A Review of Occupational Noise in New Zealand

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1. Introduction

This paper started life as an adaptation of the occupational noise chapter from the Massey University course notes for the 300-level paper '214.316 Bio-Physical Effects of Noise and Vibration'. But with the new Health and Safety at Work Act 2015 due to come into force 4 April 2016, it was decided to produce a heavily condensed version of the chapter that integrates the new legislation and then follow it up with a discussion paper on where occupational noise regulations and practice in New Zealand should go.

The International Labour Organization (ILO) defines occupational health and safety as "*the outcome of adequate protection for a worker from sickness, injury and disease arising from work*". In this context the term occupational noise includes "*all sound in the workplace, whether wanted or unwanted*".

1.1 New Zealand workforce by industry sector

In terms of sector employment by occupation, figure 1 illustrates a breakdown of the New Zealand workforce by industry sector (data sourced from the New Zealand Labour market tables [1]).

Approximately a quarter of the total workforce is in potential '*noisy*' industries, with agriculture, forestry, fishing, mining, manufacturing, electrical and construction. In terms of people in these industries, this equates to approximately 25% of the total workforce and includes both the primary and manufacturing sectors.

Occupational noise is associated with every work place, from low-levels in open-plan offices, through to very high noise levels associated with industry based activities such as manufacturing, processing or construction. Various types of workplaces are associated with a high risk of occupation noise exposure. Such workplaces include (but are not limited to) employment in various production based industries, the defence or military and musicians. High levels of unmanaged occupational noise remain a problem in all regions of the world including throughout New Zealand.

Figure 2 shows the range of sound pressure levels (L_{Aeq}) across industrial construction and music/entertainment industries. This data is sourced from OSHwiki a website developed by European Agency for Safety and Health at Work [2]. In terms of the peak sound levels (L_{peak}) for these industries, they typically range from 101 to in excess of 140 dB L_{peak}. In some sectors, like armed forces and other

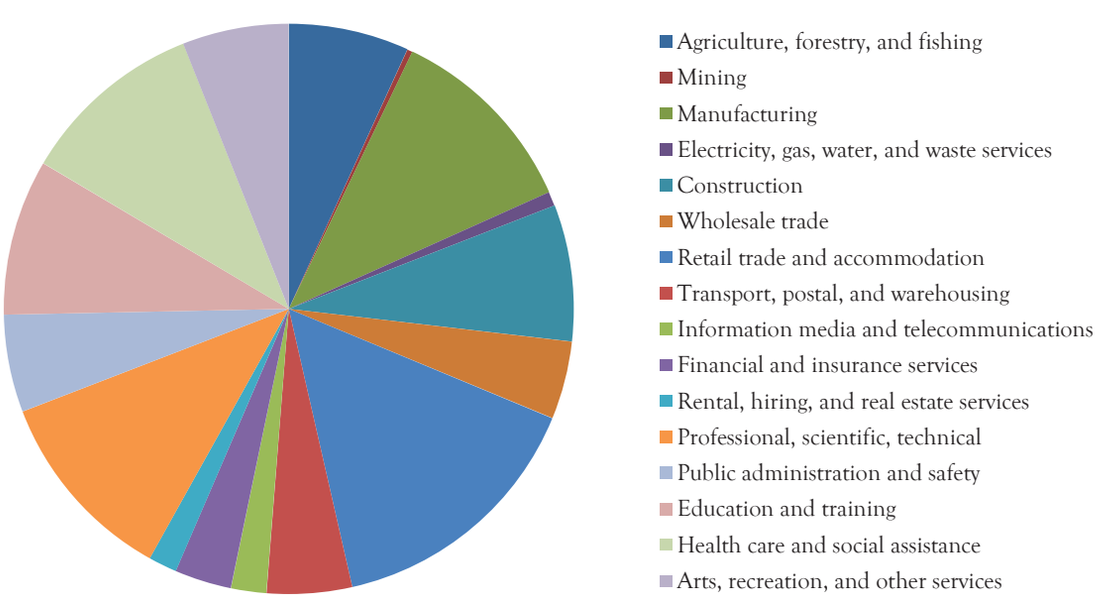

Figure 1: Occupation breakdown (of '*noisy*' Industry) by percentage of employed population

explosives work, peak sound pressure levels may be as high 170 dB.

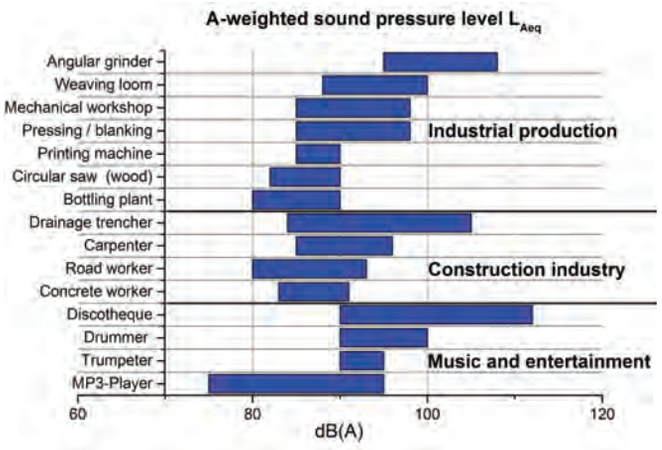

Figure 2: Measured sound pressure level L_{Aeq} (dB) range, across entertainment, construction & production industries

1.2 Occupational Noise - Health Effects

It is generally accepted by experts that at noise exposure levels of less than 70 dB L_{Aeq}, even for extended periods, there is little or no likelihood of any effect on long term hearing acuity (sensitivity). This is supported by the World Health Organization (WHO) which states that hearing impairment is not expected to occur at levels as high as 75 dB $L_{Aeq,8h}$, even for prolonged periods of noise exposure [3].

It is estimated that currently around a quarter of the total New Zealand workforce of approximately 1.47 million workers, are affected to some degree by harmful noise at work [4]. Based on current trends, this is a major cost and burden to New Zealand which will only become worse in the future. It is further estimated that somewhere in the region of 180 million persons worldwide could currently be affected to at least some degree, by noise-induced hearing loss (NIHL) from occupational noise exposure. There are several motivators to assess the burden of disease related to occupational noise. Occupational noise is a widespread risk factor with a strong evidence base linking it to an important health outcome which includes hearing loss.

Occupational noise is distinct from environmental noise, as it is defined as being associated with employees in the workplace and hence the responsibility of employers as well as individual employees. An assessment of the burden of disease associated with occupational noise can help guide policy and focus research on this problem. This is particularly important in light of the fact that policy and practical measures can be used to reduce exposure to occupational noise [5].

1.2.1 Noise Induced Hearing Loss (NIHL)

Noise induced hearing loss (NIHL) stems from long term exposure to loud sound. The effects of NIHL include permanent reduced hearing acuity through to tinnitus. Males and females are believed to be equally at risk of NIHL for the same sound exposure. The hearing impairment occurs predominantly in the higher frequency range from 3 to 6 kHz, with the largest effect typically at 4 kHz. But with increasing sound pressure levels and exposure time, NIHL occurs even at lower frequencies [3].

NIHL is one of the major causes of disability in the world. The Accident Compensation Corporation (ACC) webpage [6] defines NIHL in lay terms as:

> "*permanent deafness that happens when your ears are exposed to sounds over a period of time which are generally too loud for them to handle. It doesn't hurt and it doesn't happen straight away, so you don't know it's happening. In fact it can take ten or twenty years before you know you've got a problem, and by then there's nothing you can do except prevent further damage*".

1.2.2 Non-Auditory and second tier health effects of noise

It is well documented that there are additional health risks related to noise exposure. These 'non-auditory effects' may be defined as all those effects on health and well-being which is caused by exposure to noise, excluding NIHL. There are a host non-auditory effects that may occur in an occupational noise setting. These may include annoyance, increased accidents and reduced productivity due to interference with performance tasks such as reading, writing or speech interference resulting in communications difficulties.

These non-auditory effects can themselves have a host of second tier health effects including sleep disturbance and physiological and psychological stress. In all cases the level of effect depends on a host of factors including the sound pressure level, the type of sound and the exposure time. However, the level of annoyance and stress do not necessarily relate directly to the actual sound pressure levels, such that even at low-levels of noise, some individual may be significantly affected. The potential effects can be made worse by a host of other factors including the age of the person, whether or not they already have hearing disabilities and/or other health issues.

