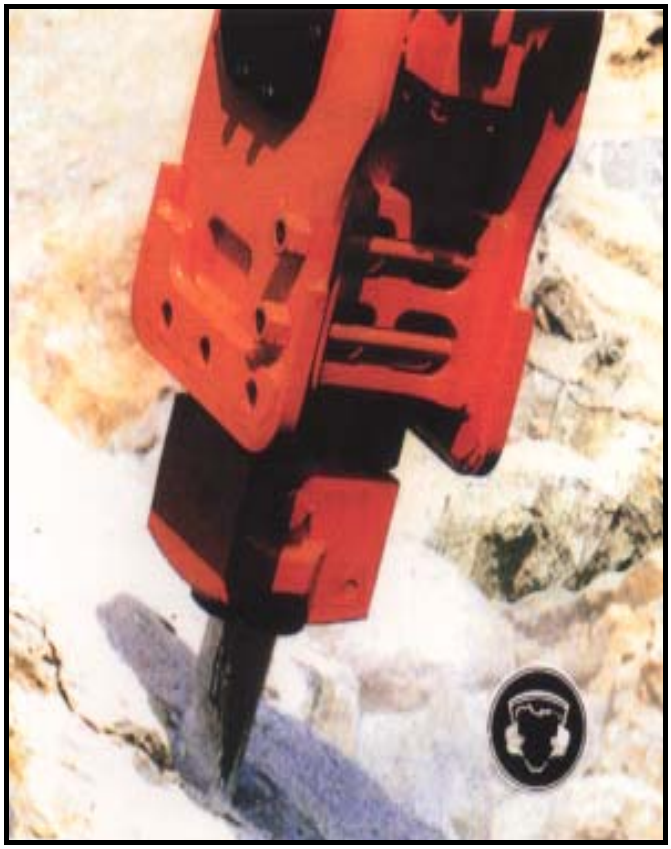
MinEx Health & Safety Council

GUIDELINES FOR NOISE CONTROL IN MINES QUARRIES AND TUNNELS



Updated March 2008

For Review in 2010

CONTENTS

ACKNOWLEDGEMENT **3**

1.0 INTRODUCTION **3**

2.0 NOISE MEASUREMENT **3**

3.0 ASSESSING NOISE HAZARDS **4**

4.0 NOISE CONTROL PRINCIPLES **5**

5.0 NOISE CONTROL - ADMINISTRATIVE CONTROLS **6**

6.0 NOISE CONTROL – ENGINEERING CONTROLS **7**

7.0 NOISE CONTROL – HEARING PROTECTION **7**

8.0 NOISE CONTROL – METHODS FOR SPECIFIC AREAS **8**

APPENDIX 1: HSE REGULATIONS 1995, REGULATION 11 – NOISE. **11**

APPENDIX 2: REFERENCES **12**

APPENDIX 3: PRELIMINARY NOISE SURVEY CHECKLIST **13**

ACKNOWLEDGEMENT

MinEx would like to thank those who have contributed to the development and review of this guideline. Special acknowledgement is given to Department of Labour (Workplace), Mines and General Inspectorate, who have allowed their original material to be used as the basis of this publication.

1.0 INTRODUCTION

A. This is a practical guide for the mining, quarrying, and tunnelling industry to understand and control noise hazards to prevent noise induced hearing loss (NIHL).

