a responsibility to look after themselves.

Employers have a duty to keep noise exposure within safe limits. The preferred ways of doing this are to

reduce the amount of noise made by plant and equipment and/or to reduce the amount of time employees are exposed to noise.

If these methods fail to reduce noise exposure below the legally specified limits, the employer has a responsibility to provide employees with suitable hearing protectors and to provide adequate information and instruction in their use.

Employees also have duties. They include:

- taking care of their own health and safety and that of others who may be affected by what they do;
- using noise controls supplied with machinery or installed in the workplace;
- reporting damaged noise control equipment and hearing protectors for repair or replacement;
- using hearing protectors in declared noise areas.

COOPERATION Cooperation between managers and employees is likely to produce the most cost-effective and mutually satisfactory solutions to noise problems in the workplace.

Managers can contribute by:

- developing noise management policies, plans and practices in consultation with workers;
- arranging for a full assessment to be made of noisy areas in the workplace;
- fully investigating engineering noise control options;
- discussing control options with workers to ensure minimal adverse effects on ease of operation, maintenance access and productivity;
- seeking outside advice on noise control as necessary;
- specifying the lowest affordable noise limits when purchasing plant and equipment;
- signposting noisy areas and equipment;
- providing good quality graded hearing protectors;
- involving workers in the selection of hearing

protectors and allowing them choice to ensure that they can obtain a suitable fit;

- always wearing hearing protectors themselves in noisy areas.

Employees can contribute by:

- taking a constructive interest in the workplace's noise problems;
- helping to develop policies, plans and practices for dealing with workplace noise problems;
- suggesting possible noise controls for machines they operate;
- helping plant engineers or consultants design solutions;
- using any noise control equipment supplied;
- taking responsibility for the preservation of their own hearing by using hearing protectors whenever they are in the presence of hazardous noise.

FACT SHEET 4: HEARING PROTECTORS

INTRODUCTION If noise exposure at work can't be made safe by limiting the level of noise or the amount of time employees are exposed to it, employers have a responsibility to provide employees with suitable hearing protectors and employees have a responsibility to use them.

The main types of hearing protector are earmuffs and earplugs. Either type can provide effective protection provided it makes an airtight seal in your ear (plugs) or around it (muffs).

Hearing protectors reduce sound to safe levels rather than block it out completely. A well-fitted hearing protector will give at least the same noise reduction as can be obtained by pressing the hands very firmly over the ears (see Figure 1).

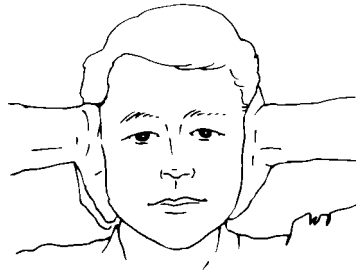


Figure 1: Well-fitted hearing protectors give at least the same noise reduction as pressing your hands firmly against the ears

WHAT TO EXPECT FROM HEARING PROTECTORS

If you have never worn hearing protectors before, use this method to find out what to expect from them:

- find a noisy place at work;
- block your ears firmly with the heels of your hands as shown in Figure 1;
- experiment with different positions of your hands and different pressures.

Your hearing protectors should give about the same noise reduction as the best you can achieve with your hands.

FITTING EARPLUGS

Always READ THE INSTRUCTIONS supplied with the ear plugs.

Some earplugs, for example, the compressible foam type, come in only one size. If the plugs are made in several sizes, you need the correct size for each ear.

To fit the left ear:

- Reach around your head with your right hand and take hold of the back of your left ear about half way down (see Figure 2).
- Gently pull your ear outwards and upwards to straighten your ear canal.
- Insert the plug into your ear canal with your left hand.

To fit the right ear:

- Reach around your head with your left hand and take hold of the back of your right ear about half way down.
- Gently pull your ear outwards and upwards to straighten your ear canal.
- Insert the plug into your ear canal with your right hand.