The main social consequence of hearing impairment is an inability to understand speech in daily lives, which is considered a severe social handicap. Even small levels of hearing impairment (10-15 dBHL (dB hearing loss) averaged over 2 to 4 kHz, and over both ears) may have an effect on the understanding of speech. When the hearing impairment exceeds 30 dB, a social hearing handicap is noticeable [7]. The masking effect of interfering noise in speech discrimination is more pronounced for hearing-impaired persons than for persons with normal hearing. This is particularly true if the interfering noise is composed of speech or sound in a similar frequency range to speech. As the sound pressure level of an interfering noise increases, people automatically raise their voice to overcome the masking effect of the interference and

this imposes an additional strain on the speaker. For someone with normal hearing, even if the interfering sound is moderately loud, most of the sentences during ordinary conversation can still be understood fairly well. Nevertheless, the interpretation required for compensating the masking effect of the interfering sounds, and for comprehending what was said, imposes an additional cognitive strain on the listener.

2. Responsibility for workplace health and safety in New Zealand

The Crown (government) Agency responsible for workplace health and safety in New Zealand is 'WorkSafe New Zealand'. They are a standalone Crown Agency, formed in 2013 and who focuses only on workplace health and safety issues, including workplace noise. Historically the 'Department of Labour' (DoL) was responsible for workplace health and safety, however they were dissolved in 2012 and its duties integrated into the then new Ministry of Business, Innovation and Employment (MBIE) formed in July 2012. The MBIE was a merger of the Department of Building and Housing (DBH), the Department of Labour (DoL), the Ministry of Economic Development (MED), and the Ministry of Science and Innovation (MSI). WorkSafe New Zealand has since undertaken MBIE's responsibilities for workplace health and safety. The key catalyst for the creation of the standalone WorkSafe New Zealand agency was a key recommendation of the Royal Commission on the Pike River Coal Mine Tragedy. Worksafe is responsible for administering health and safety legislation in all workplaces, except on ships where Maritime New Zealand is responsible and on operating aircraft where the Civil Aviation Authority (CAA) is responsible.

3. New Zealand's health and safety legislative framework and structure

3.1 The Health & Safety in Employment Act 1992

Before 4 April 2016, the Health and Safety in Employment Act 1992 (HSE Act 1992) was the principal health and safety statute. It follows other western legislative models in moving from a prescriptive approach to a general duty approach. The HSE Act came into force on 1st April 1993. Figure 3 shows the general hierarchy for the health and safety documentation with an emphasis on occupational noise. The HSE Act 1992 is at the top, followed by the Health and Safety in Employment Regulations 1995 (HSE Regulations 1995). Which in turn are supported by the Approved Codes of Practice (ACoP), followed by Standards and Technical Guidelines.

The overall aim of the HSE Act 1992 was to prevent harm occurring in the workplace, including potential harm from noise. Under each the Act, "Duty Holders" are required to take 'all practicable steps' to remove, control, or otherwise manage hazards in the workplace including noise. In general terms a '*Duty Holder*' is a person upon whom a duty is imposed. In regards to the Act, this can be employers, employees, principals, persons who control places of work, self-employed, persons in charge, or persons selling or supplying plant for use on a place of work.

To ensure compliance, the Act also gives specific duties to Inspectorates. Detail on how to achieve required performance is provided through approved codes of practice, standards, industry codes of practice and guidelines.

There are a number of additional Acts which also impact on workplace health and safety such as the Health Act 1956. The Health Act 1956 lists noise and vibration as a nuisance under Section 29 Ka. This was added to the list of (statutory) nuisances in 1978 and further amended in 1993. Section 29 Ka states where any noise or vibration occurs in or is emitted from any building premises, or land to a degree that it is likely to be injurious to health. The burden of proof is high in being able to prove that noise/vibration is of such a level and nature that it is likely to be injurious to health. Medical practitioners are required to notify the medial officer of health and local authority any cases of notifiable infectious diseases. There are also other non-person to person infectious conditions that are notifiable to the medical officer of health which include parasitic tapeworms, decompression sickness, lead absorption to a prescribed level, and poisoning arising from chemical contamination. Injury caused by noise is

Figure 3: The current Health and Safety hierarchy in New Zealand for Occupational Noise

not a notifiable condition under the Act.

Core sections of this HSE Act 1992 include Section 6 (s.6) which requires employers to take '*all practicable steps*' to ensure the safety of employees at work, and to provide a safe working environment. Under the HSE Act 1992, all employers are required:

> "*to ensure the safety of employees, thus every employer shall take 'all practicable steps' to ensure the safety of employees while at work; and in particular shall take all practicable steps to provide and maintain for employees a safe working environment; as well as provide and maintain for employees while they are at work facilities for their safety and health; and ensure that plant used by any employee at work is so arranged, designed, made, and maintained that it is safe for the employee to use; and ensure that while at work employees are not exposed to hazards in their place of work; or near their place of work*".

Under Section 2A of the HSE Act 1992, it states that all practicable steps in relation to achieving the requirements of the Act and any result in any circumstances, means all steps to achieve the result that it is reasonably practicable to take in the circumstances having regard to:

(a) the nature and severity of the harm that may be suffered if the result is not achieved; and
(b) the current state of knowledge about the likelihood that harm of that nature and severity will be suffered if the result is not achieved; and
(c) the current state of knowledge about harm of that nature; and
(d) the current state of knowledge about the means available to achieve the result, and about the likely efficacy of each of those means; and
(e) the availability and cost of each of those means.

Section 2 (s.2) 'Interpretation', of the HSE Act 1992, does not define noise and the Act does not incorporate vibration. However, other legislation such as the Resource Management Act 1991 does include vibration under the definition of noise which states "*noise includes vibration*" (refer to Part 1 'Interpretation and application' [9]).

3.2 The Health and Safety in Amendment Bill 2001 and Employment Amendments Act 2002

The Health and Safety in Employment Amendment Bill 2001 was introduced in October 2001 and enacted as 'The Health and Safety in Employment Amendment Act 2002' (HSEA Act 2002) which came into force on 5th May 2003. Amendments included (but not limited to) extending coverage of the Act so to now include the crew of aircraft in certain circumstances, and the crew of ships governed by New Zealand law. Mobile workers were also specifically covered. Additional amendments implied new duties being imposed on persons regarding the sale or supply of plant for use in a workplace as well as providing increased protection to volunteers, persons on work experience and employees 'on loan' i.e. secondment to another employee. The definitions of "harm" and "hazard" were amended to explicitly include stress and fatigue (s.2(1)) while the definition of "all practicable steps" was expanded. The amendments also prohibited persons from being "*indemnified or from indemnifying others against the cost of fines and infringement fees for failing to comply with the Act*".

3.3 The Health and Safety at Work Reform Bill and the Health and Safety at Work Act 2015

In August 2013 the National Government introduced a reform package called '*Working Safer: a blueprint for health and safety at work*'. This blue print became part of the introduction of the *Health and Safety Reform Bill*, introduced in June 2014. The Health and Safety Reform Bill represents a significant part of the Government's health and safety reform package designed to help achieve

a significant reduction in unwanted statistics relating to workplace accidents and deaths.

The Health and Safety Reform Bill was passed into legislation to create the new 'Health and Safety at Work Act 2015' (HSW Act 2015). This replaces the HSE Act 1992 and comes into force on 4th April 2016. The Acts structure and content closely follows the Australian Work Health and Safety Act and regulations. The HSW Act 2015 states the purpose of the new legislation in positive terms, through identifying that workers are to receive the '*highest level of protection*'. This ensures that the safety of workers is to take primacy in interpreting and applying the Act.

A core concept in the HSW Act 2015 is that of '*a person conducting a business or undertaking*' (PCBU). The PCBU will be the primary Duty Holder, whose duties will replace those of employers, principals and persons in control and the like under the Act. It is understood that the definition of PCBU is intentionally wide in order to reflect the wide array of modern working arrangements. The concept of 'employee' in the HSE Act 1992 is replaced by 'worker' in the new HSW Act 2015, with a wide definition that includes; contractors, subcontractor, outworkers and volunteers. The Act expressly provides that a PCBU will not include workers.

The 'all practicable steps' language of the HSE Act 1992 has been replaced with 'reasonably practical' in the new HSW Act 2015. This extends the previous concept, in particular it now includes what the person concerned knows, or ought to reasonably to know, about the hazard or risk and ways of eliminating or minimising the risk. Throughout the new Act the concept of '*reasonable care*' is applied in different ways; 'reasonable efforts', 'reasonable policy', 'reasonable steps', 'reasonable opportunities' and so forth.