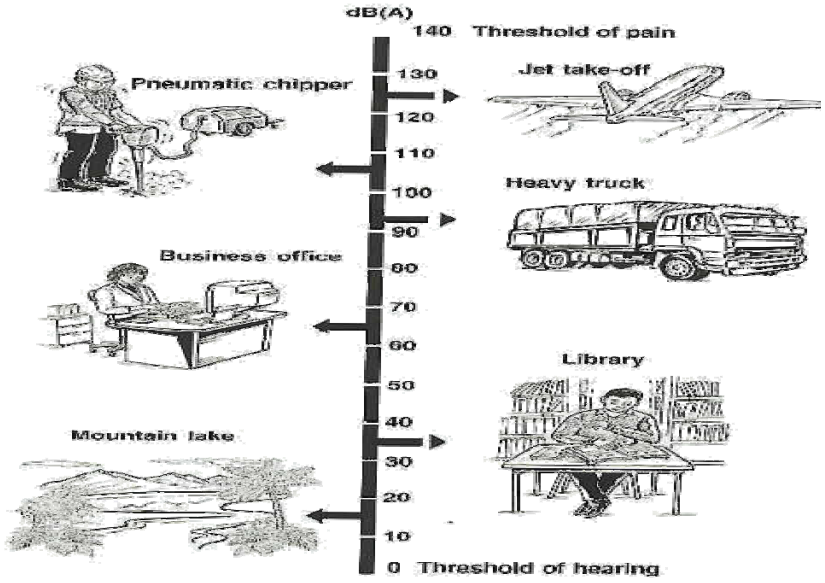
B. Noise is generally described as unwanted sound, but in the context of hazard management, it is sound at a level or intensity that has the potential to permanently damage a person's hearing.

C. It is well established that exposure to high noise levels causes hearing loss and the resulting damage to the inner ear can never be repaired. In addition to causing hearing loss, high noise environments can increase the potential for accidents when warning signals are masked and important communications interfered with. Noise is also annoying, stressful and causes fatigue.

2.0 NOISE MEASUREMENT

A. The range of human hearing is so great that noise levels cannot be conveniently represented on a linear scale and so a logarithmic unit; the decibel (dB) is used. The following figure shows some decibel levels of common sound.

Figure 1: Decibel levels of typical noise



B. Because hearing sensitivity varies with the frequency of sound received, meters used for sound measurement incorporate filters that give a similar frequency response to the human ear. The resultant readings are expressed as "A"-weighted decibels -dB(A).

C. An increase of 10 dB is perceived by the human ear as doubling in loudness but it is actually a tenfold increase in the sound pressure level.

Continuous Noise Level: LAeq, T

D. The risk of damage to a person's hearing is determined, not only by sound intensity but also by the length of exposure time. This means it is the total amount of sound energy received at the ear that determines how damaging the noise will be.

E. Where noise intensity fluctuates widely, it can be represented by an average known as the Equivalent Continuous Level (LAeq). The equivalent continuous noise level has the same acoustic energy as the original (A weighted) fluctuating levels, over the same period of time (T).

F. For every 3 dB(A) increase in measured sound level (doubling of the sound energy) the personal exposure time must be halved. This is illustrated in table 1.

Table 1: The effect on dBA when doubling sound energy

Noise level (dB(A))	Maximum daily exposure	Noise level (dB(A))	Maximum daily exposure
85	8 hour	97	30 min
88	4 hour	100	15 min
91	2 hour	103	8 min
94	1 hour	106	4 min

G. Noise Dose

a. Noise exposure can be referred to in terms of dose. Exposure to 85 dB(A) for 8 hours is a 100% dose, as is, for example 94 dB(A) for 1 hour. An 88 dB(A) noise level experienced for 8 hours is a 200 % dose and so on. *The Health and Safety in Employment Regulations* (see Appendix1) require the general occupational noise exposure not to exceed the equivalent of 85 dB(A) over 8 hours (LAeq, 8 hours of 85 dB(A)).

H. Peak Sound Levels

b. A peak sound level of 150 dB will instantaneously damage the human ear, and 140 dB will cause damage over a very brief time period. Because of this, noise regulations include a maximum peak level of 140 dB - (L peak), which should never be exceeded.

