



Physical Hazards: Noise & Vibration

Core Body of Knowledge for the
Generalist OHS Professional



Safety Institute
of Australia Ltd



Australian OHS Education
Accreditation Board

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The OHS Body of Knowledge for Generalist OHS Professionals has been developed under the auspices of the **Health and Safety Professionals Alliance**



The Technical Panel established by the Health and Safety Professionals Alliance (HaSPA) was responsible for developing the conceptual framework of the OHS Body of Knowledge and for selecting contributing authors and peer-reviewers. The Technical Panel comprised representatives from:



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The Safety Institute of Australia supported the development of the OHS Body of Knowledge and will be providing ongoing support for the dissemination of the OHS Body of Knowledge and for the maintenance and further development of the Body of Knowledge through the Australian OHS Education Accreditation Board which is auspiced by the Safety Institute of Australia.



Synopsis of the OHS Body of Knowledge

Background

A defined body of knowledge is required as a basis for professional certification and for accreditation of education programs giving entry to a profession. The lack of such a body of knowledge for OHS professionals was identified in reviews of OHS legislation and OHS education in Australia. After a 2009 scoping study, WorkSafe Victoria provided funding to support a national project to develop and implement a core body of knowledge for generalist OHS professionals in Australia.

Development

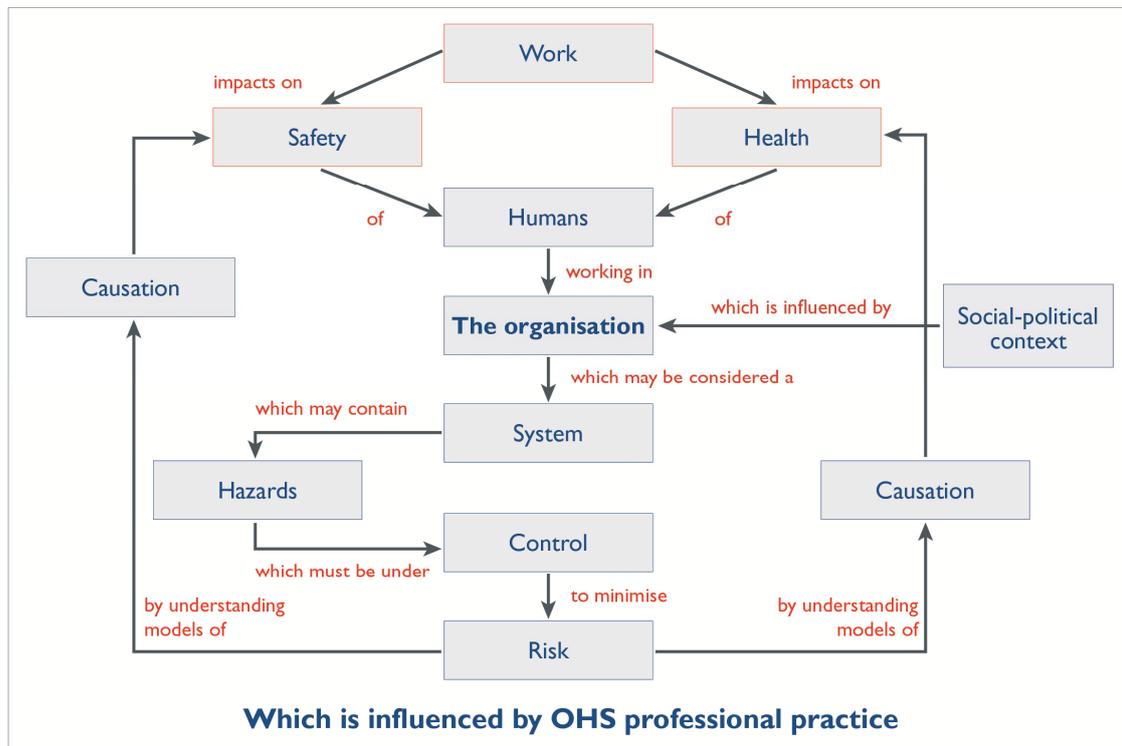
The process of developing and structuring the main content of this document was managed by a Technical Panel with representation from Victorian universities that teach OHS and from the Safety Institute of Australia, which is the main professional body for generalist OHS professionals in Australia. The Panel developed an initial conceptual framework which was then amended in accord with feedback received from OHS tertiary-level educators throughout Australia and the wider OHS profession. Specialist authors were invited to contribute chapters, which were then subjected to peer review and editing. It is anticipated that the resultant OHS Body of Knowledge will in future be regularly amended and updated as people use it and as the evidence base expands.

Conceptual structure

The OHS Body of Knowledge takes a conceptual approach. As concepts are abstract, the OHS professional needs to organise the concepts into a framework in order to solve a problem. The overall framework used to structure the OHS Body of Knowledge is that:

Work impacts on the **safety** and **health** of humans who work in **organisations**. Organisations are influenced by the **socio-political context**. Organisations may be considered a **system** which may contain **hazards** which must be under control to minimise **risk**. This can be achieved by understanding **models causation** for safety and for health which will result in improvement in the safety and health of people at work. The OHS professional applies **professional practice** to influence the organisation to being about this improvement.

This can be represented as:



Audience

The OHS Body of Knowledge provides a basis for accreditation of OHS professional education programs and certification of individual OHS professionals. It provides guidance for OHS educators in course development, and for OHS professionals and professional bodies in developing continuing professional development activities. Also, OHS regulators, employers and recruiters may find it useful for benchmarking OHS professional practice.

Application

Importantly, the OHS Body of Knowledge is neither a textbook nor a curriculum; rather it describes the key concepts, core theories and related evidence that should be shared by Australian generalist OHS professionals. This knowledge will be gained through a combination of education and experience.

Accessing and using the OHS Body of Knowledge for generalist OHS professionals

The OHS Body of Knowledge is published electronically. Each chapter can be downloaded separately. However users are advised to read the Introduction, which provides background to the information in individual chapters. They should also note the copyright requirements and the disclaimer before using or acting on the information.

Physical Hazards: Noise and Vibration

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**Core Body of
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Physical Hazards: Noise and Vibration

Abstract

Noise and vibration are closely linked in that noise originates from a vibrating body and both noise and vibration have similar physics as they are transmitted as waves through a medium. The health impacts of noise hazards are well recognised with noise-induced hearing loss identified as a priority work-related disease for Australian workers. Although noise-related legislation focusing on reduction at source has existed for many years, provision of hearing protectors is still the predominant control strategy in many workplaces. In contrast, there is no regulation of vibration hazards in Australian workplaces and these hazards are not well recognised. While the health impacts of noise and vibration differ, the controls are similar, particularly with respect to elimination and engineering. This chapter discusses the concept of noise and vibration as hazards and their effects on individuals. It provides a basic understanding of acoustics and the factors that impact on hearing loss together with the principles of noise measurement and control. Similarly, it looks briefly at the health impacts of vibration, measurement of vibration and general controls. It concludes with an examination of the role of the generalist OHS professional in the management of noise and vibration hazards.

