OHS Body of Knowledge

Vibration

Core Body of Knowledge for the Generalist OHS Professional

Second Edition, 2019

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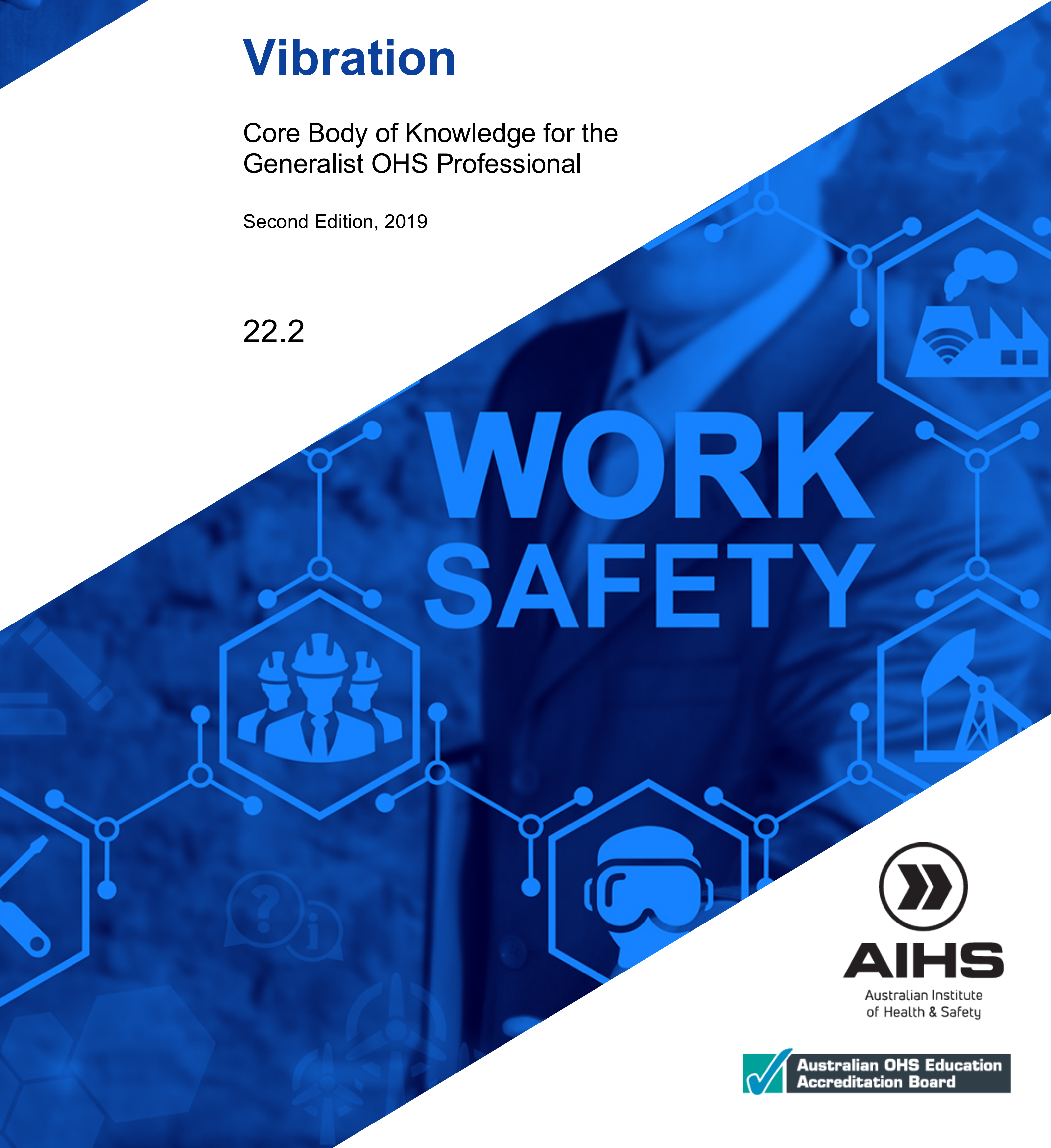

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In this edition the original chapter has been split into two chapters: 22.1 Occupational Noise and 22.2 Vibration. The changes incorporated into this chapter on vibration consist mainly of updating the Model Work Health and Safety legislation references to reflect latest editions of regulations and codes of practice and the inclusion of the guidance material on vibration noise management as published by Safe Work Australia published by Safe Work Australia in October 2015.