Figure 2: The correct method for fitting ear plugs

If the plug is a compressible foam type:

- Roll the plug slowly and smoothly into a cylinder about this round ○ (4.5- 5 mm). Depending on how small you roll the plug, it can take up to 30 seconds to do this, possibly longer if you haven't done it before.
- Immediately insert the plug well into the ear canal and hold it in place until it has begun to expand

and block the noise. Aim to get three-quarters of the length of the plug into the canal.

Points to remember are:

- Plugs can work loose and may need to be re-positioned;
- Remove plugs slowly so that suction cannot hurt your ear.

FITTING EARMUFFS

The following points will assist you to fit your earmuffs:

- Inspect the muffs and note which way they are meant to be worn. Some earmuff cups are marked TOP or FRONT and should be worn that way. Oval-shaped cups are meant to be worn so that the oval is vertical (NOT as in Figure 3).



Figure 3: Incorrect location of ear muff cups

- Extend the headband to its maximum length (Figure 4).



Figure 4: Extend headband to its maximum length

- Brush as much hair as possible away from your ears (Figure 5).



Figure 5: Brush hair away from ears while fitting muffs

- Place the muffs over your ears, making sure that the ears fit right inside the cups (Figure 6).



Figure 6: Ears fit inside the earmuff cups

- Hold the cups firmly in place by pressing inwards and upwards with your thumbs, then tighten the headband so that it takes the weight of the cups and holds them firmly in position (Figure 7).



Figure 7: Tightening the headband to hold cups firmly in position

- Now run your fingers around the cushions to check that they are making a good seal against your head everywhere. Some things that can prevent a good seal are prominent cheek bones, an unusually deep groove behind the lower jaw, thick hair, a cap (Figure 8 left) and spectacle frames (Figure 8 right).



Figures 8: Caps and spectacle frames can prevent a good seal

- If you are unable to get a good seal, try different earmuffs, change your spectacle frames to a thinner type or try earplugs instead.

**LOOKING
AFTER YOUR
HEARING
PROTECTORS**

To ensure your hearing protectors are hygienic and continue to provide adequate protection:

- Keep your earmuffs and earplugs clean with soap and water.
- Replace hard or damaged earplugs with a new pair immediately.
- DON'T stretch the headband of your earmuffs. It makes them less effective.
- Replace the cushions on your earmuffs as soon as they start to harden.
- Immediately replace worn or damaged parts of earmuffs.

**GET USED TO
WEARING
HEARING
PROTECTORS**

It takes two to three weeks to get used to wearing hearing protectors. Everyone finds them a bit strange to start with, but once you are used to them you will appreciate their good points, that is:

- You'll feel less stressed while you're working;
- You'll feel less tired at the end of the day;

AND

- You'll know your hearing is safe.

**SOME
QUESTIONS
AND
COMPLAINTS**

Is there any danger in putting earplugs in your ears?

Earplugs are soft and are not long enough to reach far into the ear canal so it's virtually impossible to do yourself any harm with them. However, if you have an ear infection, or have ever had ear surgery, check with a nurse or doctor before using earplugs.

What if I don't wear hearing protectors all the time?

Taking protectors off even for short periods can cancel their protective effect. To be fully protected, you need to wear protectors all the time you are exposed to loud noise.

My hearing protectors feel uncomfortable.

Earmuffs and earplugs will probably feel awkward and uncomfortable when you first start to wear them. Usually these feelings vanish in about two weeks and you really begin to appreciate the relative peace and quiet the protectors create. If you are having problems, speak to your supervisor or health and safety representative about trying different protectors.

If I wear hearing protectors, I won't be able to hear my machine properly.

Your machine will certainly sound different when you wear protection, but you should still be able to detect changes in the noise it makes.

Is there any point in wearing hearing protectors if my hearing is already impaired?

Your ears will go on being damaged as long as they are exposed to excessive noise. The hearing you have left is very precious. There certainly is a point in protecting it.

I won't be able to hear what people are saying if I wear hearing protectors.

Actually, if your hearing is normal the opposite is true. You will find it easier to understand what people are

saying when you wear protectors because your ears are no longer overloaded. The effect is like wearing sunglasses, that is, you can see better when the glare is cut down. If your hearing is already impaired, you may not be able to understand speech better when you wear protectors. Depending on the kind of impairment, you could find it harder to understand speech.