Keywords

noise, vibration, hearing loss, audiometry, control

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1 Introduction

The terms noise and vibration are often linked as in, for example, noise and vibration engineering. This is because exposure to vibration is usually associated with exposure to noise, and the physics of vibration and noise are similar. While the specific health effects of exposure to noise are different to those arising from exposure to vibration, they are both insidious and can manifest after a long period of latency. The health effects of noise and vibration should be taken seriously by their creators as part of their business activities. Management of noise and vibration hazards is a specialist area with advice able to be sourced from noise and vibration engineers, occupational hygienists and audiologists. This chapter deals with noise and vibration from the perspective of the generalist OHS professional and so addresses the basic knowledge required to understand, identify, assess and control noise and vibration hazards in the workplace and to engage with the appropriate specialists.

1.1 Definitions

Noise has been defined in several ways. The draft *Code of Practice: Managing Noise and Preventing Hearing Loss at Work* (Safe Work Australia, 2010a, p. 5) under the national model Work Health and Safety legislation defines noise as “any sound that is potentially harmful to the health or safety of a person,” which is the definition used by regulators. *AS/NZS Occupational Noise Management: Overview and General Requirements* (SA/SNZ, 2005) defines noise as “all sound (in the workplace), whether wanted or unwanted.” However, neither of these definitions acknowledges the damaging effects on people’s health associated with noise occurring from exposure at work, in the community or both. The World Health Organization (WHO) describes the distinction between occupational and environmental noise:

Noise is present in every human activity, and when assessing its impact on human well-being it is usually classified either as occupational noise (i.e. noise in the workplace), or as environmental noise, which includes noise in all other settings, whether at the community, residential, or domestic level (e.g. traffic, playgrounds, sports, music) (Concha-Barrientos, Campbell-Lendrum & Steenland, 2004, p. 1).

This chapter concerns occupational noise.

Vibration refers to the “oscillatory motions of solid bodies [and] arises from mechanical sources with which humans have physical contact” (McPhee, Foster & Long, 2009, p. 6). Comcare (2008) describes two main types of vibration exposure: “whole body vibration” where the body is shaken by a machine or vehicle and “hand-arm vibration” where the vibration effect is localised to the hand and arm. According to Seidel and Griffin (1998, p. 50.1), “Occupational exposures to whole-body vibration mainly occur in transport but also in association with some industrial processes.” Generally, exposures to hand-arm vibration are associated with “vibration of hand-held tools and workpieces” (Griffin, 2004, p.387).

2. Historical context

2.1 Occupational noise

The problem of noise affecting health and hearing has been recognised throughout history. Probably the earliest notation is attributable to Pliny the Elder (236/79AD) *Naturalis Historiæ* (*Natural History*), which referred to the noise of the falling water in the Nile cataracts and its ill effects on the hearing of the local inhabitants (NIOSH, 1988; Rosen, 1974). In ancient Rome, carts were banned from cities at night as their wheels made too much noise on the cobblestoned streets (Berglund, Lindvall & Schwela, 1999). Bernardo Ramazzini (1633–1714) described the hearing impairment of coppersmiths in *De Morbis Artificum Diatriba* (*Diseases of Workers*) (Rosen, 1974). With the onset of the industrial revolution, the incidence of noise-induced hearing loss increased; works by Thomas Barr (1886) on hearing loss in Scottish boilermakers, and Gottstein and Kayser (1881) on German personnel in railway works, were landmark studies in the development of our modern day understanding of occupational noise-induced hearing loss (Atherley & Noble, 1985). Georg von Békésy (1899–1972) discovered the travelling wave by which sound is analysed and communicated in the cochlea, and for which he received a Nobel Prize in 1961 (see PBRC, n.d.).

Since the early part of the 20th century, much research has been conducted into the relationship between noise exposure and hearing loss. Notably, in 1970, Burns and Robinson proposed the concept of immission, which is based on the equal-energy hypothesis, to describe the total energy from a worker's exposure to continuous noise over a period of time (i.e. months or years) (NIOSH, 1998). The equal-energy hypothesis, which states that equal amounts of sound energy will produce equal amounts of hearing impairment, regardless of how the sound energy is distributed in time, formed the basis for the US National Institute for Occupational Safety and Health recommendation for a 3-dB exchange rate (for a 3-dB increase in noise level the exposure time must be halved to maintain the acoustic energy balance concept) (NIOSH, 1998). This concept was adopted in *ISO 1999 Acoustics – Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment* (ISO, 1990). The 3dB equal energy concept has been adopted in Australian Standard 1269 for several decades now and is again used in the current 2005 edition of the AS/NZS 1269 series, 'Occupational noise management' (SA/SNZ, 2005a). Modern noise regulations use the equal energy concept as related to the normalised 8-hour shift.

2.2 Vibration

Wasserman and Reynolds (2006, p. 3) noted that the earliest diagnosis of symptoms of vibration was made in 1862 by French physician Dr Maurice Raynaud, who described:

í a debilitating condition of the fingers and hands of several of his female-housewife patients that was characterized by tingling and/or numbness followed by painful, cold-triggered, episodic finger blanching attacks of one or more fingers.

While Professor Giovanni Loriga described these Raynaud-type symptoms (vascular spasm or white fingers) in the hands of miners using pneumatic tools in Italy in 1911, the first comprehensive medical study of vibrating pneumatic tools was conducted in 1918 by Dr Alice Hamilton (*A study of spastic anemia in the hands of stonecutters: An effect of the air-hammer on the hands of stonecutters*) (as cited in Wasserman & Reynolds, 2006). Devised in 1968 and published in 1975, the Taylor-Pelmear scale allowed assessment of the severity of vibration white finger; despite widespread international use of this scale, difficulties were experienced in objectively assessing the disease as climatic conditions varied in different countries and sufferers could influence the frequency and severity of attacks through administrative controls such as avoiding cold, wearing gloves and warmer clothing or changing work away from vibration exposure (Taylor, 1988). A more objective system for grading the disease was proposed and accepted at the *Symptomatology and Diagnostic Methods in the Hand-Arm Vibration Syndrome* workshop held in Stockholm in 1986 (e.g. Griffin, 2006; IIAC, 1995). The Stockholm Workshop Scales were adopted in 1987 and accommodate the possibility that peripheral, vascular and neurological disturbances can develop independently by providing separate classifications for the vascular and sensorineural stages of the disease (e.g. CCOHS, 2008; Griffin, 2006, Gemne et al, 1987). However, it does not consider the effects from domestic and hobby activities (Groothoff, 2007). This system is still in use for the diagnosis of the various stages of hand arm vibration syndrome.

In 1990, Griffin published *The Handbook of Vibration*, which explored the many human responses to whole-body and hand-transmitted vibration. In the last three decades, significant research evidence has associated occupational whole-body vibration with spinal system health effects (e.g. Bovenzi & Hulshof, 1998; Wikström, Kjellberg & Landström, 1994). The reported effects on the spinal system are however only part of the problem with whole body vibration as other parts of the body are affected depending on the work environment, the dominant frequencies of the vibration exposure, and the ability to change postures during the exposure period (Groothoff, 2007). In general, the main effects are:

- Problems in the digestive systems
- Variations in blood pressure - leading to heart problems
- Faults in the vestibular system of the ear
- Fatigue, general reduced efficiency
- Motion sickness, affects the balancing mechanism in the ears, leading to general malaise
- Problems in the reproductive systems and may affect pregnancy (Lidström, 1990, Pelmear, 1990, Griffin, 1996, Joubert, 2004).