Although some commentators are stating that the HSW Act 2015 is a welcome modernisation of health and safety law in New Zealand, with simple plain language, some commentators have also stated that it has on face value significantly weakened occupational noise as a hazard. For example, while Schedule 1 (s2(4)) 'Serious harm' of the HSE Act 1992 specifically included "*...noise-induced hearing loss...*" the new HSW Act 2015 does not mention noise in anyway. The closest characterisation under notifiable injury or illness would be the "*loss of a bodily function*" category.

Figure 4 shows the general hierarchy for the health and safety documentation under the new HSW Act 2015 with an emphasis on occupational noise. The HSW Act 2015 is at the top, followed by regulations, in particular Regulations 11 of the transitional Health and Safety in Employment Regulations 1995. This is then followed by a new tool called 'Safe work instruments'. These have legal effects to the extent that regulations refer to them, are developed by regulators (such as Worksafe NZ) and have limited purposes. These are in turn supported by the ACoP and other documentation, such as standards and guidelines.

3.4 Health and Safety in Employment Regulations 1995

The Health and Safety in Employment Regulations 1995 (HSE Regulations 1995) were made pursuant to Section 21 (s.21) of the HSE Act 1992 and apply to all workplaces. The regulations cover:

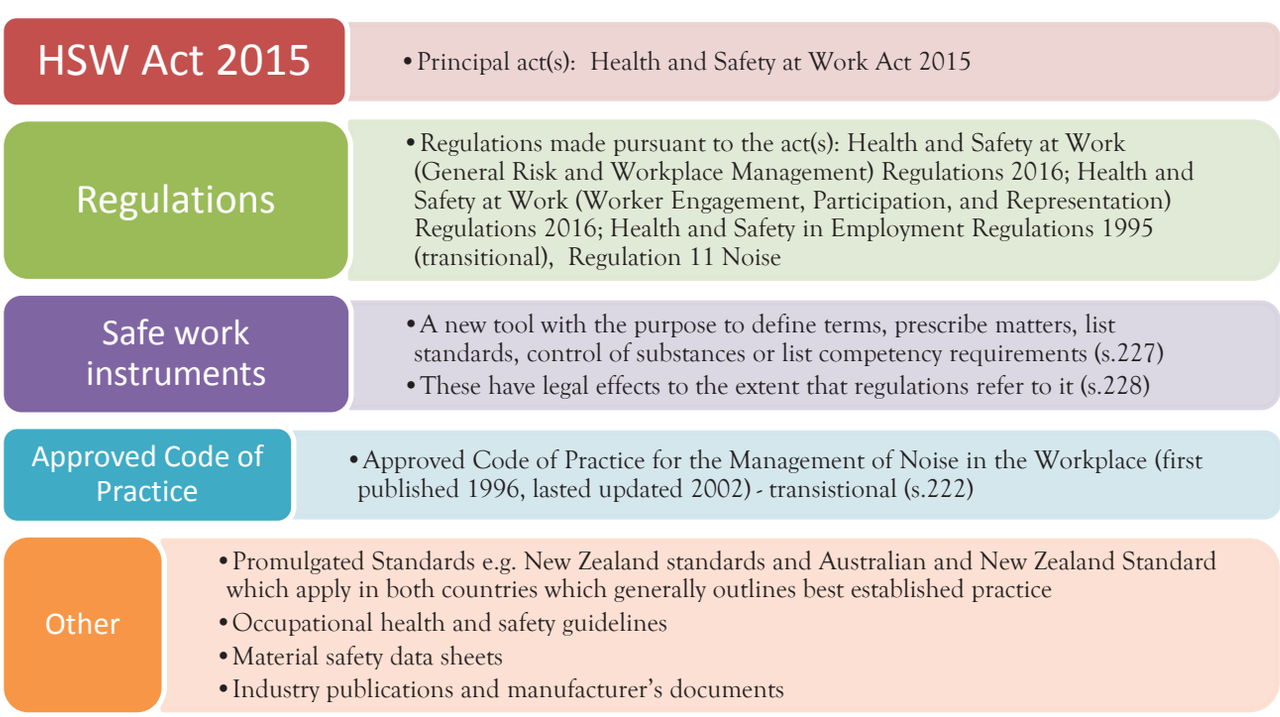

Figure 4: The new health and safety hierarchy in New Zealand for occupational noise

- Facilities required for the safety and health of employees;
- Precautions to be taken with some particular hazards;
- Notification of hazardous construction and forestry work;
- Certificates of competence for some kinds of work; and
- Young people in hazardous places of work; and
- Agricultural workers' accommodation.

Part 2 of the HSE Regulations 1995 covers 'Duties in relation to management of particular hazards' and the first named hazard concerns 'Duties of all employers in relation to noise at any workplace'. This duties section begins by stating what the terms 'employer' and 'employee' includes in relation to Regulation 11.

3.4.1 Regulation 11 – Noise (Transitional)

As part of the 'Transitional and savings provisions' of the HSW Act 2015, existing regulations remain inforce, but could be subject to amendment and revocation at a later date. The amended Regulation 11 of the Health and Safety in Employment Regulations 1995 still remains the key regulation relating to noise in the workplace and is as follows:

11 Noise

(1) Every employer must, so far as reasonably practicable, ensure in relation to every workplace under the control of that employer, that no employee is exposed to noise above the following levels:

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

(b) A peak noise level, L_{peak}, of 140 dB, —

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

(2) For the purposes of subclause (1) of this regulation,—

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

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

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

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

(a) The fact that noise levels at the workplace are or are likely to be hazardous; and

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

(c) Where such a device may be obtained.

Note 1: Subclause (2)(b) above relating to peak sound pressure level measurement states that the frequency weighting is 'unweighted' and to use 'P time-weighting'. At the time of this regulation 'unweighted' meant the most flat or linear frequency response that the instrument could measure and was not defined. With modern instruments this would more-or-less be equivalent to 'Z (frequency) weighting', which has defined characteristic. The 'P time-weighting' was specific to the Australian standard (that New Zealand adopted) at the time for sound level meters and was equivalent to the peak measurement specification of the IEC standard for sound level meters.

Note 2: Notation has undergone some transformation since the enactment of Regulation 11. The nomenclature for the units of noise exposure level in subclause (1) (a), "$L_{Aeq,8h}$, of 85 dB(A)", meaning a dB value using A (frequency) weighting, is now outdated, but still widely used. Modern notation is not to put any suffix onto the dB, for example, 85 dB $L_{Aeq, 8h}$.

There are no adjustments or penalties stated in Regulation 11 for various factors such as working for more than 8-hours per day, 5-days a week. However, guidance on this does appear in later editions of the AS 1269 when it became a joint standard with New Zealand in 1998 (see Section 3.6 below).

3.4.2 Regulation 11 – A Statistical analysis of risk for exposure to noise

As explained in "AS/NZS 1269.0:2005 Occupational noise management- Overview", the 85 dB $L_{Aeq,8h}$ exposure level is based upon statistical analysis of risk. For example, over an 8-hour day exposed to 85 dB LAeq, Part 4 of AS/NZS 1269 predicts 95% of the exposed population would not be expected to have a hearing loss that exceeded 10 dB (mild loss) over a working lifetime, while 5% would have greater than 10 dB hearing loss [10]. Other literature predicts that up to 35% of the population exposed to 85 dB $L_{Aeq,8h}$ every working day for 40 years would have a significant hearing loss (>30 dBHL) [11].

The risk analysis assumes an 85 dB $L_{Aeq,8h}$ daily exposure limit for 5-days a week and hence the remaining time they are assumed to be exposed to 'insignificant' or low-levels of noise. These assumptions may not be valid, for example, work patterns are often far more varied and may include multiple jobs and assumes no high-level noise exposure outside of work time. Without quiet periods outside of work hours, the hearing will not have time to 'recovery' from the occupational noise exposure.

Unlike the 85 dB $L_{Aeq,8h}$ continuous exposure limit, the peak sound pressure limit of 140 dB L_{peak} means a single exceedance event and hence no employee may be exposed to any single sound pressure level in excess of 140 dB L_{peak} at any time regardless of their sound exposure. It is important to note that unlike the 85 dB $L_{Aeq, 8h}$ exposure limit, the L_{peak} in not based on the daily noise exposure normalised to an 8-hour day but rather an absolute limit at any time throughout the working day. The reasoning behind the 140 dB L_{peak} exposure limit is that any sound intensities up to and in excess of 140 dB L_{peak} can cause permanent hearing loss with a single exposure. However, this limit is also based on the statistical analysis of risk and levels less than of 140 dB L_{peak} could cause hearing damage or loss to some persons. It should be noted that a sound intensity level of 140 dB L_{peak} or more would be uncommon in most industries but are commonly found defence applications such as on a firing range or munitions work.