If you have this problem, don't give up the protectors. It's important to protect your remaining hearing. Ask people to speak up, or find another way to communicate. For example, use hand signals or a note pad.

What about noise exposures outside work?

This is an important question. Noise exposures add up, so you need to watch your noise exposure outside work too. Wear hearing protectors if you use power tools like saws, grinders, motor mowers or chainsaws and limit your exposure to very loud music.

If you shoot, wear protectors if you fire anything louder than a .22 rifle. Always wear hearing protectors on indoor firing ranges.

Should I have my hearing checked?

Employers are required to provide regular free hearing checks for their noise-exposed employees. If you are concerned about your hearing, or would like to have regular hearing checks but your employer doesn't have a hearing check programme, ask your family doctor or your local branch of the Occupational Safety and Health Service of the Department of Labour for advice.

MODULE 11: TRAINING AND INFORMATION

THIS MODULE IS FOR Noise manager
Training coordinator.

PURPOSE This module is designed to assist the noise manager gain the support, commitment and participation necessary for an effective noise management programme from the following key groups:

- senior managers;
- production managers, engineers and technicians;
and
- employees and supervisors.

CONTENTS INTRODUCTION
SENIOR MANAGERS
PRODUCTION MANAGERS, ENGINEERS AND
TECHNICIANS
EMPLOYEES AND SUPERVISORS
SESSION 1: NOISE, A MAJOR ISSUE
SESSION 2: NOISE, AN ISSUE IN THIS
ORGANISATION
SESSION 3: IDENTIFYING AND SOLVING NOISE
PROBLEMS
SESSION 4: THE EFFECTIVE USE OF PERSONAL
HEARING PROTECTION
EVALUATION

TRAINING AND INFORMATION

INTRODUCTION A successful noise management programme requires the full support, commitment and participation of managers, engineers and technicians as well as employees and supervisors.

Each of these groups has a special role in ensuring that noise problems are eliminated from the organisation. They have special needs for information and must understand how they can participate in the overall programme. This module provides advice and ideas for achieving effective communication and information sharing with each group.

In addition, OSH's *Management of Noise at Work: Resource Kit* contains resources which can assist this process. These resources include a noise video (produced by Worksafe Australia), a multi-lingual cassette, fact sheets and a booklet with basic information about noise, posters and stickers to identify noisy work areas or machines, and a copy of the publication *List of Graded Hearing Protectors*.

SENIOR MANAGERS A noise management programme will not get off the ground without the financial, resource and personal support of senior managers. This module provides some ideas for achieving management support. It also includes a format for a report to senior management which would enable them to assess, approve and be involved in a noise management programme.

OBJECTIVE **Achieve management commitment to and cooperation in a long-term programme to reduce noise and noise exposure.**

Inform managers about:

- their legal obligations;
- the human and economic costs of noise-induced hearing loss and benefits of effective noise management;
- effective management of noise,

Involve managers in:

- establishing effective policies and mechanisms for the management of noise;
- preparing a forward plan for the control of workplace noise;
- implementing noise control measures.

DEVELOPING A
REPORT FOR
MANAGERS

The outline report *Noise Management Proposal - Organisation "X"*, which is included in this section, provides a handy framework to assist in the preparation of a report or presentation to senior managers or simply document your analysis of the problem and its possible solution. You will find details to assist completing such a report in the Core and other modules of this control guide.

As the initiator of the planning process to reduce noise in your organisation, you will need to design an approach that will ensure that the programme is widely accepted and successfully implemented. Consultation and participation are critical ingredients of the process.

The exact nature of the development process will depend on a range of factors including:

- your position/responsibility/authority in the organisation;
- the size and nature of your business;
- established reporting and consultative procedures;
- the organisational "climate" (for example, employee representative /management relations and communication networks);
- the source of impetus for the programme, for example:
 - a visit from a health and safety inspector;
 - compensation claims for industrial deafness;
 - awareness of senior management of the problem and its costs;
 - the action and enthusiasm of an occupational health and safety (OHS) practitioner (for example, an OHS nurse or hygienist);
 - the undertaking of a noise survey.