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Vibration

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Core Body of Knowledge for the Generalist OHS Professional

Vibration

Abstract

Vibration and noise are closely linked in that both originate from a vibrating body and both have similar physics as they are transmitted as waves through a medium. In contrast to occupational noise, there is to date no regulation for vibration hazards in Australian workplaces and these hazards are not well recognised. The health impacts of vibration can be significant and career limiting. Controlling the effects of vibration relies mainly on elimination and engineering measures. This chapter discusses the concept of vibration, its associated hazards and the effects on individuals. It provides a basic understanding of the health impacts of vibration, measurement of vibration, general controls and concludes with an examination of the role of the generalist OHS professional in the management of vibration hazards.

Keywords

Hand-arm vibration, whole-body vibration, control

Contextual reading

Readers should refer to 1 *Preliminaries* for a full list of chapters and authors and a synopsis of the OHS Body of Knowledge. Chapter 2, *Introduction* describes the background and development process while Chapter 3, *The OHS Professional* provides a context by describing the role and professional environment.

Terminology

Depending on the jurisdiction and the organisation, Australian terminology refers to 'Occupational Health and Safety' (OHS), 'Occupational Safety and Health (OSH) or 'Work Health and Safety' (WHS). In line with international practice this publication uses OHS with the exception of specific reference to the Work Health and Safety (WHS) Act and related legislation.

Jurisdictional application

This chapter includes a short section referring to the Australian model work health and safety legislation. This is in line with the Australian national application of the *OHS Body of Knowledge*. Readers working in other legal jurisdictions should consider these references as examples and refer to the relevant legislation in their jurisdiction of operation.

Table of contents

1 Introduction

The terms vibration and noise are often linked, as for example, ‘noise and vibration engineering.’ This is because exposure to vibration is usually, but not always, associated with exposure to noise, and the physics of vibration and noise are similar.[1] While the specific health effects of exposure to vibration are different to those arising from exposure to noise, they are both insidious and can manifest after a long period of latency. The health effects of vibration should be taken seriously by their creators as part of their business activities. Management of vibration hazards is a specialist area with advice able to be sourced from mechanical engineers, noise and vibration engineers, ergonomists and occupational hygienists. This chapter deals with human vibration from the perspective of the generalist OHS professional and so addresses the basic knowledge required to understand, identify, assess and control vibration hazards in the workplace and to engage with the appropriate specialists.

1.1 Definitions

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).

> Vibration is an oscillation wherein the quantity is a parameter defining the motion of a mechanical system.
>
> Oscillation is the variation, usually with time, of the magnitude of a quantity with respect to a specified reference when the magnitude is alternatively greater and smaller than the reference. (Harris & Crede, 1976)

This chapter describes two main types of vibration exposure: “whole body vibration – the body is shaken by a machine or vehicle” and “hand-arm vibration – where the vibration effect is localised to the hand and arm”.

Exposure to whole body vibration (WBV) mainly occurs in vehicles used off-road or on un-sealed roads, for example on farms and construction, mine and quarry sites. It can also occur in other places like in small, fast boats and in helicopters (SWA, 2015a). 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,

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[1] See *OHS BoK* 22.1 Occupational Noise for information on identifying, assessing and controlling work-related noise.

exposures to hand-arm vibration (HAV) are associated with “vibration of hand-held tools and workpieces” (Griffin, 2004, p.387) such as jack-hammers, chainsaws, grinders, drills, riviters and impact wrenches (SWA, 2015b).

2 Historical context

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:

> “…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). In their follow up study on stonecutters in the same quarries in 1984, Taylor et al., reported an 80% prevalence of vibration white finger and commented that over the 60 years there had been no change in the design of the air hammers and that their measured values were *“outside the recommended limits”* (Burgess & Foster, 2012). 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, 1990, Joubert, 2004).

3 Extent of the problem

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* survey, which collected self-reported information via telephone interviews of 4500 people,[2] 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
- 23% of vibration-exposed workers reported that none of the surveyed control measures were provided in their workplace.
- Only 27% of vibration-exposed workers reported they received training.
- Large percentages of vibration-exposed workers in smaller workplaces reported they were not provided with any vibration control measures. (Safe Work Australia, 2010a, p. 1).