One issue that is not covered by the statistical analysis of risk in assessing occupational noise on hearing impairment is the susceptibility of an individual to NIHL. There is increasing evidence that some individuals are far more susceptible to NIHL at significantly lower noise levels than 85 dB $L_{Aeq,8h}$ or the equivalent.

3.5 Approved Code of Practice: Noise in the workplace

Section 20 (s.20) of the HSE Act 1992 enabled the Minister of Labour to direct the Department of Labour to prepare, and submit for the Minister's approval, a statement of preferred practices, aims, arrangements, principles, characteristics, components, configurations, elements or states relating to work, plant, protective clothing or protective equipment, substances or practices relating to a particular health and safety issue. Such statements are approved by the Minister and become an '*Approved Code of Practice*' (ACoP).

Approved codes of practice are not legislation themselves but statements of preferred practice or best practice which may be produced in courts as evidence of suitable means of compliance with the Act. They do not necessarily provide the only way of complying with the Act, but they do offer acceptable solutions. There are currently thirty health and safety ACoPs. In regards to occupational noise management in the workplace, there is only one, the 'Approved Code of Practice for the Management of Noise in the Workplace'. This ACoP was originally issued in 1996 and reviewed again in 2002 but has not since been updated and over 13 years have passed. As part of Schedule 1, 'Transitional and savings provisions' of the new HSW Act 2015, an ACoP issued under Section 20 of the HSE Act 1992 continues in force as if it had been made under this Act subject to any necessary modifications. Currently no amendments or modifications to this ACoP, has been published by Worksafe.

The ACoP for the 'Management of Noise in the Work Place' requires a preliminary assessment to identify the areas in a place of work where noise levels are likely to, or actually, exceed the exposure limits. The ACoP states the results of the preliminary assessment should determine which tasks, processes or areas in the workplace require detailed assessment. The approved codes states that preliminary assessments should be carried out when there has been no previous assessment, or when previous assessments are greater than 5 years old. Practically this means they should be carried out at least once every 5 years. Once the preliminary assessment is conducted a detailed assessment is required, this detailed assessment will among other things quantify the amount of noise to which employees are exposed, identify sources of noise and assist in developing noise control strategies and including if required, prescription of appropriate hearing protectors. The ACoP also stressed that follow up assessment should be required to monitor any change.

An important issue raised by the ACoP is that assessment work shall be carried out by 'Competent Persons'. The ACoP acknowledges that employers are not expected to become experts in noise or related areas however employers are expected to obtain the assistance of 'competent persons' with expertise in noise control and noise measurement and assessment. The ACoP states that examples of persons who possess competency through a combination of education, formal qualifications and experience are acoustic engineers. Further details on assessments and 'The competent person', can be found in Sections 6.2 and 6.3 of this paper.

3.6 New Zealand Standards for occupational noise

A 'New Zealand Standard' means a standard promulgated by the 'Standards Council' as a New Zealand Standard under the Standards Act. In essence, Standards are documents that provide requirements, specifications, and guidelines or benchmarks that, when applied correctly; promote consistency to ensure an agreed way of doing something, i.e. "standardisation". For example, standardised methods of measuring and assessing sound, if applied correctly, should produce consistent results.

The Australian Standard AS 1269 started out in 1989 with a single part titled 'Acoustics - Hearing conservation' as referenced in Regulation 11 of HSE Regulations 1995. It was withdrawn in 1998 and replaced by a far more comprehensive five part (0 to 4) standard on occupational noise management that was jointly adopted by both Australia and New Zealand as AS/NZS 1269:1998. All parts of the standard were updated in 2005 and part 4 on 'Auditory assessment' was updated in 2014.

AS/NZS 1269.0:2005 'Occupational noise management-

Overview', provides an overview and general requirements for the occupational noise management series AS/NZS 1269:2005. This standard sets out requirements for, and provides guidance on, the types of noise assessments which may be necessary and suitable noise measuring instruments to carry them out. The procedures for noise measurement are also included.

AS/NZS 1269.1:2005 'Occupational noise management-Measurement and assessment of noise immission and exposure', provides detailed information pertaining to the noise survey types and triggers. Section 6 of this Standard sets out the types of noise surveys: preliminary; detailed; follow up; or supplementary. The standard states that a preliminary assessment should be carried out if previous assessments are more than 5 years old as well as if any changes to the noise environment are made; generally the preliminary assessment is a walk through audit. It also states that detailed surveys are required if any employee is likely to be exposed to excessive noise (levels that exceed 85 dB $L_{Aeq,8h}$ or 140 dB L_{peak}). This is the 'trigger' for a detailed survey, the fact that after conducting a preliminary assessment that any employee is exposed to limits over that permitted in the legislation. AS/NZS 1269.1:2005 also notes that follow up or supplementary assessments should be taken at least every five years, or if for example there are changes for various factors such as new plant, layout changes or new production processes.

Overall the key objective of noise surveys are to guide and determine if employees are being exposure to excessive noise and if so, to obtain further detailed and specific survey information that will help reduce noise and ensure suitable engineering methods are adopted as well as assisting with planning and hearing conservation.

3.6.1 Instrumentation and calibration

Section 7 of AS/NZS 1269.1:2005 'Instrumentation and calibration', provides a guide for the instruments that may be used when performing occupational noise surveys and references the international standard for sound level meters, IEC 61672. Section 7.2 implies that an integrating averaging sound level meter should be used, the sound level meter should be at least Class 2/Type 2[1] and preferably Class 1/Type 1 but allows for the use of Class 2/Type 2 noting that any person using this instrument must allow for the reduced accuracy of this instrument. AS/NZS 1269.1:2005 also states that any acoustic testing should ensure, especially for Type 2/Class 2 that the instrument is capable of accurately measuring peak sound pressure levels. Overall the use of a Class 1/Type 1 with frequency analysis is recommended by the standard. Of importance, the standard also recommended observed measurement.

1 The 'Type' designation is not used in IEC 61672 but in earlier standards for sound level meters. Generally speaking the newer 'Class' designation provides stricter tolerance on performance of the instrument than the older historic 'Type' designation.

Section 7.3 of AS/NZS 1269.1:2005 covers the use of a personnel sound exposure meter (PSEM), also known as a dosimeter. The specification of PSEMs is defined in IEC 61252 (Electroacoustics - Specifications for personal sound exposure meters). Section 7.3 then goes on to state that the use of hand-held sound level meters by a competent person is preferred over PSEMs due to confounding issues. All the stated '*confounding issues*' relate to the unmonitored or uncontrolled use of these devices where the untrained wearer may shout across the microphone or tap the microphone or take it off for short periods. However, the use of PSEM in certain circumstances in preferred to hand-held meters and the stated 'confounding issues' can be suitably addressed by ensuing that the wearer of the PSEM is observed during the entire measurement period and sufficient detailed notes are recorded of the activities undertaken by the wearer. This would be consistent with best practice for making environmental noise measurements where observation is a key requirement. The last sentence in Section 7.3 confirms this by stating that if PSEMs are used, the wearer should be carefully monitored by a competent person to minimise any potential confounding issues.

Section 7.5 of AS/NZS 1269.1:2005 emphases the importance of the ability of the instrumentation to accurately measure peak sound pressure levels. While Class 2/Type 2 instruments can be used for preliminary assessment, Class 1/Type 1 should be used for detailed and follow-up assessments. The measurement of peak sound pressure levels are much more prone to confounding issues and by simply knocking or taping the microphone of an instrument can readily produce peak readings higher than 140 dB L_{peak}.

Section 7.6 of AS/NZS 1269.1:2005 specifies that the reference sound sources for field reference testing of the sound measuring instruments should be at least Class 2 and in accordance with IEC 60942. Section 7.10 covers the measuring system calibration and states that equipment should be calibrated in accordance with the relevant Standards at regular intervals not exceeding two years. In New Zealand the periodic testing of sound level meters and calibrators is undertaken in accordance with international standards, depending on the type of instrument being calibrated by laboratories that have quality assurance systems and calibration procedures independently accredited to the specific laboratory. All acoustic testing reports should include the calibration certificates.

3.6.2 Noise measurement procedures

Section 8 of AS/NZS 1269.1:2005, 'Noise measurement procedures', covers the type of instrumentation and measurement methodology and states that the analysis techniques used should be determined in accordance with the type of problem being assessed. It allows for

the use of two key measurement quantities for continuous noise exposure assessment. The traditional $L_{Aeq,T}$ or equivalent A-weighted sound pressure level (in dB) over the measurement period T and $E_{A,T}$, the A-weighted sound exposure (in Pascal-squared hours (Pa^2h)) over the measurement period T. This second measurement quantity (descriptor) E_A, is linear, so partial sound exposures can simply be added to produce the total sound exposure. Also, the $L_{Aeq,8h}$ sound level limit of 85 dB simply becomes 1.0 Pa^2h or 100% dose using this measurement quantity.