Planning a noise management programme requires careful research of the problem and its effects on your organisation.

To adequately address the points raised in the outline, you will need to discuss the problem with a range of workplace personnel and be well acquainted with specific workplace problems. In larger organisations, such a report would ideally be prepared under the aegis of an OHS committee or an especially convened committee representing the major interest groups. As well as ensuring access to the necessary information to compile such a report, this process will foster broader ownership of the programme and facilitate implementation.

Key groups to inform and involve are:

- supervisors and leading hands;
- employee representatives;
- engineering design and production managers and staff;
- purchasing staff;
- maintenance staff,
- occupational health and safety and rehabilitation staff;
- employees.

The level of involvement of each group will depend on the size and nature of the organisation, but all should be informed of the development of the noise management programme.

Other steps you can take to ensure the successful design and implementation of the noise management programme are:

- Address the major concerns relevant to the style and climate of your organisation. For example, in an organisation with an ethos that highly values “looking after” its workforce, highlight the debilitating effects of noise on the company’s employees and in a cost-conscious organisation emphasise the cost or potential cost of noise.
- Involve influential personnel in the development process to maximise the programme’s credibility and assist in the implementation phase.

- Involve your senior managers by accompanying them on a walk through areas to demonstrate and highlight problems that exist on the shop floor.
- Generate an initial interest in the problem of noise before going too far with a detailed proposal (for example, use promotional material such as fact sheets and videos to generate interest).
- Establish an on-going, active role for senior managers in the implementation of the programme by:
 - providing regular progress reports on implementation;
 - involving them in presenting employee education and briefing sessions to demonstrate management commitment and support;
 - obtaining personal endorsement of policies and programmes;
 - encouraging them to wear personal hearing protectors whenever they enter noisy work areas.
- Where possible in the report, use examples from your workplace to illustrate solutions and their benefits and costs.

SAMPLE NOISE
MANAGEMENT
REPORT

Background (Core Step 1 plus Module 10)

What sort of a problem is noise? Include information on:

- the effects of noise;
- how noise can be controlled.

What legislative requirements apply?

Situational Analysis (Core Step 2 plus Modules 1, 2, 6)

How serious a problem is noise in this organisation? Include information on:

- existing noise exposures (noise levels and exposure durations);
- current costs of noise;
- effects on organisation's employees.

What is the organisation currently doing about noise?

Include information on:

- the cost of existing measures;
- the effectiveness of existing measures;
- whether the organisation is complying with legislation.

What are our competitors doing?

What is the attitude of employee representatives, employees, supervisors and managers to this problem?

Possible Action (Core Steps 3, 4, 5 plus Module 6)

What can this organisation do to improve its current action (options)?

What will the options cost?

What benefits will accrue?

What is the attitude (actual or expected) of key players to this initiative (for example employee representatives/production managers/finance staff)?

Proposed Noise Management Strategy (Core Step 3, 4, 5 plus Modules 3, 5, 11, 12)

(This section may not be presented in much detail until a noise survey is conducted and costs are estimated.)

Programme outline

Resource plan and budget

Implementation strategy

Evaluating the effectiveness of the programme

Recommendations

Agree to a tour of the problem areas

Agree to the proposed noise management strategy

Appendix A

Results of walk-through noise assessment (Modules 2, 5)

PRODUCTION MANAGERS, ENGINEERS AND TECHNICIANS

Where noise is a major problem for an organisation, it will be important to ensure that in-house expertise in noise control is available or built up over a period of time. The effective use of consultants can assist with developing and enhancing in-house expertise.

Material in the Core and other modules of this control guide will assist competent engineers and technicians develop and implement noise control measures.

OBJECTIVE **Achieve cooperation, commitment and action to design and purchase quiet machinery.**

Inform technical/production staff about:

- their legal responsibilities;
- the human and economic costs and benefits;
- the organisation's policies and programmes.

Involve the technical/production staff in:

- controlling noise at source;
- implementing "buy quiet" policies;
- effective maintenance.