[2] 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 and small vessels on the water, e.g. rigid hull inflatable boats. 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 vibration

4.1 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 – in the audible frequency range – it is normally also experienced as sound (Groothoff, 2015). 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.

4.2 Health effects of whole body vibration

The Guide to Managing Risk of Exposure to Whole Body Vibration in Workplaces (SWA, 2015a) states that exposure to whole body vibration is linked to increased risk of musculoskeletal disorders involving the lower spine, neck and shoulders with high exposure increasing the risk of lower-back pain, herniated discs and early degeneration of the spine.

Exposure to whole body vibration may also cause or make worse:

- cardiovascular, respiratory, neurological, endocrine and metabolic changes
- digestive problems
- reproductive organ damage in both men and women, and
- impairment of vision, balance or both.

Exposure to WBV may also cause discomfort, fatigue and other problems when work activities are being carried out. This could lead to incidents. (SWA, 2015a.)

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). [3]

Factors that influence the development of harmful effects of whole body vibration include:

- Individual characteristics including worker health status, pregnancy, diabetes, worker size and weight, driver skill, familiarity with the terrain, ability to change posture, years of exposure
- Work environment including condition of road surfaces, speed limits, shocks and jolts, operating durations and exposures, vehicle/vessel cabin conditions, visibility without need for twisting or stretching, controls within easy reach, air conditioned cabin, weather conditions, exposure to vapours and fumes
- Plant characteristics including design, condition, size, engine and cabin vibration damping, vehicle suspension and tyres, suspension dampened seats, cabin layout, plant operating activities and traveling speed.

4.3 Health effects of hand-arm vibration

Safe Work Australia (2015b) report the long term exposure to excessive vibration can disrupt a person's circulation in their hand and forearm, and cause damage to nerves, tendons, muscles, bones and hand and arm joints. The resultant conditions include:

- Carpal tunnel syndrome – a disorder of the hand and arm which may involve tingling, numbness, pain and weakness in parts of the hand.
- Musculoskeletal disorders – muscular and vascular disorders like weakness, pain and stiffness in the joints of the hands and arms and little or no grip strength.
- Vibration white finger (Raynaud's phenomenon) – a sudden constriction of the blood vessels which slows blood flow to the extremities, most often fingers and toes. The skin will change in colour, usually accompanied by discomfort like pain, tingling and numbness. Severe cases can result in complete loss of touch sensation and manipulative dexterity which can interfere with work and increase the risk of acute injuries due to incidents.
- Dupuytrens contracture – fingers becoming permanently curled towards the palm and reduced grip strength.

Workers with HAVS may find it impacts their work, social and family life. Periodic attacks of reduced blood circulation may happen at any time and everyday tasks like handling small buttons on clothing, opening jars and turning door knobs may become difficult. (SWA, 2015b)

[3] For more information about the health effects of whole-body vibration, see Wikström, Kjellberg & Landström, 1994; HSE, n.d.-a).

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 which result in damage to blood vessel walls 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 sensation 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). In addition to structural changes to blood vessel wall elasticity and the resulting fibrosis affecting the peripheral blood supply and nervous systems in the fingers, 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.[4]

Factors that influence the development of harmful hand-arm vibration effects include:

- Individual characteristics such as operator posture, including awkward postures, gripping the tool's handlebars more tightly than necessary, unfamiliarity with the process or inadequate operator training, susceptibility to naturally occurring blanching of the fingers due to cold weather conditions (primary Raynaud's syndrome), health status, diabetes, smoking.
- Tool characteristics including the wrong tool for the operator i.e. too big and/or too heavy, wrong tool for the activity to be performed, incorrect combination of tool and consumables, worn tools, handle bars not vibration insulated, hardness of material being worked on.
- Work organisation including the workers' daily exposure to vibration, trigger time of the worker using the tool, work and rest periods, temperatures and opportunities to keep hands warm and dry.