3.0 ASSESSING NOISE HAZARDS

A. In any workplace the potential hazard of noise can be evaluated by conducting surveys.

a. **Preliminary Surveys -** Identify areas in a place of work where noise levels are likely to, or actually exceed the exposure limits. A "Preliminary noise survey checklist" can be found in Appendix 3 of this Guideline.

b. **Detailed Surveys -** Provide an assessment of the noise environment, establishing whether or not the workplace exceeds the exposure limits. A detailed assessment is required:

i. Where complex noise sources are present.

ii. If there is doubt about whether the noise levels exceed the exposure limits: or

iii. If there is any reason to believe, (such as from preliminary assessment results), that noise levels are, or may exceed the exposure limits.

B. Detailed assessments will provide information that will:

a. Quantify the amount of noise to which employees are exposed:

b. Help identify sources of noise;

c. Assist in developing noise control strategies; and

d. Determine appropriate hearing protector needs.

C. Full noise surveys make use of very sophisticated instruments and specialist, competent person (defined in the ACOP) are required to carry out the measurements and to interpret the data.

D. Noise control options are based around: administration controls, engineering controls and provision of hearing protection. However it is important to firstly understand the principles of noise control.

4.0 NOISE CONTROL PRINCIPLES

A. Generation, Transmission and Reception

a. Before steps are taken to develop noise control solutions, the problem should be analysed in terms of; the source of the noise, the pathway of transmission and the receivers being exposed.

Figure 1: Diagram showing the source, path and receiver elements of a noise problem

B. **Identify the Source** - Frequently, a single piece of mining equipment will combine several individual sources of noise.

C. **Determine the Transmission Pathways** - Sound can be propagated over long distances through structures and noise from individual sources may reach the receiver through different pathways.

D. **Consider the Receivers -** Consider options on the amount of exposure to the noise rather than the noise itself

E. **Distance Considerations -** Sound, which propagates from a point source in free air, attenuates (reduces by) 6 dB for each doubling of the distance from the source. Sound propagating in an enclosed space is attenuated less than this value, because of contributions to the sound level brought about by reflection from walls and ceilings.

F. **Addition of Noise from Several Sources** - Noises from different sources combine to produce a sound level higher than that from any individual source. Two equally intense sources operating together produce a sound level that is 3 dB higher than one alone. Note that decibels cannot be directly added, as they are logarithmic values.

G. **Sound Insulation** - When a sound meets a wall or partition, only a small proportion of the sound energy passes through as most is reflected.

H. **Sound Absorption** - Sound energy is absorbed whenever it meets a porous material. Porous materials that are intended to absorb sound are called sound absorbents and they absorb between 50 to 90% of the incident sound energy.

5.0 NOISE CONTROL - ADMINISTRATIVE CONTROLS

A. Administrative controls may include the following:

   a. Avoiding purchasing hazards by adopting a "buy quiet" policy, there is a growing demand for quieter plant and manufacturers are responding to this.

   b. Establishment of job procedures that will reduce employee exposure e.g. Job Rotation.

   c. Planned plant maintenance specifically for noise control.

   d. Setting targets for noise levels in existing work areas.

   e. Cover off noise management in employee induction and training.

   f. Cover off noise control in work agreements with contractors.

   g. Protection of visitors on site.

   h. Monitoring employees by initial audiogram and regular repeats.

   i. The use of warning signs.

   j. The use of hearing protection related to designated hearing protection areas.

6.0 NOISE CONTROL – ENGINEERING CONTROLS

A. When attempting to attenuate noise, bear in mind that noise radiates from most machinery as both airborne and as structure-borne sound at the same time.

B. **Enclosure of Machines -** Where it is not possible to prevent or reduce the noise at its source, it may be necessary to enclose the entire machine. A relatively simple sealed enclosure can reduce noise by 15 to 20 dB(A). e.g. Figure 4.

C. **Attenuation of Structure-Borne Sound -** Preventing transmission of vibration from machines to the load-bearing structure can considerably reduce structure-borne sound:

   a. Large heavy machines should be mounted on foundations which are completely separated from buildings or other structures

   b. Place other machines on a stable foundation and where possible use an elastic separation such as rubber blocks or steel springs.