3 Extent of the problem

3.1 Noise

In 2007–8, there were 4000 claims for occupational noise-induced hearing loss (ONIHL) at a median cost of \$11,200 per claim (Safe Work Australia, 2009). However, due to the long latency and cumulative effect of ONIHL, workers' compensation claims do not give a true indication of the health impact. In 2008, the Australian Safety and Compensation Council declared ONIHL to be one of eight priority diseases that must be addressed by regulators and industry (ASCC, 2008a). The report *Work-related Noise Induced Hearing Loss in Australia* (ASCC, 2006) estimated that about 1 million employees in Australia were exposed to hazardous levels of noise (in the absence of hearing protection), accounting for about 16% of adult-onset hearing loss. The occupational groups most affected were blue-collar workers such as labourers, tradespersons, and plant or machine operators. The 2003 Australian Bureau of Statistics' *Survey of Disability, Ageing and Carers* revealed that people with hearing loss were less likely to be found in highly skilled jobs and were overrepresented among low-income earners (Hogan, O'Loughlin, Miller & Kendig, 2009).

3.2 Vibration

In Australia, vibration exposure is one of the most overlooked health hazards with a very low level of risk assessment. Currently, there is no clear picture as to how many workers are likely to be exposed to levels of vibration with the potential to harm. However, the 2008 *National Hazard Exposure Worker Surveillance* (ASCC, 2008b) survey, which collected self-reported information via telephone interviews of 4500 people,¹ found that:

- Approximately 24% of Australian workers were exposed to vibration in their workplace.
- Young workers were more likely to report vibration exposure than older workers [however, more claims for vibration-related conditions were made by older workers].
- The industries where workers had the highest likelihood of reporting exposure to vibration were Agriculture, forestry and fishing, Transport and storage and Construction.
- The occupations in which workers had the highest likelihood of reporting exposure to vibration were Machinery operators and drivers, Technicians and trades workers, and Labourers.
- 43% of vibration-exposed workers were exposed to hand-arm vibration only, 38% were exposed to whole body vibration only and 17% were exposed to both hand-arm and whole body vibration.
- 41% of vibration-exposed workers reported that they were exposed for up to a quarter of their time at work, while 21% reported they were exposed for between a quarter and half of their time at work, 15% reported they were exposed for between half and three-quarters of their time at work, and 24% reported they were exposed for more than three-quarters of their time at work (Safe Work Australia, 2010b, p. 1).

¹ As the Manufacturing; Transport and Storage; Construction; Health and Community Services; and Agriculture, Forestry and Fishing industries were specifically targeted for this survey, there may be an element of bias.

In the modern industrial world, exposure to vibration is widespread, either as a by-product of an activity or deliberately introduced. Processes where vibration occurs as a by-product include use of hand-held power tools, machines and vehicles such as trucks, tractors and earthmovers. Processes where vibration is deliberately introduced include concrete pours with vibrators to shake wet concrete into place, vibrating beds in rock quarrying to select particle size and cleaning baths for industrial products. Industries with significant vibration exposures include forestry, mining, metal manufacturing, agriculture, furniture making, construction, cleaning and transportation.

4 Understanding noise

Noise and vibration are closely linked in that noise originates from a vibrating body and both noise and vibration are transmitted as waves through a medium. In the case of noise the medium is usually air. Vibration may be transmitted through solid structures such as the floor or the hand grip of tools. Knowledge of units of measurement such as hertz and decibels together with some understanding of the physics of waves including frequency, wavelength, amplitude and reflection, absorption and transmission is important in understanding the behaviour of noise and vibration and so the development of controls².

4.1 Basic acoustics

Sound consists of very small pressure changes, which are superimposed on the atmospheric pressure. Air molecules move in a pendulum motion backwards and forwards from their resting position, causing momentary compression and rarefaction of the air pressure. The air molecules pass some of their energy on to neighbouring molecules and so spread their energy over an increasingly larger volume, much like the ripples when a stone is thrown into water. The pressure changes are detected by the eardrum, which vibrates in response. The vibrations are transferred via a lever system consisting of three tiny bones in the middle ear to the fluid-filled inner ear. In the inner ear, tiny hair cells convert the vibrations into electrical pulses that are sent to the brain. The brain is then able to process these electrical pulses into meaningful sounds.

A primary indicator that noise may be hazardous to hearing is when a person has to raise their voice to talk to someone who is about an arm's length away in a noisy workplace. A risk assessment, including noise measurement, should then be conducted to identify the processes, noise sources and workers likely to be exposed above the exposure standard. The draft *Code of Practice: Managing Noise and Preventing Hearing Loss at Work* (Safe Work Australia, 2010a, Appendix B) includes a basic noise hazard identification checklist.

² See *OHS BoK Foundation Science*.

4.2 Noise and its measurement

A noise assessment may be simple or quite complex depending on circumstances such as the type and size of the workplace, the number of workers and whether previous noise-assessment data is available.

A noise assessment can be carried out with a sound level meter (SLM) or a noise dose meter (NDM). An SLM is usually hand held and therefore the assessor is present as the measurements are made; this has the advantage that the assessor can observe firsthand what is being measured. An NDM is designed to be worn on a person for a period of time whilst that person conducts work. In practice, the assessor is not always present during the entire assessment period and so may rely on the wearer to provide input to the survey. In each case, the meter's microphone should be held within a sphere of 10 centimeters of the ear, in accordance with the requirements of *AS/NZS 1269.1 Occupational Noise Management – Measurement and Assessment of Noise Immission and Exposure* (SA/SNZ, 2005b). Both ears may need to be assessed and the worst exposed ear results used for noise management purposes. Both types of instruments measure the sound pressure variations as a sound pressure level expressed in decibels (dB). The decibel scale is logarithmic, or compressed, as the human ear is capable of hearing over a large range of sound pressures.³

Measurements are normally made using a weighting scale, which is A-weighting for sounds such as the ' $L_{Aeq,8h}$ ' (i.e. sound measured over a period of time), and C-weighting ' $L_{C,peak}$ ' for impulsive type sounds (i.e. sounds of less than 1 second duration, such as explosions and impact sound). The A-weighting is an electronic frequency filter used in sound level measuring instruments to simulate the measured sound as if perceived by the human ear. The human ear's sensitivity varies with the pitch of sound (frequency). It is less sensitive at low-pitched sounds, and more sensitive at high-pitched sounds. The A-weighting filter follows this variability by reducing the sensitivity of the sound level meter at low and high frequencies compared to those within the 1000Hz to 4000Hz frequency range.

A person carrying out a noise assessment should meet the competency requirements listed in *AS/NZS 1269.1*, including:

- know and understand the correct way of using sound level measuring instruments and their limitations
- be familiar with the normal operating conditions of the workplace
- know and understand the aim of the assessment
- be familiar with the relevant Australian Standards and statutory requirements (SA/SNZ, 2005b, Appendix 2).

³ Commercially available sound measuring apps for smart phone and tablets are useful *indicative* tools for estimating sound levels and but cannot be used to demonstrate legislative compliance.

4.3 Noise-induced hearing loss

Except for extremely loud noise of an explosive or impact nature where some amount of hearing loss and/or structural damage occurs (*acoustic trauma*), loud noise initially fatigues the delicate hair cells in the inner ear causing a shift in hearing threshold. This is called a *temporary threshold shift* (TTS). A simple test can be conducted by workers to assess the effects of occupational exposure to noise and its impact on hearing acuity:

Drive to work and switch off the engine, but not the ignition. Switch on the car radio and reduce the volume to just audible. Do not switch off the radio, but switch off the ignition and go to work. After work, switch on the ignition. The radio should come on as well. If the radio cannot be heard, a temporary threshold shift has occurred during the workday. The change in hearing threshold is experienced as dull or blocked hearing and sometimes ringing in the ears (tinnitus). This may last from hours to days after the exposure.