In addition, this group of employees will need to increase their skill levels in producing engineering controls of noise.

COMMUNICATING
WITH
PRODUCTION
MANAGERS,
ENGINEERS AND
TECHNICIANS

The remainder of this control guide contains information and further references to assist in the engineering control of noise. If your organisation has a number of technical staff who design, commission and maintain plant, a specific training exercise on noise control may be required as a refresher or to put noise control on their agenda.

The best approach is to demonstrate what other organisations have been able to achieve (see *Module 1: Case Studies*) and work through an actual workplace noise problem. *Module 2: Walk-through Audit, Module 3: In-house Control and Module 9: Evaluating Options*, provide an effective basis for problem analysis and discussion. If a comprehensive noise survey has been undertaken, this could assist in deciding where to begin.

It may be necessary to precede the case study with some general information about the organisation's noise management policy and programme and the legislative context. Session 2 "Noise - An Issue in this Organisation", which is outlined later in this module, provides an appropriate format.

**WORKERS
AND
SUPERVISORS**

While the onus for maintaining a safe and healthy workplace is a management responsibility, employees have a right to know the hazards they face and, particularly with appropriate training, can contribute to their identification and control.

The involvement of supervisors and employees in noise control becomes particularly important where the wearing of personal hearing protection is required. In addition, the workforce represents a considerable body of knowledge from which to draw information about noise problems and their control. Employees are more likely to cooperate in effectively using personal hearing protection where they can see that the organisation has a commitment to a long-term programme to reduce noise levels to safe limits and where their contributions to the control of noise at source are being sought and used. Employees should also have a say in priority-setting through representatives on the noise or occupational health and safety committees.

OBJECTIVE

Achieve cooperation and participation of employees in the reduction of noise and noise exposure.

Inform employees about:

- the hazard and its personal effects;
- methods of noise control and hearing protection;
- the organisation's policy and programme to control noise;
- the relevant legislative requirements (that is, employees' rights and obligations).

Involve employees in:

- identifying local noise problems;
- generating possible solutions to noise problems;
- ensuring proposed noise control solutions meet operator requirements for access, control, comfort and productivity;
- the effective use of personal hearing protection.

A proposed series of four sessions which could form the basis of a comprehensive training programme for employees, are outlined below. These outlines can be used in the following ways:

- An in-house person with good communication skills can use them to obtain the detail necessary to prepare and conduct sessions.
- They can form the basis for briefing external consultants to present sessions.
- They can be used as a checklist to see whether your existing training programmes cover the information recommended for employees.
- They can be included in existing in-house training programmes (for example, induction or apprentice training).

Include representatives of the target groups in planning and implementing the training programme (for example, through the OHS committee or a specially designated group).

Planning

Assess the existing level of knowledge of your audience, their attitudes to noise and their interests, then direct the information accordingly.

Avoid relying heavily on one method of communication alone. Use a combination of lecture sessions, written materials, audio-visuals, on-the-job training and posters.

Contact supervisors and production managers well in advance of training to ensure the release of employees to attend sessions.

Request that senior management directly supports attendance of employees where sessions are conducted in normal working hours.

Content and presentation

Make information as directly related to the workplace as possible through the use of local examples and activities.

Draw on the expertise and the influential people, both inside and outside the organisation, to deliver and support key information.

Be aware of community literacy levels and provide information in community languages where required. A variety of services are available to assist in doing this and materials such as multilingual audio-tapes are also useful for this purpose.

Use a participative approach which draws on and utilises the expertise and knowledge of the workforce through, for example, scheduling group discussions and tasks.

NOTE: Be aware that there may be members of your workforce who are already suffering the effects of noise-induced hearing loss. This may be due to exposure to noise in their job with your organisation, a previous job or non-occupational exposures. Ensure you are sensitive to the possibility of emotional responses from sufferers and, prior to conducting these sessions, have a plan which can be explained at the first session for constructively assisting these employees.

SESSION 1: Purpose

NOISE A MAJOR ISSUE To establish the relevance of noise as a workplace problem which can dramatically affect the quality of their lives.

Desirable Outcomes

I understand what noise can do to my family and me.