Section 8 also emphasises that there is always uncertainty in the measurements made but does not explicitly state how this should be handled. Section 8.2 on field reference level checking, says that if a discrepancy of more than +/- 0.5 dB (or +/-10% in the reference exposure reading) occurs between two successive checks, the measurements should be considered invalid. This is significantly tighter than normal practice for environmental noise assessment where a tolerance of +/-1.0 dB is used. There seems little scientific justification or benefit for such a tight tolerance, which if applied routinely, is likely to result in a significant number of measurements being treated as invalid, especially for dosimetry that is often occurs over many hours.

3.6.3 Noise evaluation and adjustments

Section 9 of AS/NZS 1269.1:2005, 'Noise Evaluation', covers the determination of key continuous noise quantities (descriptors) from the measurements. Section 9.1 emphasises that the preferred way to determine $E_{A,T}$ is to use a PSEM or integrating-averaging sound level meter and also shows the ease in which partial exposures can simply be added together to produce the total exposure and the average exposure over a 5-day working week. Sections 9.2-9.4 cover the determination of $L_{Aeq,T}$, converting it to an equivalent level over an 8-hour period and a normalised exposure level over a 5-day working week.

Section 9.4 provides detailed information on extended work-shifts and adjustments to normalised noise exposure level over an 8-hour work day. The standard states for work-shifts less than 10 hours, no adjustment is applied and for work shifts between 10 and 24 hours, up to +3 dB adjustment is applied. There is no equivalent adjustments stated when using sound exposure ($E_{A,T}$) as the descriptor but the dB values shown in Table 2 of the standard can be readily converted into a linear scalar. The +3 dB adjustment for work shifts between 20 and 24 hour would therefore become 2.0 multiplier for $E_{A,T}$.

3.6.4 Other Part of AS/NZS 1269

In addition to Parts 0 and 1 of AS/NZS 1269, there is Parts 2 to 4, summarised as follows:

- AS/NZS 1269.2:2005 'Occupational noise management-Noise control management'. This standard sets outs requirements and guidance on the management of noise control in occupational settings and applies to all types of workplaces and to all types of sounds.
- AS/NZS 1269.3:2005 'Occupational noise management-Hearing protector program'. This standard specifies administrative responsibilities associated with a hearing protector program; the selection, use and maintenance of various types of hearing protectors; and training and motivation in regard to hearing protector programs.
- AS/NZS 1269.4:2014 'Occupational noise management-Auditory assessment'. This standard supersedes AS/NZS 1269.4:2005 and is the most updated standard in the series which specifies procedures and requirements for air conduction pure tone audiometry (without masking) that are applicable to individuals whose hearing sensitivity might be adversely affected by occupational noise exposure and/or ototoxic agents (chemicals that can cause hearing impairment. It is understood that the relationship between these agents and exposure to hearing remain unclear and have not been altered to reduce hearing impairment risks. AS/NZS 1269.0:2005 'Occupational noise management- Overview' and related Appendix C provides further details on this topic.

3.6.5 Ultrasound and Infrasound in the workplace

Ultrasound is sound that is at a frequency above 20 kHz which humans cannot hear and Infrasound is at frequencies below 20 Hz that humans cannot hear but may feel as a vibration sensation. Exposure to ultrasound in the workplace would be limited to certain employment, such as medical practitioners and specialised fabrication. However infrasound exposure is likely to be more widespread, particularly for heavy goods vehicle drivers, workers at power plants or other heavy industries.

There are many international publications on both ultrasound and infrasound and guidelines exist internationally on safe exposure levels which it is believed adverse effects would not occur. Appendix H of the ACoP for the 'Management of Noise in the Workplace' provides comment on ultrasound and infrasound but the referenced technical reviews are now very outdated. Section 8.7 of AS/NZS 1269.1:2005 provides further guidance and comment on assessment of infrasound and ultrasound and recommend the use of one-third octave frequency measurements if there is a suspicion of exposure to infrasound or ultrasound. It also has a note to see 'AS/NZS 2243.5:2004 Safety in laboratories - Non-ionizing radiations - Electromagnetic, sound and ultrasound' for further guidance. This last Standard is of interest because Section '8.3.1 Effect of noise', states that these can include:

a) Temporary or permanent loss of hearing acuity;
b) Interference with speech and communication;
c) Disturbance of concentration tasks.

And that "*...infrequent, single, extremely loud sounds can cause instantaneous, permanent hearing damage*". In Section '8.3.4 Disturbance of concentration tasks', it states that "*... various levels of background noise can disturb concentration... the more complex the task the greater the disturbance... keep levels below AS/NZS 2107, and these problems will not arise*". Then in the next Section '8.3.5 Low-frequency sound and infrasound non-auditory effects', it states that:

a) Low-frequency sound, up to 200 Hz can have non-auditory effects on the body;
b) At low levels, can lead to an individual feel unwell and can include feelings of nausea and headaches;
c) At high levels can result in physical damage;
d) Infra-sound is below 20 Hz...has similar non-auditory effects on the body to those of low-frequency sound.

This section concludes by saying see the guidelines for infra-sound exposure in the 'Approved code of practice for the management of noise in the workplace'.

3.7 Occupational noise mitigation and management hierarchy

The hierarchy of approaches explicit in the HSE Act 1992 are:

1. Significant hazards to employees are to be **eliminated** if practicable;
2. Significant hazards to employees are to be **isolated** where elimination impracticable;
3. Significant hazards to employees are to be **minimised**, and employees to be **protected**, only where elimination and isolation are impracticable (not before).

This hierarchy has been reinforced and extended under the 'Health and Safety at Work (General Risk and Workplace Management) Regulations 2016' (HSW-GRWM Regulations 2016), released 15 February 2016. These regulations introduce the detail to comply with the Health and safety duties - key principles of Section 30 of the HSW Act 2015 - Management of risk (s.30).

Duty to eliminate risks as far as reasonable practicable and if not possible:

- Risks are to be **minimised** as far as reasonably practicable ;
- Not transferable to another person;
- One person can have more than one duty;
- Must consult other persons with the same duty.

Clearly the elimination of any hazard must be the ultimate aim if at all reasonably practicable. The above regulations require a risk management process to be implemented in the minimisation of hazards.

- There is a duty to identify hazards (reg. 5)
- A hierarchy of control measures applies if not reasonably practicable to comply with (s.30) of HSW Act 2015, that is, eliminate risk, minimise risks to health and safety, implement control measures in accordance with this regulation by taking 1 or more of following (reg. 6):
  (a) substitution (wholly or partly) with something that gives rise to a lesser risk
  (b) isolating the hazard giving rise to the risk to prevent any person coming into contact
  (c) implementing engineering controls
  (d) if risk remains – implement administrative controls
  (e) if risk remains then personal protective clothing.
- There is a duty to maintain effective control measures fit for purpose and set up correctly (reg. 7) and duty to review control measures (reg. 8).
- There is a duty to provide information supervision training and instructions to workers (reg. 9).

Although the HSW Act 2105 does not mention noise as a hazard, the authors have assumed that under item (e) above 'personal protective clothing', that hearing protection devices would be part of *protective clothing*.

There are a host of methods that can be adopted in noise control at the design and planning stage. This includes design and specification of work spaces, areas and equipment ('buy quiet' [12]), through to location of plant, vents and so forth through the work areas. Once implemented, processes need to be put in place round maintenance of equipment and plant to ensure that sound pressure levels do not rise over time.

There are many cost effective administrative controls that may be effective in reducing the risk of NIHL and this includes signage in high noise areas where hearing protection is required and on-going staff training and education around noise hazards.

3.7.1 Selection of hearing protection devices

When controls measures cannot reduce noise exposure levels to comply with the lawful noise criteria, hearing protection will need to be used as part of the overview noise management programme. The primary criterion for selection of hearing protectors is that the continuous level of noise entering the ears is reduced to below 85 dB $L_{Aeq,8h}$. Appendices A and B of AS/NZS 1269.3:2005 cover methods for the selection of hearing protectors. It is important to correctly select hearing protectors that are not only effective in reducing the noise level, but are also compatible with the working environment, in particular use with any other protective equipment.