D. Severely vibrating machines may require separate foundations and isolation joints between floor slabs to prevent propagation of structure-borne noise.

E. **Attenuation by Using Absorbents -** Hard surfaces on the ceiling, floor and walls of an enclosed processing plant or workshop will reflect back nearly all the sound reaching them.

F. **Sound Insulated Rooms** - Cabins should be constructed of materials with good sound attenuation properties and ideally will have:

   a. Double glazed windows - (two 6 mm glass panes with 50 mm air space can give 10 dB(A) attenuation).

   b. Good seals on doors and windows pipe and cable cut-outs filled with an acoustic sealant (with allowances for expansion and contraction).

   c. Ventilation openings with attenuators such as acoustic louvers.

   d. An adequate air conditioning system, to avoid doors being left open, e.g. Figure 6 use of sound absorbing material may vary within a building.

7.0 NOISE CONTROL – HEARING PROTECTION

A. Hearing protection is not an acceptable alternative to noise control – but there are circumstances where this is likely to be the only option.

B. As part of a hearing protection programme, employers need to consider:

   a. The need for hearing protectors;

   b. Defining hearing protector areas;

   c. Selection of hearing protectors

   d. The issuing of hearing protection to individuals;

   e. Cleaning, maintenance and replacement of hearing protectors;

   f. Training and education of people wearing hearing protectors.

Table 2: The grade of protection to be used in 5 categories of noise environment.

Class	Noise level $L_{Aeq,8h}$	Hearing protection type
1	<90	Earplugs or earmuffs
2	90 < 95	Earplugs or earmuffs
3	95 < 100	Earplugs or earmuffs
4	100 < 105	Earplugs or earmuffs
5	105 < 110	Earplugs or earmuffs

C. Proper procedures for the selection, use, storage and maintenance of hearing protectors should be put in place and enforced.

8.0 NOISE CONTROL – METHODS FOR SPECIFIC AREAS

8.1 Blasting

A. Blasting noise is of very short duration and, depending on the distances involved, can reach the peak action level of 140 dB. Noise reduction is achieved by:

   a. Use of in-hole detonators for initiation

   b. Adequate burden and stemming

   c. Avoidance of detonating cord trunklines

   d. Use of adequate cover on any surface explosives including detonators

   e. Keeping people at safe distance

   f. Avoid blasting in adverse weather conditions (temperature inversion)

   g. Use of bunds or other acoustic barriers

B. Note, warning sirens and hooters should not be unduly loud.

C. With secondary breaking, unconfined plasters shots cause the greatest problems and often lead to complaints on environmental grounds. Small diameter hole 'pop shots' are better but mechanical secondary breakage is definitely preferable. Figure 7 shows some factors that contribute to air blast.

D. Drilling - The two main types of drill rigs in use are drifters and down-the-hole hammer machines, usually powered by compressed air or hydraulic motors.

E. Compressed air-operated drifters are particularly noisy and the reciprocating hammer and rotation motor are situated on the mast near the controls. Noise levels in excess of 110 dB(A) have been measured at the operator position.

F. With down-the-hole machines, the hammer is located above the drill bit and is inside the hole for most of the drilling cycle. Initial penetration will still expose the operator to high noise levels.

G. Consider the following controls:

   a. The use of down hole hammer machines with hydraulic drive motors

   b. Silencers fitted to the pneumatic exhausts

c. Piping pneumatic exhaust to a remote position

d. Operator control cabins can keep noise levels below 85 dB(A) as well as providing protection from dust.

H. Hand-operated compressed air drills generate noise by the action of the motor, hammer and air vent. Modern jackhammers have mufflers on the machine body and many of the older types of machine can be retrospectively fitted.

I. Underground roof bolting machines generate high noise levels that can be significantly reduced by fitting pneumatic exhaust silencers. The noise reduction method can cause some loss of efficiency and discussion with the supplier is recommended.