I want my exposure to noise to be safe.

I am prepared to talk about how noise currently affects me.

I know what to do if I suspect that I am currently suffering from the symptoms of noise-induced hearing loss.

I am interested in learning what this organisation is doing about noise in the workplace.

Contents

1. What it is like to have noise-induced hearing loss:
 - explain and demonstrate the nature of the disability;
 - indicators of hearing loss or risk of hearing loss.
2. Basic physiology of the ear and the effects of noise exposure:
 - effects of noise intensity;
 - exposure duration;
 - effects such as tinnitus, stress and irritation.
3. How common is the problem:
 - national statistical picture;
 - organisation statistics, audiometry results (if available) or anecdotal information;
 - what industries and occupations are most at risk.
4. (GROUP DISCUSSION) The effects of this type of disability on:
 - work activities;
 - relationships with family and friends;
 - recreation (for example, participation in sport, radio, TV and music);
 - use of telephone;

- group activities (for example, parties, meetings and conversations).
5. Access to advice/ counselling/ rehabilitation on noise-induced hearing loss for employees:
- organisation rehabilitation adviser;
 - staff counselling facilities.

Resources

The Noise Video and Fact Sheets in OSH's *Noise Management At Work - Training Resources*.

**SESSION 2:
NOISE, AN
ISSUE IN THIS
ORGANISATION**

Purpose

The purpose of this session is to:

- establish that noise is an important issue in this organisation;
- outline what is being done to manage the problem;
- outline employees' roles in the process.

Desirable Outcomes

I understand what this organisation is doing about noise and its motives for doing this.

I understand who is responsible (specifically) for managing noise in this workplace and I know the policies and procedures that apply.

I understand how I can contribute and am prepared to participate in the management of this problem.

Contents

1. Noise management and the law:
 - relevant sections of the Health and Safety in Employment Act, 1992 (for example, rights and obligations);
 - relevant sections of the Health and Safety in Employment Regulations, 1994 (the noise regulation).
2. Presentation of organisation's noise management policy and procedures, roles and responsibilities.
3. Presentation of plan for management of noise (for example, 3-year plan) including where this training programme for employees "fits".

Resources

The Fact Sheets in OSH's *Management of Noise at Work: Resource Kit* and *Module 8: Case Studies*, of this control guide.

Consider seeking the assistance of a senior manager and a employee representative official to present organisation and employee representative policy and attitude.

**SESSION 3:
IDENTIFYING
AND SOLVING
NOISE
PROBLEMS**

Purpose

To practically involve employees in monitoring and solving noise problems relevant to their work tasks.

Desirable Outcomes

I know the level of risk which I am currently facing in my work.

I understand what could increase the level of risk (for example, changes to current duties or work procedures).

I know what to do if I assess that my exposure to noise significantly worsens.

I know some basic principles about controlling noise at source and will make suggestions if I can see a way to reduce noise levels.

Contents

1. Measuring noise and noise exposure
 - quantitative and qualitative (rule of thumb) examples
(estimate dB(A)'s associated with these common tasks and look what happens as exposure time increases).
2. Noise levels in this organisation
 - presentation of relevant workplace data (if available);
 - conduct walk-through survey with employees (use checklists).
3. Controlling noise exposure
 - engineering control (principles and examples);
 - hearing conservation (outline role of personal hearing protection briefly only, see next session).
4. (GROUP DISCUSSION) Identification of noise hazards and generation of solutions by participants.
 - consider problems identified from walk-through survey or employees' own knowledge/experience.

If you undertake this final part of the session as a problem-solving exercise, ensure that there is a procedure for acting on employees' suggestions, and report back on what has happened as a result. Otherwise false expectations will be raised.

Resources

The video in OSH's *Management of Noise at Work: Resource Kit* and *Module 1: Case Studies* and *Module 2: Walk-through Audit*, of this control guide.

**SESSION 4:
THE EFFECTIVE
USE OF
PERSONAL
PROTECTION**

Purpose

To ensure employees understand the correct selection and use of personal hearing protection.