Generally, hearing recovers overnight, giving a false impression that all is well. However, the effects of regular exposures are cumulative. The hair cells are eventually destroyed causing a *permanent threshold shift* (PTS) that normally is not noticed until the damage is well advanced. Damaged hair cells are incapable of repairing themselves; the loss of hearing is therefore permanent as there is no cure available and hearing aids cannot restore the natural hearing (e.g. Safe Work Australia, 2010a; Safe Work SA, 2008).

Noise-induced damage to the inner ear hair cells usually occurs in the high-pitched frequency range of 4000-6000 Hz. This range is critical for understanding speech and the nuances involved with speech. In contrast to other forms of hearing loss, the person suffering from noise-induced hearing loss can hear well, but cannot understand the words because sounds such as -ff, -th and -sh, and high-pitched consonants such as -s, -t, -k and -e, are harder to hear or not heard at all. This causes misunderstandings in conversations, particularly where there is background noise. Audiometric tests can be conducted to assess the degree of noise-induced hearing loss. (See, for example, SafeWork SA, 2008.)

4.4 Audiometric testing

Under the model *Work Health and Safety Act* (WHS Act s 19.3g), persons conducting a business or undertaking (PCBU) are required to monitor the health of workers (Safe Work Australia, 2011a). Under certain conditions (as described in Safe Work Australia, 2010a) where workers are likely to be exposed to noise, ototoxins and/or vibrations, this requirement to monitor health includes audiometric testing. *AS/NZS 1269.4 Occupational Noise Management – Auditory Assessment* (SA/SNZ, 2005c) describes audiometric testing

as ̄ Pure tone audiometric testing of threshold sensitivity is the method of auditory assessment usually used in noise management programsí ̄. Audiometric testing requires specialised equipment that is appropriately calibrated and the testing must be conducted by suitably qualified persons as described in *AS/NZS 1269.4*.

It is important to note that while audiometric testing forms an important part of identifying and managing the risks from noise exposure at the workplace, ̄such testing is not itself a protective mechanism and is relevant only in the context of a comprehensive noise management programö (NOHSC, 2004, p. 32). Any changes in a person's hearing levels as revealed by audiometric testing should be investigated as to the cause and the need for corrective action.

4.5 Ototoxicity

During the last three decades, research (see, for example, Prasher et al., 2004) has been conducted on ototoxic agents, which are chemical substances that either alone or in concert with noise may have a more detrimental effect on hearing than noise (oto = ear, toxic ó poisonous) There are three main classes of ototoxins: solvents, heavy metals and asphyxiants. Also, some medications such as anti-inflammatory, anti-thrombotic and antibiotic drugs, and salicylic acid (aspirin) are considered to be ototoxic. A list of common ototoxins can be found in Appendix A of the draft *Code of Practice* (Safe Work Australia, 2010a, p. 29).

The most common routes of entry into the body of these ototoxins are via inhalation, skin absorption and, to a lesser extent, ingestion due mainly to poor personal hygiene practices at work. Because of the action variability between the many chemicals identified to date it is difficult to come up with a ̄safeø method of risk assessment. Also, Safety Data Sheets (SDS) generally do not give information on the ototoxic effects of a substance. However, workplaces using known or suspected ototoxic chemical substances should look for information on the chemical's general toxicity, neurotoxicity and nephrotoxicity as such chemicals also may affect the auditory system. (See, for example, Government of Western Australia, 2011.)

Exposure limits of chemical substances are stated in Safe Work Australia's (2010c) Hazardous Substances Information System.⁴ However, exposure standards for chemicals and for noise have not yet been altered to take account of increased risk to hearing. The draft *Code of Practice* (Safe Work Australia, 2010a) recommends that until revised standards are established, the daily noise exposure of workers exposed to ototoxins should be reduced to a maximum of 80 dB(A). Workers then should also undergo audiometric

⁴ see: <http://hsis.ascc.gov.au/>

testing and be given information on ototoxic substances. Monitoring hearing with regular audiometric testing is recommended where workers are exposed to:

- Any of the ototoxic substances listed in Appendix A where the airborne exposure (without regard to respiratory protection worn) is greater than 50 per cent of the national exposure standard for the substance, regardless of the noise level
- Ototoxic substances at any level and noise with $L_{Aeq,8h}$ greater than 80dB(A) or $L_{C,peak}$ greater than 135dB(C)⁵ (Safe Work Australia, 2010a)

A listing of ototoxic substances most commonly used in industrial settings is given in Appendix A of the draft *Code of Practice*. More information on ototoxins can be found in *AS/NZS 1269.0* (SA/SNZ, 2005a, Appendix C).

4.6 Social and community noise

Community noise has been acknowledged throughout the centuries as a health issue (section 2). Since the early 1900s, many studies have investigated the effects of noise in communities. To date, the main findings include health effects such as stress, annoyance, sleep disturbance, interference with concentration and activities, increased blood pressure and heart rate, and ischaemic heart disease (e.g. CDC, 2011). Furthermore, there is some evidence that the intellectual development of children in noisy suburbs may be compromised compared to those living in quiet suburbs (e.g. Tamburlini, von Ehrenstein & Bertollini, 2002).

The enormous popularity of personal music players such as MP3s is another source of community concern as they can be used for many hours at high volume, and insufficient warning is provided by the makers of the devices on the potentially damaging effects of regular exposure to loud noise on hearing (see SCENIHR, 2008). Unlike the situation in Europe where the maximum volume of MP3s is regulated, Australian regulators do not deem the risks important enough to deal with the issue. In 2010, Australian Hearing found that almost 40% of young Australians had trouble hearing in background noise and 13% received a yearly noise dose from nightclubs, concerts and sporting activities which alone exceeds the maximum acceptable dose in industry⁵ (Australian Hearing, 2010, p. 2).

The Access Economics report *Listen Hear!* (2006) stated that 37% of all hearing losses are noise induced from occupational and leisure activities. This amounts to direct and indirect costs to the community of about 4 billion dollars annually (Access Economics, 2006).

⁵ See Section 6.1 for explanation of terms of measurement for noise exposure.

4.7 Noise 'stress'

While the draft *Code of Practice* (Safe Work Australia, 2010a) comments on noise levels that do not damage hearing but may have other adverse health effects, there is no regulation of noise levels below $L_{Aeq,8h}$ 85 dB(A). These lower noise levels are typically found in open plan offices, hospital and call centre environments. The draft code notes that relatively low levels of noise can chronically interfere with concentration and communication [and that] persistent noise stress can increase risk of fatigue and cardiovascular disorders including high blood pressure and heart disease (Safe Work Australia, 2010a, p. 10). While safe levels of noise to guard against health problems other than hearing loss have not yet been determined, the draft code advises that the risk of adverse health effects can be minimised by; keeping noise levels below 50 dB(A) where work is being carried out that requires high concentration or effortless concentration, and below 70 dB(A) where more routine work is being carried out that requires speed or attentiveness or where it is important to carry on conversations (Safe Work Australia, 2010a, p. 10). To mitigate the chances of adverse health effects occurring in workers careful consideration must be given to the acoustic environment in which open plan offices and particularly call centres operate. Guidance in this regard can be obtained from AS/NZS 2107:2000 *Acoustics-Recommended design sound levels and reverberation times for building interiors*. This Standard provides design sound levels for a range of occupancies in the un-occupied state but ready for occupancy.