Section 6.2.2 of AS/NZS 1269.3:2005 covers the issue of over-protection and states that attention should be paid to the risk this presents where the wearer may feel isolated making it difficult to perceive useful sounds. In extreme cases over-protection has been one of several factors leading to death of employees who could not hear and thus were not aware of impending danger. Over-protecting

can lead to a number of secondary issues ,including employees not wearing or inconsistently wearing of the hearing protectors thus also potentially leading to hearing loss. The authors note from direct experience that over protection is common. Most employers in noisy environments simply provide protectors with the highest standard rating and are ignorant of the potential risks of over-protection. The guidance in AS/NZS 1269.3:2005 on how much is over protection is rather weak, with it simply stating that "*generally Leff of 70 dB(A) or less could lead to over-protection*". It would be better if the standard referenced some of the other international standards such as 'BS EN 458:2004 Hearing protectors', which specifies 75 dB L_{Aeq} as acceptable and 80 dB as a good target "*in-ear*" noise level.

Sections 7 to 9 of AS/NZS 1269.3:2005 cover the fitting of hearing protectors, cleaning and maintenance, and inspection for defects to ensure that once selected, the protectors continue to perform as expected.

The Appendix A of AS/NZS 1269.3:2005 covers the selection of hearing protectors based on their 'Class' rating. This method involves measuring and assessing workplace noise using the equivalent $L_{Aeq,8h}$ over the working shift and then selecting from a suitable protector by Class 1-5 (see table 1). An alternative selection method is detailed in AS/NZS 1270:2002 "Acoustics– Hearing Protectors", based on the SLC_{80} rating (see Section 3.7.2 below). This involves measuring and assessing workplace noise using the equivalent $L_{Ceq,8h}$ (**note** the use of C weighting here) over the working shift and subtracting off this the target "in-ear" noise level (e.g. 80 dB L_{Aeq}) to produce the required SLC_{80} value.

The following table shows the relationship between the calculated exposure level ($L_{Aeq,8h}$) and the 'Class' number and the corresponding SLC_{80} range.

Table 1: Hearing protector rating

Class	Calculated exposure $L_{Aeq,8h}$ (dB)	SLC_{80} range
1	< 90	10 to 13
2	90 to < 95	14 to 17
3	95 to < 100	18 to 21
4	100 to < 105	22 to 25
5	105 to < 110	26 or greater
	> 110	Seek expert advise

The Appendix B of AS/NZS 1269.3:2005 covers the selection of hearing protectors when the peak value, L_{peak} (note no frequency weighting specified) exceeds 140 dB. It states that "*there is no standard method for quantifying the attenuation of hearing protectors to impulse sound*". At the time of the writing of the standard that was true, however in 2010 the new standard 'ANSI/ASA S12.42-2010- *Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures*' was released. This enabled hearing protectors to be rated under impulse noise conditions. Measurements using this standard have shown that generally the attenuation of peak levels is higher than the attenuation of continuous levels for a given hearing protection device.

3.7.2 Rating of hearing protectors

Hearing protectors in New Zealand are tested in accordance with AS/NZS 1270:2002 "Acoustics– Hearing Protectors." Detailed test results are commonly found on the packaging of ear plugs and ear muffs and they will state if they are rated under this standard.

In New Zealand SLC_{80} is the method that is used to rate hearing protection devices and it is defined in the standard, AS/NZS 1270:2002 'Acoustics–Hearing protectors'. SLC stands for 'Sound Level Conversion' and the '80' in SLC_{80}, refers to the amount of protection attained by 80% of users when the protector is properly fitted and maintained. This is based upon laboratory testing involving multiple fittings of a batch of the same hearing protectors, producing an average and a standard-deviation

Figure 5: Sample of hearing protectors illustrating AS/NZS certified ratings

of the level of attenuation in octave frequency bands. These results are then combined to produce the single number SLC_{80} rating. It should be noted that the SLC_{80} rating is significantly lower than the *average* attenuation across all frequencies to ensure 80% protection for a population of wearers.

In addition to the SLC_{80} system, there are other rating systems used internationally. NRR is an American based value that stands for '*Noise Reduction Rating*'. It is determined in accordance with the standard ANSI 3.19:1974, and the calculation is very similar to SLC_{80}. The other common value is SNR, which stands for '*Single Number Rating*'. The SNR estimates attenuation performance according to the noise spectrum of the environment in which the protector is to be worn. This system rating number is used by the European Union and affiliated countries. The SNR rating descriptor is defined in ISO 4869-2 Acoustics – Hearing Protectors. It should be noted that both the NRR and SNR systems are not used in New Zealand and Australia but information accompanying hearing protector may include a rating under one or both of these systems as well as SLC_{80}.

4. HSW Act 2015 - Inspectors, Compliance and Enforcement

The HSE Act 1992 and the new HSW Act 2015, provide for accident investigations and set suitable powers for enforcement measures which range from notices, fines through to imprisonment. Section 163 (s.163) of the HSW Act 2015 defines an inspector as a person duly appointed by WorkSafe or any regulatory authority duly appointed by the Prime Minister (s.191). Criteria are detailed, but include an employee of the State (Government) Sector, statutory officer, or an employee of a regulator who is suitably qualified for the work involved. Like all inspectors/officers, they must have an ID card with appropriate details included, showing that they hold a certificate of appointment.

The powers of entry and inspection are set out in Section 168 (s.168) of the HSW Act 2015 and an inspector can enter any workplace at any reasonable time to carry out an inspection.

The Worksafe New Zealand webpage states:

"*...each year health and safety inspectors carry out 12,500 workplace assessments. These are proactive, planned visits and are not usually triggered by a report of serious harm or a health and safety complaint. At least 80% of workplace assessments are targeted to industries identified in the Health and Safety National Action Agenda 2010–2013 as high risk, which includes Agriculture, Forestry, Construction and Manufacturing*" [13].

The webpage then goes onto state:

"*...at least 1,000 Health and Safety and HSNO onsite investigations are undertaken by WorkSafe NZ each year. Investigations may be carried out to determine the causes of harm in the workplace, whether action has been taken or needs to be taken to prevent recurrence or where compliance or enforcement action [including prosecutions] may be required*" [13].

Of the fore mentioned workplace assessments, it is unclear from the data available how many of them were specifically for occupational noise.

Duties relating to exposure monitoring and health monitoring is covered under Part 3 of the HSW-GRWM Regulations 2016. Regulation 32 (reg. 32) states that "*exposure monitoring required by regulations, must be carried out*":

- At appropriate intervals or after significant change in work

- By or under the supervision of a competent person
- Must be kept for (asbestos) 40 years and 30 years others.
- Readily accessible to person who was exposed
- Must be kept confidential

5. Hearing conservation programmes compared to Noise management programmes

Hearing conservation programmes are designed primarily to protect individuals in noisy occupational settings from developing NIHL. Programmes normally including noise monitoring, the use of hearing protectors, audiometric testing, training and recording keeping.

The conservation programs usually begin with a noise survey of the workspace to establish exposure levels and identification of 'noise hazard areas', along with the use of personal hearing protectors and education and some form of engineering noise control. This is undertaken in conjunction with regular and standardised audiometry administered to all noise-exposed personnel, the results of which are monitored to identify any threshold shift to evaluate the effectiveness of the program [14].

Dobie [15] conducted a methodological analysis of the efficacy of programmes including hearing conservation programmes and found a number of shortcomings which led him to conclude that:

"*Although noise reduction for individuals obviously can prevent noise-induced hearing loss, to my knowledge, no single study offers convincing evidence of the efficacy of occupational hearing conservation programs, primarily due to methodologic flaws.*"

In addition to Dobie's findings, other experts also acknowledge that while conservation programmes are effective at identifying, monitoring and lessening the severity of noise exposure, they cannot be considered a total and perfect solution. It should also be noted that such programs are only effective when implemented well and there is much scope for error, such as incorrect measurements and incorrect use of hearing protection.

Many experts, including the authors, view hearing conservation programmes based on assessment of hearing damage (audiometry or otherwise) as a remedial method to reduce the severity of potential NIHL, rather than as a proactive measure to prevent it from occurring in the first place.

Noise management programmes differ from hearing conservation programmes in that management programmes are based on the control of noise exposure across all levels with the primarily goal being to eliminate noise first, followed by exposure reductions via the use of hearing protection only when higher level elimination strategies are not yet implemented.

This is the exact approach in the duties of HSE Act 1992 and the new HSW Act 2015, which require identification of hazards, followed by elimination, isolation and then hearing protection if other measure are not reasonably practicable. Similarly this is the same approach suggested in the New Zealand Standards for 'Occupational Noise Management' series AS/NZS 1269. Waugh [16] reports that overall it would appear that there is a trend internationally to shift from a focus on 'hearing conservation' programmes to 'noise management' programmes in order to provide the conceptual change required to further develop the avoidance of dangerous noise exposure in the workplace.