Desirable Outcomes

I understand that action is happening in the organisation to reduce noise levels so that the need to wear protection is minimised.

I know the type of protection most suitable for my job now.

I know how to obtain, use and maintain it.

I understand that if my job changes, the type of protection may need to change.

I will use protection appropriately.

Contents

1. Types of hearing protectors and their application
2. Choosing and obtaining hearing protectors
3. Fitting and wearing hearing protection

Resources

The video and fact sheets in OSH's *Management of Noise at Work: Resource Kit, Module 10: Fact Sheets*, and *Module 12: Personal Protection*, in this control guide.

Information is available from your hearing protector supplier. Some suppliers may be prepared to provide a speaker for this session.

EVALUATION Evaluation is an important tool that can provide details about the effectiveness of the training and information programmes that have been implemented and assist with future planning.

The evaluation will assess:

- if objectives are being met;
- if resources are being used most effectively.

Evaluation should be a straightforward and uncomplicated exercise and need not require too many resources.

Where findings demonstrate the effectiveness of the training programme, and where participants have become more actively involved in the noise management programme, the results can be used to support the case for the continuation of the programme and allocation of resources.

EVALUATION
OUTLINE The following outline may assist you structure your evaluation.

1. Describe the programme.
2. List objectives (Sample objectives for the three categories of employees are provided in this module).
3. Measure appropriateness by considering:
 - Whether the programme adequately addressed the needs of the participants and what their responses were to it.
 - Whether management responded positively to the recommendations in the report.
4. Measure effectiveness by assessing:
 - The extent to which the training programme met its objectives.
 - The extent to which the programme contributed to noise management.
5. Measure efficiency by considering whether the programme made the best possible use of resources.

6. Report back to management and participants on evaluation findings.
7. Incorporate appropriate changes to programme.

METHODS OF
COLLECTING
DATA

A range of methods exist to collect the data necessary to evaluate your programme. Some methods are outlined below.

<i>Method</i>	<i>What is recorded</i>	<i>Example</i>
Observation/ checklist	Behaviour	Has NIHL appeared on the management agenda?
Knowledge test	Knowledge and understanding	Has knowledge of legislative requirements of employers' responsibilities been raised?
Performance test	Specific skill/ability	Are personal hearing protectors being correctly fitted?
Interview/ questionnaire/ group interview/ discussions	Opinions/experiences	What are participants' opinions about the programme?
Record analysis	Changes in the occurrence of an event	Has the programme resulted in changes to occurrence of NIHL?

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.

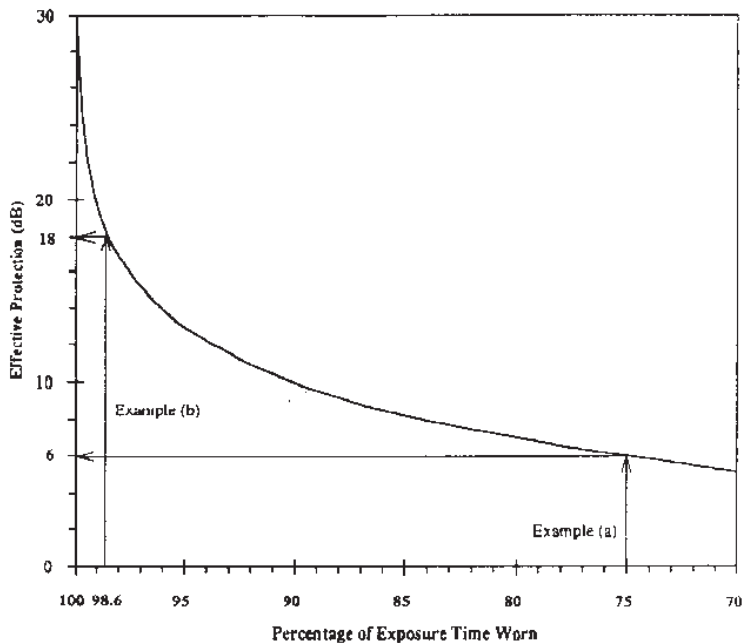
ACCEPTABILITY
TO THE
WEARER

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.