4.8 Acoustic shock

As outlined in the draft *Code of Practice*:

Acoustic incidents are sudden, unexpected loud noises occurring during telephone headset use, including crackles, hisses, whistles, shrieks or high-pitched noises. Acoustic shock is not caused by the loudness of a telephone, as all phone noise is electronically limited to a peak noise level of 123 decibels, but by a sudden rise in noise levels. (Safe Work Australia, 2010a, p. 29)

It is important that the acoustic environment of a call centre is optimal, e.g. meets the recommendations of AS/NZS 2107-2000, and the space between telephone operators not too cramped as that enables the operators to keep their conversation volumes low and in turn keep the volume in their headsets low.

Noises that may cause acoustic incidents symptoms can originate from two main sources, i.e. either from within the call centre telephone system or from the customer end. Sources from within the telephone system may include; mobile phones or fax machines used in a call centre, faulty telephones or headsets, individual telephone systems not protected by shriek rejection devices (Volume limiter amplifiers), or the whole of the call centre telephone network not protected by an Uninterrupted Power Supply (UPS). Sources from the customer end may include; loud noise in a workplace close to the phone, oscillation feedback from an old style cordless phone, misdirected fax tones over the telephone line

and deliberate abuse by customers. In most cases these noises may cause an acoustic incident in the telephone operator but the operator is likely to be able to continue work, after having reported the incident. Where these noises are severe however, they may lead to an acoustic shock and the operator may not be able to continue work, either for a limited period or not at all. (Groothoff, 2005).

The symptoms of acoustic shock ó experienced by only a small proportion of people after an acoustic incident ó are grouped into three categories:

Primary (immediate) symptoms, which can include but are not limited to:

- a feeling of fullness in the ear
- burning sensations or sharp pain around or in the ear
- numbness, tingling or soreness down the side of face, neck or shoulder
- nausea or vomiting
- dizziness, and
- tinnitus and other head noises such as eardrum fluttering.

Secondary symptoms, which include but are not limited to:

- headaches
- fatigue
- a feeling of being off-balance, and
- anxiety.

Tertiary symptoms, which include but are not limited to:

- hypersensitivity (sensitivity to previously tolerated sounds such as loud noises, television and radio); and
- hyper vigilance, i.e. being overly alert. (Safe Work Australia, 2010a, p. 30)

The likelihood that acoustic shock will result from an acoustic incident is low; however, factors including high background noise, the operator's psychosomatic state (e.g. experiencing feelings of tension) and physiological state (e.g. suffering a middle ear infection) may increase the likelihood of occurrence. While acoustic incidents may occur in any workplace, call centres are the most common sites. Control strategies for acoustic incidents should target:

- Workplace design, including acoustic requirements
- Systems of work, performance monitoring of workers, training and stress management, systems for reporting and measures for dealing with acoustic incidents and shock
- Technical control systems including compliance with telecommunication requirements, suitable shriek rejection devices such as Volume Limiter Amplifiers for each telephone operator, and uninterrupted power supply (UPS) systems to prevent brown-outs and black-outs causing signals in headsets (Groothoff, 2005).

5 Understanding vibration

5.1 Nature of vibration

Vibration consists of oscillatory movements of particles (molecules) around their equilibrium in a solid body, liquid or gas, in the area of infrasound (i.e. < 20 Hz), and partially also in the audible sound frequency range (up to 1500 Hz). Because in industrial situations vibration usually occurs in air ó in the audible frequency range ó it is normally also experience it as sound. (Groothoff, 2007) Understanding the source and mode of transmission of vibration and so the appropriate control measures can be complex and it is appropriate to seek specialist advice.

5.2 Health effects of vibration

The main health effect from whole-body vibration is damage to the lower spine area; however, damage to internal organs also may occur (CCOHS, 2008; Comcare, 2008; HSE, 2011). Research has demonstrated that whole-body vibration òcan increase heart rate, oxygen uptake and respiratory rate, and can produce changes in blood and urineí [and] produce an overall ill feelingí [and] decreased performance in workersö (CCOHS, 2008). Motion sickness, which affects the centres for orientation and posture and the vestibular cortex (balancing mechanism in the ear), may occur with vibration exposure in the 0.1-1 Hz frequency range (e.g. as experienced on ships).⁶

The main health effect from hand-arm vibration is caused by the disruption of blood and oxygen supply to the fingers from prolonged vibration exposure, resulting in damage to blood vessels and nervous systems that initially are reversible, but with continued exposures eventually become irreversible. Vibrations from hand-held power tools transmit to the operator's fingers and may cause tingling and numbness after a relatively short period of time. Vibrations caused by hand-held power tools are usually found in the higher frequencies (e.g. 40-300 Hz). With prolonged exposures, structural changes and damage to the peripheral blood supply and nervous systems in the fingers occur. In addition, damage to bones, tendons and joints may occur as a result of long-term regular exposure to hand-arm vibration from hand-held power tools. Also, there is evidence (e.g. Miyakita, Miura & Futatsuka, 1991) that a reflex sympathetic vasoconstriction action of the cochlea blood vessels is caused by exposure to hand-arm vibration and noise, thus producing a synergistic effect in the likelihood of hearing loss caused by noise exposure.⁷

⁶ For more information about the health effects of whole-body vibration, see Wikström, Kjellberg & Landström, 1994.)

⁷ For more information about health effects of hand-arm vibration, see CCOHS, 2008; Comcare, 2008; Griffin, 2006; HSE, 2011; Reynolds, 2004.)

5.3 Measurement and evaluation of risk associated with vibration

The evaluation of human vibration is complex and requires many factors to be considered apart from measurement of the surface vibration. For example, the grip of a tool by a worker affects the amount of vibration energy that enters the worker's hands (e.g. Griffin, 2006). Differences between individuals' biological make-up, health, history of smoking, body stature and posture, motivation and arousal are many and complex. The risk to a pregnant worker requires specific evaluation (European Directive 92/85/EEC). Standards cannot account for all human variables so tend to concentrate on level, duration, magnitude, frequency and direction of the vibration.

The current Australian Standard for the assessment of whole-body vibration is *AS 2670.1 Evaluation of Human Exposure to Whole-body Vibration – General Requirements* (SA, 2001), which indicates how vibration should be assessed and how to evaluate the significance of the measured vibration and its possible effects on human health, comfort and perception. The Standard does not set exposure limits for whole-body vibration, but indicates 'caution zones' for risks to health.

The current Australian Standard for the measurement and assessment of hand-arm vibration, *AS 2763–1988 Vibration and Shock – Hand-transmitted Vibration – Guidelines for Measurement and Assessment of Human Exposure* (SA, 1988) is basically a copy of International Standards *ISO 5349–1* and *ISO 5349–2* (ISO, 2001a,b) and deals with segmental (e.g. hand-arm) vibration. The Australian Standard does not set exposure limits for safe exposure. It provides guidelines for the assessment of hand-arm vibration exposure and when health surveillance should be made available to workers.⁸

Measurement of human vibration exposure involves the use of accelerometers and specialised vibration meters (e.g. CCOHS, 2008; Griffin, 1990). The magnitude of the vibration is expressed as acceleration in m/s^2 and is measured in three directions – horizontal front-aft (X) direction, horizontal side-to-side (Y) direction and vertical up-down (Z) direction at the point of contact with the vibrating object. There are specific requirements and techniques for measurement of vibration that are described in *AS 2763–1988* (SA, 1988). Modern vibration meters measure a range of parameters simultaneously and provide the results such as rms acceleration, peak and vibration dose value (VDV) for further evaluation.⁹

⁸ It is the author's opinion that AS 2763-1988 is in urgent need of updating to reflect the current knowledge and understanding of the effects of hand arm vibration.