We note of concern however that first-hand experience by the authors shows that some employers or Health and Safety Personnel believe that adopting hearing conservation programmes is the only requirement under the HSE Act 1992 (and now the HSW Act 2015). They often believe that going straight to hearing protection, satisfies there requirements as employers under the Act. General evidence suggests this is probably the case due to a misunderstanding of their responsibilities under the Act. While in other cases some employees do not wish to spend the time and funds on a hearing management programme, this being one of the reasons they choose to only adopt hearing protection and not other measures.

Legislation concerning occupational noise exposure as well the ACoP and other guidelines, are relatively easy to source. The exception here would be the AS/NZ 1269 series of standard that currently require them to be purchased at a total cost of about $630.

New Zealand legislation on occupational noise exposure is in line with international best practice however the author's first-hand experience is that the implementation and enforcement of this legislation may be insufficient due to a number of issues including (but not limited to):

- Education of both employers and employees regarding their requirements under the HSE Act 1992 and the HSE Regulations 1995.
- Education of both employers and employees regarding 'competent persons' to undertaken work in occupational noise assessment
- Attitudes and cultural behaviours (attitude issues can range from safe work place attitude through to various other things such as hearing protection being viewed as not being required)
- Resources and willingness to invest in occupational noise, noting that for small business, in particular those with less than ten employees; they are much more likely to bear greater costs per employee than larger businesses
- Resources for those responsible for enforcement and a willingness to ensure existing regulations.

6. Health and safety training

In regards to general health and safety training, there are a host of service providers ranging from industry training organisations (ITOs) delivering courses that achieve New Zealand Qualifications Authority (NZQA) Unit Standards in occupational health and safety practice, through to certificates, diplomas and degree levels courses at Universities.

Section 13 (s.13) duties under the HSE Act 1992 includes providing training, and in Section 19G, the '*Minister may approve occupational health and safety training*'. Part 1 of Section 19G states that the Minister may approve, by notice in the Gazette, courses of occupational health and safety training to be carried out at a place of work or elsewhere. Part 2 states that these courses may be approved only if the Minister is satisfied that the course is:

(a) consistent with the object of the Act; and
(b) relevant to the role of a health and safety representative.

The recently introduced Health and Safety at Work (Worker Engagement, Participation, and Representation) Regulations 2016 (HSW-WEPR Regulations 2016) covers "*training about work health and safety*". Part 1, 'Preliminary provisions', states that "*additional training*" means:

(a) that is within the occupational health and safety subfield of the New Zealand Qualifications Framework; or
(b) that the PCBU and the health and safety representative agree is relevant to the health and safety representative's role.

It also has provisions for an "*annual training entitlement*" and that "*initial training*" means training that covers content required to achieve the New Zealand Qualifications Authority (NZQA) Unit standard 29315 [17]. This is a new unit standard, entitled '*Describe the role and functions of the Health and Safety Representative in a New Zealand workplace*' dated 18th February 2016. It replaces unit standard 20198, titled '*Identify the roles and responsibilities of the health and safety representative in the workplace*'. The new unit standard is listed as Level 3 ('Some operational and theoretical knowledge in a field of work or study') and of 2 credits value whereas the previous unit standard was at Level 4 ('Broad operational and theoretical knowledge in a field of work or study') and of 8 credits. This means that initial training about work health and safety is at a lower level and less substantial than previously. However Section 21 (s.21) of HSW-WEPR Regulations 2016 states that "*a health and safety representative must complete initial training*", so it is compulsory for PCBUs that have a health and safety representative.

6.1 Current occupational noise, health and safety training

There are many reasons why in the context of health and safety that occupational noise is often a very low priority for many businesses. However, there is no lack of groups in New Zealand which require training in occupational noise. This includes various stakeholders such as employers and employees who are likely to be or are exposed to noise levels above permitted exposure limits on a day-to-day basis, delegated health and safety officers/representatives (the language under the HSW Act 2015) through to persons purchasing plant, to the simple acquisition of hearing protection. It is clear the requirements of each of these groups are diverse and hence any content and methods of training, including for occupational noise must be tailored to meet the specific needs of the groups, who in many cases will be lay persons.

It is the author's view that a pragmatic approach to education about occupational noise is required. It is also important that occupational noise courses should ensure that limitations of the training are made clear and that a person conducting a limited broad one or two day course is not going to have sufficient training compared to someone doing a detailed or specialist course.

There appears to be some large gaps relating to education and training in occupational noise. Occupational noise can be broadly defined as two branches; acoustic consultants/engineers and health professionals/specialists usually dealing with auditory assessment. It would be unusual for someone to be qualified in both these areas of expertise. However, direct evidence from experience by the authors shows that health professionals such as occupational health nurses or occupational hygienist conducting various occupational noise assessments are also conducting acoustic workplace reviews and providing advice on acoustic engineering. In such situations often very basic mistakes are being made, such as persons advising their clients of incorrect hearing protection (often leading to over-protection) through to inaccurate measurement or assessment or over engineering solutions for noise control. Ultimately poor or incorrect advice can cost employers significant time and money or place employees at risk.

A real concern is that currently there appears to be no standardised qualifications, competence standards or practicing certifications that must be achieved before practice in a subject area can be undertaken for occupational noise. This creates issues for employers wanting to engage professionals as generally they may not be aware of the level of competence or qualification held by someone practicing under a certain title.

One concern if the current system required formalised certification and registration, is that this would result in higher costs to employers. Compliance costs associated with a performance based framework generally do not fall equally on all businesses and small businesses (say < 10 employees) are likely to disproportionally bear greater costs per employee than larger businesses. However, small businesses can in principal contract suitably qualified

professionals on as-need-to basis as opposed to having in-house staff complete the work.

From direct observation of the authors, larger organisations (including both government and non-government organisations) are able to address occupational noise issues through the organisations structure, culture and health and safety processes. For smaller companies, often they cannot afford such health and safety 'infrastructure' and there may be little willingness to put it in place 'standard operating procedures' unless they are forced to.

6.2 The Competent Person

In regards to workplace noise, Section 8 of the ACoP for the 'Management of Noise in the Workplace' sets out requirements for training and education. *Appendix B* of the ACoP, titled "*The Competent Person*", clearly differentiates between persons conducing noise assessments and those performing audiometric testing.

The ACoP states under *Appendix B1* that people carrying out acoustic assessments shall be able to demonstrate a thorough understanding of a host of issues, this includes but is not limited to an understand of acoustics and the physics of sound, correct application and use of sound level meter, correct understanding and application of relevant statutory requirements, codes of practice and standards used in New Zealand through to principles of engineering noise control and noise management measures. The list set out in the ACoP is detailed.

Many experts acknowledge from the outset of an assessment and review of an employee's noise exposure that audiometry (that is, audiometric testing) should be given equal weight with any noise exposure assessment which requires accurate knowledge of both noise level assessment and assessment of noise exposure histories. The term '*audiometry*' comes from the latin term 'audre' meaning to "to hear" and 'metria', "to measure". Audiometry is itself a specialist branch of Audiology, the wider field concerned hearing disorders, including evaluation of hearing function and rehabilitation of patients with hearing impairments. Audiometric ('*hearing*') testing is very important as it is the only tool that can verify the success of hearing conservation programme.

In regards to audiometric testing, Section 7 and Appendix B.2 of the ACoP defines what a "Competent Person" is for both noise measurement and audiometric testing and states that "*most employers will need to employ or engage a competent person to do this work for them*". Appendix B.2 '*Audiometric Testing*' states that:

> "*Audiometric testing for the purposes of the Act may only be carried out by a person who has received proper training in basic pure tone audiometry. The level of training, education and experience required of the tester may be specified by the Occupational Safety and Health Service of the Department of Labour and may include a licence, approval or accreditation system with associated time frames*".

It is unclear however that if this actually occurs. Furthermore, it is unclear as to why the ACoP does not require the same level of competency and licensing requirements for noise assessment. It should be noted that where a detailed noise assessment shows noise levels to be above the exposure limits, or for any reason it is assumed the noise level exceeds the exposure limits, an employer must gain the informed consent of employees exposed to noise to carry out audiometric tests and the employer must then arrange for those audiometric tests to be carried out. This testing is required by Section 10 (s.10) of the HSE Act 1992. For the purposes of audiometric testing, an employee exposed to noise above the exposure limits means the direct measured noise and not the noise level with attenuation by hearing protection.

6.3 Towards a Competent Person for occupational noise

Both the ACoP for the 'Management of Noise in the Workplace' and AS/NZS 1269.1:2005 'Occupational noise management-Measurement and assessment of noise immission and exposure' (Appendix B) provide information and definitions around a competent persons training and what minimum skill set they should have. However, in both these documents, there is no clear definition of what constitutes a 'competent person'.