5 Measurement and evaluation of risk associated with vibration

The evaluation of human vibration is complex and requires consideration of many factors 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 status, history of smoking, body stature and posture, motivation and arousal are many and complex. The risk to a pregnant

[4] For more information about health effects of hand-arm vibration, see CCOHS, 2008; Griffin, 2006; HSE, n.d.-b; Reynolds, 2004.)

worker requires specific evaluation (EC, 2000). Standards cannot account for all human variables so tend to concentrate on level, duration, magnitude, frequency and direction of the vibration.

Measurement of human vibration exposure involves the use of accelerometers and specialised vibration meters (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. Modern vibration meters measure a range of parameters simultaneously and provide the results such as r.m.s. acceleration (m/s^2), vibration total value (VTV), peak and vibration dose value (VDV) for further evaluation.[5]

5.1 Vibration Standards

The current Australian Standard for the assessment of whole-body vibration is *AS 2670.1-2001 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. It provides workplaces and statutory agencies with methods for the assessment and evaluation of whole body vibration and indications of their possible effects on health, comfort and perception in humans. The standard also states that more research is needed to get a more definitive dose response relationship between exposure to vibration and resulting symptoms so that safe levels of exposure can be established and occupational hazards from vibration eliminated. In the meantime, vibration exposure in the workplace should be minimized (Groothoff, 2015). Annex B of AS 2670.1 provides guidance for the assessment of whole body vibration with respect to human health. It applies to people in normal health and who are regularly exposed to vibration. Annex B indicates ‘health caution zones’ for both r.m.s. frequency weighted acceleration (B1) and vibration dose value (B2) caused by shocks and jolts and enables evaluation of risks to health

The current Australian Standards for the assessment of hand-arm vibration are *AS ISO 5349-2013 Mechanical vibration – Measurements and evaluation of human exposure to hand-transmitted vibration*, *Part 1: General requirements*; and *Part 2: Practical guidance for measurement at the workplace* (SA/ISO, 2013a, b). These standards do not set exposure limits for safe exposure but provide guidelines for the assessment of hand-arm vibration exposure and when health surveillance should be made available to workers.

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[5] For more information on measurement of vibration see manufacturers details/websites; such as Brüel & Kjær https://www.bksv.com/en; or Larson Davis http://www.larsondavis.com/ld-atlas; Svantek https://www.svantek.com/lang-en/about#company_profile.

AS ISO 5349.1 requires that hand arm vibration is evaluated based on the vibration total value (VTV). The VTV is obtained from the root-sum-of-squares of the three root-mean-square component values (X, Y and Z). This is because the vibration characteristics of power tools are not dominated by a single vibration directional component (Groothoff, 2015). Vibration exposure evaluation based on this method will have values greater than evaluations based on measurement of a single vibration direction. The VTV will be typically between 1.2 and 1.5 times higher but can be up to 1.7 times higher. The daily vibration exposure is expressed in the 8-hour energy equivalent acceleration value A8. This is in line with the traditional 8-hour 'Time Weighted Average' normally used for evaluating things like noise and chemical exposures (Groothoff, 2015).

Annex B in Part 1 of the standard provides extensive information on the vascular, neurological and musculoskeletal disorders that may result from exposure to hand-arm vibration. Annex C provides, among others, a chart which indicates the vibration exposure for predicted 10% prevalence of vibration-induced white finger in a group of exposed persons, based on *A8* acceleration values in m/s^2. Annex E provides information on preventative measures which should be taken by those workplace parties with OHS responsibilities. In Annex C it identifies people who are at greater risk due to medical conditions and should be assessed before they use vibrating equipment. Among these are people who suffer from Primary Raynaud's disease (SA/ISO, 2013a).

5.2 National policy

In the absence of regulations limiting vibration exposure, Safe Work Australia has released in October 2015 a series of guidance documents for both whole body vibration and hand arm vibration. These are:

For Whole Body Vibration:

- Whole body vibration information sheet (SWA, 2015c)
- Guide to measuring and assessing workplace exposure to whole body vibration (SWA, 2015d),
- Guide to managing risks of exposure to whole body vibration (SWA, 2015a).

For Hand-Arm Vibration:

- Hand-arm vibration information sheet (SWA, 2015e),
- Guide to measuring and assessing workplace exposure to hand-arm vibration (SWA, 2015f)
- Guide to managing risks of exposure to hand-arm vibration in workplaces (SWA, 2015b).