⁹ For more information on measurement of vibration see manufacturers details/websites; such as Brüel & Kjær, Larson Davis, Svan

6 Legislation and standards

6.1 Noise

The national model legislation (Safe Work Australia, 2011a) requires a person conducting a business or undertaking (PCBU) to ensure, so far as is reasonably practicable, the health and safety of workers (*WHS* s 19). This obligation requires elimination of risks to health and safety so far as is reasonably practicable or, if elimination is not reasonably practicable, minimisation of those risks so far as is reasonably practicable (*WHS* s 17). The Work Health and Safety legislation applies also to designers, manufacturers, suppliers and installers of plant with regards to their obligations to provide plant and information so that it is safe for use. This requirement applies equally to the prevention of noise-induced hearing loss or excessive vibration for the end user. Because the risks of sustaining occupational noise-induced hearing loss are foreseeable, exposure limits are set under health and safety and mining legislation. The draft *Model Work Health and Safety Regulations* (Safe Work Australia, 2011b) stipulate exposure standards for noise as:

- $L_{Aeq,8h}$ of 85 dB(A) or
- $L_{C,peak}$ of 140 dB(C).

In this regulation:

$L_{Aeq,8h}$ means the eight-hour equivalent continuous A-weighted sound pressure level in decibels (dB(A)) referenced to 20 micropascals, determined in accordance with AS/NZS 1269.1:2005 (Occupational noise management ó Measurement and assessment of noise immission and exposure).

$L_{C,peak}$ means the C-weighted peak sound pressure level in decibels (dB(C)) referenced to 20 micropascals, determined in accordance with AS/NZS 1269.1:2005 (Occupational noise management ó Measurement and assessment of noise immission and exposure) (*WHSR* s. 4.1.1).

These limits are determined without taking into account any protection that may be provided to the person by the use of personal hearing protectors. Due to the recovery time for temporary hearing loss, the eight-hour equivalent exposure limit must be adjusted for longer shifts. For example, the draft *Code of Practice* (Safe Work Australia, 2010a) advises that for shifts of ö10 hrs or more to less than 14 hrs,ö 1 dB(A) should be added to the measured $L_{Aeq,8h}$ dB(A).

The draft *Code of Practice* (Safe Work Australia, 2010a) provides information on noise and occupational noise-induced hearing loss (ONIHL), and how to control risks and so comply with the regulated exposure limits. The Australian/New Zealand Standard series *AS/NZS 1269 Occupational Noise Management Set* (SA/SNZ, 2005d) provides extensive information on all facets of noise assessment, including instrumentation, evaluation of results and noise management. By following the guidance in the draft *Code of Practice* and the relevant sections of *AS/NZS 1269* (particularly Part 1), a PCBU or other responsible person should, in most cases, be able to demonstrate compliance with the regulated exposure standard and thus prevent ONIHL.

Other relevant standards include *AS/NZS 1270 Acoustics – Hearing Protectors* (SA/SNZ, 2002) and *AS 2436 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* (SA/SNZ, 2010).

6.2 Vibration

In contrast to the European *Directive 2002/44/EC – Vibration* (European Parliament, 2002), no Australian OHS jurisdiction has regulations in place to set limits for the exposure of workers to vibration and it is not addressed in model Work Health and Safety Regulations. However, Safe Work Australia is considering whether to produce a Code of Practice on human vibration or adopt limits under a regulation in the near future.

7 Control of noise hazards

Generally, workplaces contain various noise sources that are not always used at the same time, or consistently, throughout shifts. Therefore noise levels will vary with time. Also, worker movement around machines and work areas may result in variations in noise exposure. In production areas, it may be costly or not possible to stop production to measure individual noise sources. However, effective noise control requires identification and analysis of noise sources to determine the priority sources for attention (see Safe Work Australia, 2010a). Where noise sources have been identified that are likely to produce excessive noise, the next step is to prioritise noise control by determining the duration of use of each machine or item of equipment during a typical shift and the time the operator spends using them or working near them. For instance, a machine or equipment item with a high noise level, but with short usage per shift may well have a lower priority for noise reduction than a machine or equipment item with a low noise level, but long usage per shift. For example, a milling machine operated for six hours per day at 88 dB(A) at the operator's ears, needs more urgent noise reduction than an auger operating for 15 minutes per day at 94 dB(A). The Ready Reckoner of Table C1 of the draft *Noise Code of Practice* shows clearly that at 88dB(A) the exposure can be up to 4 hours before the red (danger) area has been reached. It also shows that at 94db(A) it only takes one hour to reach the red area. Therefore the auger needs more urgent treatment than the milling machine.

The national model legislation (*WHSR* s 4.1.2) requires that the hierarchy of control be followed with control measures considered in the following order:

- a) Eliminate the source of noise to which the worker is exposed as far as reasonably practicable
- b) If a) is not reasonably practicable, then the noise level to which a worker is exposed must be minimised by substituting quieter plant or processes or using engineering control measures
- c) If b) is not reasonably practicable, then the noise level must be minimised by implementing administrative control measures
- d) If c) is not reasonably practicable, then the noise level must be minimised by providing the worker with personal hearing protectors (Safe Work Australia, 2010a, p. 15).

Workplaces cannot automatically rely on the use of hearing protectors, or other forms of personal protective equipment, where it is reasonable and practicable to use higher-order controls

In practice, provision of hearing protection is the predominant method employed for preventing ONIHL. The 2008 *National Hazard Exposure Worker Surveillance* report found that of the 4500 workers interviewed:

- 17% were at workplaces where no controls were implemented
- 63% were provided with earplugs
- 60% were provided with earmuffs
- 41% received training on how to prevent hearing loss
- 36% had job rotation
- 36% were at workplaces where quieter machinery was purchased whenever possible
- 22% were at workplaces where noisy equipment was placed in an isolated room (ASCC, 2008b, p. 25).

The draft *Code of Practice: Managing Noise and Preventing Hearing Loss at Work* (Safe Work Australia, 2010a) and the *AS/NZS 1269* series (SA/NZS, 2005d) provide information on managing occupational noise. Information on noise control also may be found in other codes of practice such as those for plant, risk assessment, construction and tunnelling.

7.1 Elimination or minimisation through Safe Design

Workplace noise that exceeds the exposure standard must, so far as reasonably practicable, be reduced to non hazardous exposure levels. The best way to do this is by eliminating the source of noise emission. One way of doing this is by no longer carrying out the work that creates the noise. Where this is not practicable, substitution of the activity or process by changing the noisy components of the activity or process for a quieter one should be considered, e.g. instead of hammering a piece of metal to bend it, the metal could be heated and then bend with pliers or a press.