8.2 Compressors

A. Diesel-powered compressors, either mounted on the drilling unit or on a wheeled trailer, are often used with pneumatic drills. Trailer units can be located away from the drill but the noise will still contribute to the driller's exposure.

B. Make sure silencers are kept in good order and that all acoustic covers and doors are well maintained and kept closed.

8.3 Excavators, wheel loaders and dump trucks

A. On new machines, cabin noise levels are not normally a problem. Insulation around engines and fans greatly reduces noise and sound-proofing of the cab can keep operator exposure well below 85 dB(A). The benefits of soundproofing will be lost if windows and doors are not kept closed and low noise output air-conditioning units might be needed.

B. Retrofitting can be worthwhile but it is seldom easy. The following features will improve operator protection:

a. Anti-vibration mountings

b. Vibration damped panels

c. Acoustic lining of the cab

d. Low noise fans

e. Air intake silencers

f. An efficient exhaust silencer, placed away from the operator position.

C. Noise from back-up alarms can be minimised by using laser-activated units. Alternatively, use strobe lights.

8.3 Crushing and milling

A. The heavy components and the high-energy environment of crushing and milling machines inevitably result in excessive noise. The following will help:

a. Foundations which completely separate the machine from other structures

b. Synthetic chute linings

c. Acoustic curtains

d. Stone boxes

B. In many situations, compliance with the prescribed maximum exposure will only be achieved by housing the operator in a sound-insulated control cabin, which may be situated some distance away if closed-circuit television is used.

8.4 Screening

A. The use of synthetic screen mats in place of metal plate or woven wire has great noise reduction benefits. Other systems include synthetic chute linings and partial or even full enclosure of the units.

B. If a screening plant is completely enclosed, personnel should only be allowed to enter using suitable hearing protection and noise warning signs should be posted.

8.5 Feeders and Conveying

A. Well-maintained belt conveyors are not normally a problem, but noise is often generated at the loading and discharge areas. Generally the larger the product, the greater the problem. Control measures include:

   a. Reducing impact noise by keeping some material in bins and hoppers when operating

   b. Reducing the drop height

   c. Using stone baffles and chute linings

   d. Using spiral chutes or lined cascade towers for longer falls

   e. Maintaining the conveyor idlers to minimise squeal.

8.6 Underground Ventilation

A. The main source of high noise levels is from auxiliary fans that typically produce 90 to 110 dB(A) and are usually suspended in tunnels close to ear level. The noise stems from the motor and from air turbulence, mainly at the intake end. Vibration transmitted from the fan housing to the duct and the suspension system radiates as noise.

B. Air intakes may be fitted with silencers containing synthetic fibre sound absorption material, reducing noise by as much as 11 dB(A). However, this is at the expense of some loss of fan performance. Consultation with the fan suppliers is recommended.

8.7 Roads

A. The noise generated by vehicles on roads can be minimised by:

   a. good maintenance of vehicles used on the road,

   b. good maintenance of the road (the better the road, the less noise), and

   c. good control of the speed of vehicles.

   d. low gradients on haul road near workplaces

APPENDIX 1: HSE REGULATIONS 1995, REGULATION 11 – NOISE.

A. Every employer shall take all practicable steps to ensure, in relation to every place of work under the control of that employer, that no employee is exposed to noise above the following levels:

   a. A noise exposure level, $L_{Aeq,8h}$, of 85 dB(A); and

   b. A peak noise level, Lpeak, of 140 dB-,

   Whether or not the employee is wearing a personal hearing protection device.

B. For the purposes of subclause (1) of this regulation

   a. The noise exposure level, $L_{Aeq,8h}$, is the level of the daily noise exposure normalised to a nominal 8 hour day, in dB(A) referenced to 20 micropascals; that is to say, it is the steady noise level that would, in the course of an eight hour period, cause the same A-frequency-weighted sound energy as that due to the actual noise over the actual working day; and

   b. The peak noise level, Lpeak is the highest frequency-unweighted peak sound pressure level in the place of work in decibels referenced to 20 micropascals, measured using sound measuring equipment with "P" time-weighting, as specified in the Australian Standard numbered AS 1259.1-1990 and entitled "Sound level meters Part 1: Non integrating"; and

   c. The levels of noise referred to in subclause (1) of this regulation shall be measured and assessed in accordance with the Australian Standard numbered AS 1269-1989 and entitled "Acoustics hearing conservation".