These documents can be freely accessed from the Safe Work Australia website.[6]

The guides to measuring and assessing vibration follow the relevant Australian Standards mentioned above as well as the European Vibration Directive 2002/44/EC (EC, 2002; European Parliament, 2002). By adopting the Vibration Directive in its guidance material Safe Work Australia has set a clear path to follow for Australian workplaces when managing all aspects of vibration exposure and demonstrating due diligence under work health and safety and mining legislation.

In the guides for measuring and assessing whole-body and hand-arm vibration Safe Work Australia has adopted the Exposure Action Values and Exposure Limit Values expressed over a normalised 8 hour work shift, A(8), as stated in the Vibration Directive. When a worker is exposed to vibration above the Exposure Action Value, steps should be undertaken to reduce exposure to below this value (SWA, 2015d, f .

The Guides acknowledge that measurement of vibration, be it whole-body or hand-arm, could be difficult and complex. The guide to measuring and assessing whole body vibration indicates that where workers report whole body vibration as uncomfortable it may be that the exposure to vibration has reached levels that could affect their health. Similarly with hand-arm vibration, where workers report symptoms like tingling and numbness after using vibrating tools it is likely that their exposure level is reaching levels which could lead to Hand-Arm Vibration Syndrome (HAVS).

A simple test that workers could do is to tap the fingers of both hands with their fingertips after about ten minutes of continuous vibrating tool use. If that gives a tingling sensation the tool may, in the long run, produce too much vibration for the task performed. A measurement of the vibrating tool is then recommended to provide information of the vibration emission levels (Groothoff, 2015).

The guide for measuring and assessing whole-body vibration provides detailed information on risk management and control, whereas the guide for measuring and assessing hand-arm vibration concentrates on the measuring of hand-arm vibration and introduces an Exposure Point system. This system assigns 100 points to the Exposure Action Value of $A(8)$ 2.5m/s^2 and 400 points to the Exposure Limit Value of $A(8)$ 5m/s^2. The guide provides a few worked examples on how to determine the total daily vibration exposure $A(8)$ with the Exposure Point system. The Exposure Point system, together with manufacturer declared emission

[6] See www.swa.gov.au.

values for the tools, may give useful information to the generalist OHS professional for the management of vibration hazards without having to do the complex measurements, unless these may still be required after the initial investigation.

6 Legislation

In contrast to the European *Directive 2002/44/EC – Vibration* (EC, 2002), no Australian OHS jurisdiction has regulations in place limiting the exposure of workers to vibration and it is not addressed in the model Work Health and Safety Regulations. At present it is not known when a Code of Practice for Vibration will be established by Safe Work Australia, despite discussions about it for some time now. However, the Code of Practice: Hazardous Manual Tasks (SWA, 2018) provides information on the identification, assessment and management of tasks involving vibration exposure of workers whose health may be at risk. In this regard the guides produced by Safe Work Australia provide supporting material for managing and controlling vibration exposure of workers.

As there are no regulated exposure limits specified under health and safety legislation or mining legislation in Australia, obligation holders must take reasonable precautions and apply due diligence to reduce the risks from exposure to vibration in their workplaces.

Under health and safety legislation, persons conducting a business or undertaking (PCBUs), employers etc. must ensure that workers who operate vibrating plant or equipment can do so without their health and safety being affected. Under mining legislation senior mine executives must have systems in place ensuring risks from mining operations, including plant or substances are at an acceptable level. Hereto these parties must develop, implement and maintain management structures that accommodate training, supervision and control of all operations on each shift and regularly monitor and assess the working environment, plant and equipment to ensure risks to health and safety are at an acceptable level (Groothoff, 2015).

Designers, manufacturers, importers and suppliers of plant and erectors and installers of plant also have obligations under both work health and safety and mining legislation. Their obligations include the requirement that plant and equipment are so designed and installed that they do not cause risks to health and safety when operated correctly and that sufficient information is provided with the plant and equipment that it can be operated safely at the workplace.