7.2 Engineering controls

Engineering noise controls address control at the source by modifying the noise source itself or through enclosures (e.g. made from a solid material and lined internally with a sound-absorbent lining), modifications and/or additions (e.g. silencers or mufflers to existing noise sources), placing barriers in the noise path or by enclosing the receiver end

(e.g. a control room). Generally, engineering noise control is the most effective way of controlling noise, but may sometimes be cost prohibitive.¹⁰

Some basic principles of engineering noise control consist of;

- Mounting vibrating sources within machines on isolators or dampeners
- Replacement of metal components with quieter materials such as plastic, nylon or compound components
- Installing local enclosures around particular noisy machine components
- Incorporation of sound absorbent materials
- Provision of air and gas exhausts with silencers
- Change to a quieter type of fan, fan blade pitch or number of blades, or fitting sound attenuators in ventilation ducts.

Most of the above options are commercially available from suppliers and much of the work can be done in-house by maintenance or engineering departments.

7.3 Administrative controls

Administrative noise control measures aim to reduce the amount of noise to which a worker is exposed via organisational methods, for example, delineating hearing protection areas, noise mapping to identify safe/unsafe noise areas, rescheduling workers' duties to limit exposure times, optimising maintenance, replacing old plant and equipment with new quieter plant and equipment through a 'Buying Quiet' program (e.g. Safe Work Australia, 2010a).

7.4 Hearing protection

Hearing protectors should be worn where hazardous noise levels exist in the workplace that cannot be reduced by higher-order controls or until such times that the noise levels have been reduced to non-hazardous levels through elimination, substitution or engineering noise-control measures (Safe Work Australia, 2010a). There are three basic types of hearing protectors available: disposable or individually moulded earplugs, ear canal caps, and passive or active earmuffs. Passive earmuffs are the conventional type while electronically active level-dependent earmuffs allow noise up to 82 dB to enter the ear after which an electronic system shuts the reception down and they act like passive earmuffs. Noise-cancelling earmuffs reduce (mainly) low-frequency noise by monitoring the noise environment outside the earmuff and introducing an anti sound of 180-degree phase difference to the original sound sine wave. The principle of this is that a positive and a negative cancel each other out, hence the term 'noise cancelling'. In reality while not all

¹⁰ For more information on engineering controls, see Tillman, 2007, Chapter 10.

noise is cancelled out a significant noise reduction is obtained. (See, for example, Sound Advice, 2007; WHSQ, 2011.)

The ideal in-ear noise level under the protector should fall between 75 and 80 dB(A) to reduce workplace noise to safe levels while enabling hearing and communication without over-protection and thus the likely removal of the protector in noisy environments.

Removing personal hearing protectors for even short periods significantly reduces the effective attenuation (noise reduction) and might provide inadequate protection. For example, a worker wearing a hearing protector of 30dB rating for a full 8-hour day will receive the 30 dB maximum protection level. However, one hour without wearing the hearing protector causes the maximum protection level to fall to 9 dB. (Safe Work Australia, 2010a, p. 17)

While there are several methods for selecting hearing protection AS/NZS 1269.3 (SA/SNZ, 2005) recommends the classification method for selecting hearing in most circumstances (Table 1). The class of the specific hearing protection is determined by a testing regime as prescribed under AS/NZS 1270 *Acoustics and hearing protection* (SA/SNZ, 2002) and is marked on the packaging of the protective device. A selection is then made based on the measured $L_{Aeq,8h}$ noise level. (e.g. if the worker's $L_{Aeq,8h}$ noise level is 96dB(A) then a Class 3 hearing protector would be required for that worker.)

Table 1: Class of hearing protection (SA/SNZ, p20)

$L_{Aeq,8h}$, dB(A)	Class
less than 90	1
90 to less than 95	2
95 to less than 100	3
100 to less than 105	4
105 to less than 110	5

A common misconception is that hearing protectors control noise: hearing protectors do not control workplace noise as the noise in the workplace is still there but the wearing of a hearing protector reduces the in-ear noise level. Exposure is not reduced by the wearing of personal hearing protectors. A person wearing hearing protectors in a sound field is in a situation of protected exposure, not non-exposure (SA/NZS2005b, p8). Thus hearing protectors should be used only when other means of control are not reasonably practicable. When hearing protection is required, there should be a systematic approach that includes:

- Selection of hearing protection by a suitably qualified person
- Training in fitting and wearing of the hearing protection for those required to use the hearing protection

- Establishment of arrangements to fit the hearing protectors before entering the noisy work area
- Establishment of arrangements for cleaning, maintenance and secure storage
- Marking of areas where hearing protection is required
- Appropriate documentation
- Monitoring of the effectiveness of the hearing protection use
- Management and oversight by a suitably qualified person (See, for example, SA/NZS, 2005e).

AS/NZS 1269.3 Occupational Noise Management – Hearing Protector Program (SA/SNZ, 2005e) provides information on the details and scope of the requirements for a systematic approach to implementing a hearing protector program as well as a training program for hearing protectors.

7.5 An occupational noise management program

Where noise is likely to be in excess of the noise exposure standard, the workplace should implement a systematic noise management program.¹¹ The basic steps of a noise management program are outlined in *AS/NZS 1269.0–2005 Occupational Noise Management – Overview and General Requirements*.

A cost effective way to manage noise is to apply noise control measures to existing noisy equipment and processes and to purchase quieter equipment in the future...While these control measures are being formulated and implemented, people need to be protected from the effects of excessive noise through hearing protector programs (SA/SNZ, 2005a).

A noise management program contains the following key elements:

- Hazard identification
- Risk assessment
- Hearing conservation policy statement
- Noise level and noise level exposure surveys
- Engineering and administrative noise-control measures
- Education and training
- Personal hearing protection
- Audiometric testing
- Evaluation of effectiveness of the program
- Record keeping system (See, for example, SA/NZS, 2005a).

¹¹ While some workplaces may refer to hearing conservation programs, generally this implies the prevention of noise-induced hearing loss in workers by protecting their hearing through the use of hearing protectors.

The *AS/NZS 1269 Occupational Noise Management* series of standards (SA/SNZ, 2005d) provides full details of effective noise management programs. Additional information can be found in the draft *Code of Practice* (Safe Work Australia, 2010a).

8 Control of vibration hazards

Because there are no legislative exposure limits to vibration in Australia, Persons Conducting a Business or Undertaking (PCBU) must show due diligence in the management of workers' vibration exposure (see, WHSA s 27). Due diligence in the management of vibration hazards include taking reasonable steps to:

- Acquire and keep up-to-date knowledge of vibration hazards
- Gain an understanding of the nature of the operations of the business and the vibration hazards and risks associated with those operations
- To ensure the availability of appropriate resources to eliminate or minimise risks of vibration hazards
- To ensure appropriate processes for receiving and considering information regarding incidents, hazards and risks and responding in a timely way to that information. [See, for example WHSA s 27(5)]

In the absence of exposure limits for vibration exposure in the Australian Standards and health and safety legislation, the *Directive 2002/44/EC – Vibration* (European Parliament, 2002) can be used to determine the acceptability, or otherwise, of human vibration exposure in the Australian situation (see also Griffin, 2004). The Vibration Directive provides for *daily exposure action* and *daily exposure limit* values, which are specified as 8-hour energy equivalent frequency weighted acceleration values and expressed as $A(8)$ values. For whole-body vibration, the Directive also provides for *vibration dose value (VDV)*, as an alternative. The values are:

For hand-arm vibration:

daily exposure action value (EAV): $2.5\text{m/s}^2 A(8)$

daily exposure limit value (ELV): $5\text{m/s}^2 A(8)$

For whole-body vibration:

daily exposure action value (EAV): $0.5\text{m/s}^2 A(8)$ or $VDV 9.1\text{m/s}^{1.75}$

daily exposure limit value (ELV): $1.15\text{m/s}^2 A(8)$ or $VDV 21\text{m/s}^{1.75}$

The exposure values are derived from *ISO 5349-1:2001* (ISO, 2001a) and *ISO 2631-1:1997* (ISO, 1997) for hand-arm and whole-body vibration, respectively.