C. Where an employer has taken all practicable steps to ensure that no employee at any place of work under the control of that employer is exposed to noise above the levels specified in subclause (1) of this regulation but has not eliminated the risk that any employee may be exposed to noise above those levels, the employer shall communicate clearly, by way of signs, labelling of machinery or other appropriate means

   a. The fact that noise levels at the place of work are or are likely to be hazardous; and

   b. The sort of personal hearing protection device that is suitable to protect against the noise levels; and

   c. Where such a device may be obtained.

APPENDIX 2: REFERENCES

A. *Approved Code of Practice for the Management of Noise in the Workplace.* Department of Labour, Occupational Safety and Health Service. Revised October 2002

B. Health and Safety in Employment Act 1992.

C. Health and Safety in Employment Regulations 1995.

D. AS/NZS1269.

E. Summary of Noise Controls for Mining Machinery, US Department of Labor, Mine Safety and Health Administration. www.msha.gov

F. Safe and Efficient Blasting in Quarries, Orica Quarry Services

G. Noise Reduction, http://www.boscoitalia.it/english/cabine.html

H. Soundproofing materials, http://www.soundservice.co.uk/soundhavens.htm

APPENDIX 3: PRELIMINARY NOISE SURVEY CHECKLIST

Date: ___ / ___ / ___
Assessed by: . . . . . Position: . . . . . .
Location of assessment: . . . . . .

NOTE
• The existence of any one of the following key factors indicates the need for further asssessment (see Part 4 of this code).
• Some employers may not have enough information to answer questions 7 and 8.

1 Is there difficulty in communication between two people at 1 metre distance? (Difficulty means that the speaker must raise his/her voice, or that the listener may not understand what is said.)
Yes ✎ No ✎

2 Do employees in the area notice a reduction in hearing over the course of the day? (This reduction might not be noticed until after work.)
Yes ✎ No ✎

3 Do employees experience ringing in the ears (tinnitus) or blurred/dull hearing?
Yes ✎ No ✎

4 Are hearing protectors being used?
Yes ✎ No ✎

5 Are signs posted at the entrance to or in the work area indicating that hearing protectors should be worn?
Yes ✎ No ✎

6 Does noise in any part of the workplace sound as loud as or louder than 85 dB(A) using the scale in Figure 2 below.
Yes ✎ No ✎

7 Do results of past noise measurements or assessments indicate noise levels equal or greater than any of the following?:
(a) 85 dB(A) "Slow" or Fast" response;
Yes ✎ No ✎
(b) 85 dB(A) $L_{Aeq,T}$
(See Note 1) (or L_{eq})
Yes ✎ No ✎
(c) 80 dB(A) Sound Power Level
Yes ✎ No ✎

8 Does any equipment have noise information including labels that indicate noise levels equal to or greater than any of the following?
(a) 80 dB(A) L_{Aeq},T (or L_{eq})
Yes ✎ No ✎
(b) 130 dB Peak (unweighted)
Yes ✎ No ✎
(c) 80 dB(A) Sound Power level (See Note 2)
Yes ✎ No ✎

9 Do the results of the audiometry indicate that any past or present employees have a hearing loss due to noise?
Yes ✎ No ✎

10 Have there been any industrial deafness claims?
Yes ✎ ☠☐ ✎

Notes:
1. For a variety of reasons, the $L_{Aeq, T}$ quoted may underestimate noise levels that actually result.
2. Sound Power Level is not a noise level. For example, under some circumstances equipment generating a sound power level of 80 dB(A) may result in a noise level of 85 dB(A) or higher.