7 Control of vibration hazards

Since the establishment of the *Directive 2002/44/EC – Vibration* in July of 2002 it has become accepted practice in Australia to follow this Directive to demonstrate 'due diligence' in the management of workers' vibration exposure (see, WHSA s 27, SWA, 2016, SWA 2015 a, b, c, d, e, f; Griffin, 2004). Due diligence with respect to management of vibration hazards includes 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)]

With the publication of Safe Work Australia's vibration guidance material in 2015, which adopted the EC Vibration Directive, following this Directive for the assessment and management of vibration is now established as the norm and should go a long way in demonstrating due diligence.

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): 2.5m/s^2 *A*(8)

daily exposure limit value (ELV): 5m/s^2 *A*(8)

For whole-body vibration:

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

daily exposure limit value (ELV): 1.15m/s^2 *A*(8) or *VDV* 21m/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 (EC, 2002) requires employers, where there is likely to be a risk from exposure to vibration, to:

- Reduce exposure to a minimum
- Assess the risk and exposure
- Plan and implement control measures to reduce risks
- Keep exposures to below the exposure limit value
- Provide information and training on the risks and their control
- Provide appropriate health surveillance when an assessment indicates a risk for vibration disorders
- Monitor and review the effectiveness of the risk-control program (EC, 2002).

These requirements of the Directive assist in demonstrating due diligence.[7]

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 springs 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.[8]

Recommended controls for hand-arm vibration include:

- Elimination/design
    - Incorporating anti-vibration handles in tools
- Engineering

[7] 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.

[8] For more information on controls for whole-body vibration, see SWA 2015a; Mc Phee, Foster and Long (2009).

  - 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.[9]

8 Implications for OHS practice

Assessment of vibration is one of the most overlooked health hazards with a very low level of risk assessment. Reasons include: difficulties in measurement; uncertainties in outcomes; and cost of instrumentation. Vibration exposure is however a hazard in many industries. Prevention of vibration caused disorders is not only a legal obligation under OHS and mining legislation, but also an ethical issue as people's health is affected by vibration, impacts their social life and potentially reduces career prospects.

The *Directive 2002/44/EC – Vibration* (European Parliament, 2002) provides guidance for the assessment of vibration exposure. The guidance material produced by Work Safe Australia (SWA, 2015a, b, c, d, e, f) provides comprehensive information on all aspects for the management and measurement of both hand-arm and whole body vibration.

[9] For more information on controls for hand-arm vibration see SWA 2015b.

The generalist OHS professional has an important role in identifying the presence of potentially hazardous vibration, undertaking basic assessments and providing preliminary advice on control measures. Management of vibration hazards is a specialist area with advice able to be sourced from mechanical engineers, noise and vibration engineers, ergonomists and occupational hygienists. The generalist OHS professional should recognise when specialist advice is required and be able to coordinate and work with specialists.

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

- Policies and procedures are developed for the vibration management program
- Purchasing policies include buying plant and equipment with lowest vibration emissions
- Hazard-identification processes and workplace inspections include subjective and/or objective assessment of vibration exposure surveys conducted by suitably qualified persons
- Maintenance processes address both noise and vibration issues, and include monitoring of condition of plant and equipment for vibration
- Managers, supervisors and workers receive appropriate information and training on vibration hazards
- The effectiveness of the vibration management program is monitored through audits and other appropriate measures and updated where necessary.

9 Summary

While ‘blue collar’ occupations are most affected by noise and vibration hazards, vibration is less likely to be investigated because of perceived difficulties in its assessment and management. This situation is not helped by the absence of exposure standards regulating vibration exposure. The establishment of *Directive 2002/44/EC – Vibration* (European Parliament, 2002), and Safe Work Australia’s guidance material for the management of vibration risks and the measurement and assessment of hand-arm and whole body vibration (SWA,2015 series) provides guidance to those parties with OHS obligations to comply with their duties under WHS and Mining legislation.

Despite different health impacts, noise and vibration hazards have similar sources, behave similarly and, from a prevention and engineering perspective, have similar controls.

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

Key thinkers

Brammer, A.J. Crede, C.E. Griffin, M.J, Hamilton, A. Taylor, W. Lalor, N. Pelmear, P.L. Raynaud, M. Wasserman, D.E.

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[10] Safe Work Australia updates the model Act, regulations and codes of practice from time to time. OHS professionals should check the SWA website (www.safeworkaustralia.gov.au) for the latest editions.