Directive 2002/44/EC – Vibration requires employers to:

- Assess the risk and exposure

- Plan and implement control measures
- Provide and maintain a suitable work environment
- Provide training and information on vibration risks and their controls to workers
- Monitor and review the effectiveness of the risk-control program (European Parliament, 2002).

These requirements of the Directive assist in demonstrating due diligence. Also, the Directive states that workers have a right to health surveillance where a risk has been identified. This ties in well with a provision in Appendix B of *AS 2763* (SA/NZS, 1988) for hand-arm vibration, which states that segmental vibration workers shall be medically examined where their exposure to hand arm vibration exceeds 2.9m/s^2 .¹²

Recommended controls for whole-body vibration include:

- Elimination/design
 - Treating the vibration source, the transmission path or the receiver, or a combination of the three, to eliminate or minimise exposure of workers
 - Ensuring drivers of vehicles can regularly change posture without compromising control of the vehicle
- Engineering
 - Insulating seats and head rests in cases where vibration is transmitted through the seat or headrest, through incorporation of spring and dampers
- Administrative controls
 - Ensuring that plant and equipment are well maintained to avoid resonance and excessive vibration
 - Maintaining roads or other surface areas in good condition (i.e. fill in potholes as soon as they occur)
 - Limiting the speed at which vehicles travel depending on terrain conditions
 - Limiting the time spent by workers on vibrating surfaces
 - Incorporating mini breaks on a regular basis
 - Incorporating seat maintenance and replacement programs.

For more information on controls for whole-body vibration, see CCOHS (2008); HSE (2005a); McPhee, Foster and Long (2009).

Recommended controls for hand-arm vibration include:

- Elimination/design

¹² For further information on vibration refer to the UK Health and Safety Executive's website; <http://www.hse.gov.uk/vibration/index.htm>. This site contains excellent information on both hand arm and whole body vibration management.

- Incorporating anti-vibration handles in tools
- Engineering
 - Lagging handles with soft resilient material after purchase
- Administrative controls
 - Employing a minimum hand grip consistent with safe work operation of the tool or process
 - Avoiding continuous exposure through incorporating pauses of approximately 20 minutes in every two-hour period
 - Practicing job rotation through teamwork so that, where practicable, working with vibrating tools does not exceed four hours in the course of any one working day
 - Resting the tool on the work piece whenever practicable
 - Maintaining properly sharpened cutting tools
 - Personal protective equipment
 - Wearing adequate clothing, including gloves, to keep warm
- Other
 - Avoiding smoking as it constricts the blood vessels
 - Understanding the physiological and sensorineural effects of prolonged vibration exposure
 - Consulting a doctor at the first sign of vibration disease and inquiring about the possibility of changing to a job with less exposure.¹³

9 Implications for OHS practice

Noise can be a hazard in any industry and any workplace. Noise control and prevention of hearing loss is not only a legal obligation under WHS legislation and mining legislation, but also an ethical issue as people with hearing loss suffer from social isolation and have reduced career prospects. While there are simple tests for the presence of hazardous noise levels, identification and analysis of noise sources as a basis for control can be complex, requiring specialist and expertise. The generalist OHS professional has an important role in identifying the presence of hazardous noise, undertaking basic noise measurements, and providing preliminary advice on noise control measures, including the role of hearing protection. The generalist OHS professional should recognise when specialist advice is required, including the nature of the advice (e.g. acoustic engineering or occupational hygiene) and be able to coordinate and work with the specialists.

The generalist OHS professional has a key role in ensuring that a noise management program is an integral part of the OHS management system. This includes ensuring that:

- Policies and procedures are developed for the noise management program

¹³ For more information on controls for hand-arm vibration, see CCOHS (2008), HSE (2005b).

- Buy quiet principles are included in purchasing policies
- Hazard-identification processes and workplace inspections include subjective and/or objective assessment of noise levels
- When indicated, risk-assessment processes include noise surveys conducted by suitably qualified persons
- Maintenance processes address noise and vibration issues, and include monitoring of condition of plant and equipment for noise and vibration
- Managers, supervisors and workers receive appropriate information and training on noise and vibration hazards and, where required, the fitting, wearing and maintenance of hearing protectors
- Areas where hearing protection are required are identified and signposted
- Where required, appropriate processes are in place for selection and supply of hearing protectors
- The need for audiometric testing is identified and appropriate processes are in place for conduct and documentation of hearing testing
- The effectiveness of the noise management program is monitored through audit, noise survey and other appropriate measures.

10 Summary

While blue collar occupations are most affected by both noise and vibration hazards, noise in particular is a hazard in many workplaces and occupational noise-induced hearing loss has been classified as one of eight priority diseases in Australian workplaces. Identification of noise hazards in the workplace is fairly simple; however, awareness of individual hearing deficit may be delayed due to the cumulative nature of noise exposure and the complicating impact of leisure noise and age-related hearing loss. Although regulations and guidance for noise hazards that emphasise the importance of control at source have existed in Australia for many years, hearing protectors are reported to be the predominant control measure. Thus, in many workplaces, there is a need for change in the approach to control of noise hazards.

Despite different health impacts, noise and vibration hazards have similar sources, behave similarly and, from a prevention and engineering perspective, the controls are similar. In contrast to the situation for noise hazards, there is no Australian regulation and little guidance relating to vibration hazards and their control. However, the European Vibration Directive provides useful guidance.

The generalist OHS professional has a role in identifying, assessing and controlling noise and vibration hazards, and particularly in implementing a noise and vibration management program as part of an OHS management system. Specialist expertise may be required to conduct noise or vibration surveys, and to advise on development of control strategies.

Key thinkers

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Useful sources

Noise: SA/SNZ (Standards Australia/Standards New Zealand). (2005). *AS/NZS 1269 Set:2005 Occupational Noise Management Set*. Sydney and Wellington: Standards Australia/Standards New Zealand.

Includes:

AS/NZS 1269.0:2005 Overview and General Requirements

AS/NZS 1269.1:2005 Measurement and Assessment of Noise Immission and Exposure

AS/NZS 1269.2:2005 Noise Control Management

AS/NZS 1269.3:2005 Hearing Protector Program

AS/NZS 1269.4:2005 Auditory Assessment

AS/NZS 2107-2000 Acoustics-Recommended design sound levels and reverberation times for building interiors

Vibration: European Parliament. (2002). EU Vibration Directive. Retrieved from <http://www.vibrationdirective.com/>

Mc Phee, B., Foster, G., & Long, A. (2009). *Bad Vibrations: A handbook on whole body vibration and exposure in mining* (2nd ed.). Sydney, NSW: Coal Services Health & Safety Trust. Retrieved from <http://mines.industry.qld.gov.au/assets/hiac/badvibrations2april09final.pdf>

Information on equipment vibration levels and management can be found at:

<http://www.hewden.co.uk/pdf/healthsafety/Noise-Booklet-2006.pdf>

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