In the first round of regulations released supporting the HSW Act 2015, the HSW-GRWM Regulations 2016 implies that a competent person is one "*who has sufficient knowledge, skills, and experience in the appropriate techniques and procedures, including the interpretation of results*". But this is hardly a robust or comprehensive definition.

A possible definition for the competent person for occupational noise assessment is:

> '*A competent person in the context of occupational noise assessment means a person whom has acquired suitable knowledge and skills, through a combination of formal training, education and direct field practice and experience that enables that person to correctly perform a specified task required in providing occupational noise assessment*'.

The level of competence required will depend on the complexity of the situation and hence even a qualified competent person should ensure they exercise their technical skills and judgment to ensure that they are not misrepresenting their level of competence. They should disclose up-front the limits of their expertise and should not undertake work outside their actual area(s) of expertise. Members of the Acoustic Society of New Zealand are required under the 'Rules and Code of Conduct for Members' to ensure they exercise their professional and technical skill with careful judgement. Rule 5.0 of the '*Rules of Conduct and Disciplinary Measures for the Acoustical Society of New Zealand*' specifically notes that "*No member*

shall misrepresent their competence nor, without disclosing its limits, undertake work outside their area(s) of expertise".

It follows that in order for someone to be competent they must first be trained by competent and experienced persons. Acoustics and the science of sound is a technical field and hence poor training or limited training could be detrimental, especially if a person believes they are more of an expert that that actually are. Generally because the science of acoustics is a complex subject area, a longer duration course of training is required to ensure someone is competent.

6.3.1 Courses available in occupational noise

Industrial/Occupational hygienist's in New Zealand can obtain an internationally accredited intermediate level qualification that includes the core subject: W503 'Noise - Measurement and its Effects' [18]. The documentation states that "*these are designed as 5-day taught courses that provide practical, hands-on training. Students are taught in small groups by Approved Training Providers*". When delivered in New Zealand this subject is nationalised to the Standards and procedures of New Zealand. A recent review by the authors of the subject course book showed that it is somewhat outdated and in need of revision. Although the course coverage appears adequate, it is unlikely that sufficient competency, especially practical competency, would be achieved in such a short time frame.

Environmental noise assessment is a key competency required for Environmental Health Officer (EHO) roles. Currently only two tertiary providers in New Zealand provide degree level qualifications that are accepted under that 'Environmental Health Officers Qualifications Regulations 1993' [19]. Of these two providers, only Massey University includes a full course ('paper') on noise measurement and assessment. This course is at 300-level and covers: theory and practice; legislation and standards concerning noise and vibration in terms of the health effects; and involves significant practice field work. The course has evolved over many years to now include both environmental and occupational noise measurement and assessment in significant detail. In total, students spend about 150 hours doing this course and the compulsory assessments. However, the course coordinator does not consider this to be adequate to meet the competencies of Appendix B.1 of the ACoP for the 'Management of Noise in the Workplace'. Recently Massey University trialled a professional extension to the noise course with the aim of formally achieving Appendix B.1 'The Competent person' status. The main thrust of this extension course was to develop experience and practical competencies in carrying out noise assessment in a range of different real-world, complex workplace scenarios. The course participants were also required to develop and deliver an education and training course for at risk workers in their workplace.

7. National budget for health and safety

The National Occupational Health and Safety Advisory Council (NOHSAC) Technical Report 7 [8], Part V, advises that as of 2005, the national budget for occupational health and safety activities is approximately $47 million. This report states that approximately $37 million of this funding is provided through the Department of Labour for compliance and enforcement services with a further $10 million being provided to the Accident Compensation Corporation (ACC) for injury prevention activities. The report notes that the amount of funding provided to prevent workplace harm appears to be significantly less than what may actually be required to address these issues. For example, it is reported that the cost of injury amounts to approximately 3.4 % of New Zealand's Gross Domestic Product (GDP) while the expenditure to prevent such harm amounts to less than a hundredth of that (0.0033 %).

The predicted budget 2014-2015 for the occupational health and safety activities of Worksafe NZ for was $85 million [20]. However, there is currently no information available on what portion of this was used for activities involving occupational noise.

7.1 The cost of workplace noise

In New Zealand it is difficult to identify exactly how many people are affected by NIHL and how many are at potential risk of developing it. Between 1992 and 1998 in New Zealand there were around 2,400 validated cases (95 % male) of NIHL reported to the 'Notifiable Occupational Diseases System' (NODS), a voluntary register maintained by the Occupational Health and Safety Service [21]. From 1998 to 2000 Statistics New Zealand reported that there were a further 709 notifications. While these are voluntary reports and cannot be taken as a reliable indication of the actual prevalence of occupational NIHL, they do place NIHL as the second most *voluntarily* reported occupational disease in the country (after 'occupational overuse syndrome/osteoarthritis') and with more cases reported than all the remaining categories of occupational diseases combined [10]. In researching available data, one study [10] states that in 2004/05 around eleven New Zealanders were successfully in claiming ACC compensation for a new case of NIHL each day. This same study states that over the last decade ACC has met 28,805 claims for NIHL, at a total cost of about $218 million. Furthermore, over the last decade the cost of NIHL has increased by an average of 20 % each year.

There appears to be a crossover of data provided for workplace noise cost on both government agency webpages, for example the MBIE webpage has a link to a 'Department of Labour' document from 2007 [22] that states the following figures:

- Current ACC statistics indicate that total costs of noise induced hearing loss to New Zealand exceeds $40 million per year (double that of 5 years ago).
- About 4000 new serious injury claims are made to the ACC annually, which about eleven (11) new claims every day.
- Noise induced hearing damage appears in the top five (5) of all claims.

A publication titled 'Classified Hearing Protectors Booklet' dated March 2013 [23] prepared by MBIE, also states that:

"*Between July 2007 and June 2008, ACC received 4,865 new claims for noise induced hearing loss. The sectors with the highest claim rates were agriculture, forestry and fishing (1,145 claims) and manufacturing (1,109 claims), construction (851 claims)*".

Statistics New Zealand's webpage provides annual statistics of work-related injury claims which include NIHL but these statistics appear to be outdated and hard to find, as the statistics are included in larger groups such as 'cause of injury' including the entire '*workplace*'.

One of the most recent pieces of literature able to be sourced as part of this review was a paper titled "*Epidemiology of noise-induced hearing loss in New Zealand*" prepared by a panel of medical experts for the Journal of the New Zealand Medical Association [24]. This review paper states:

"*There is currently no reliable information regarding the overall incidence and prevalence of NIHL in New Zealand. ACC data reveals a substantial increase in the number of new NIHL claims annually, rising from 2823 in July 1995–June 1996, to 5580 in July 2005–June 2006. Together with ongoing claims the overall costs of NIHL claims increased by an average of 20% each year (a six-fold increase over the decade) resulting in a total cost to ACC of $194 million over the review period. Collectively, agriculture and fisheries workers, trades workers, machine operators, and assemblers accounted for 53% of new claims. Most claims were lodged in middle age or later, with the vast majority of claimants (95%) being men. The relationship of age with the probability of making a claim changed significantly over the study period with rates in older age groups increasing faster than in younger*".

The conclusion of the review paper states the "*substantial and increasing societal costs despite decades of NIHL control legislation suggests that current strategies addressing this problem are not effective, inadequately implemented, or both*".

Many employers may consider their obligations to undertake noise assessment surveys to be high without even starting to consider potential obligations of noise control or even the ongoing costs of exposing employees to excessive noise. The actual cost of NIHL is commonly referenced in monetary terms which do not include social costs or potential future costs, meaning that the actual real life cost of noise induced hearing loss goes well beyond the simple dollar amounts. Examples range from the low end where someone could sleep in as they have trouble hearing there alarm clock, through too more serious risks where an employee cannot hear a warning signal and this leads to a potential or even fatal accident. Interesting high pitch sound from such a warning device would also be hard to hear with the presence of NIHL such as on a moving crane would also likely directional and the directional 'cues' that help us locate danger the source of a sound. NIHL loss also has social costs the fact the "consonant" sounds of human speech, which help separate words into syllables and hence make communication frustrating. Further without the full function of hearing voices particularly those of women and children become muffled. The isolation people can also experience can lead to serious stress-related illnesses, withdrawal from the friends and family as well as a shying away from social activities. Noise Induced hearing loss is a potential accident risk and a serious quality of life issue. Fortunately it can be avoided; unfortunately it cannot be reversed or treated.

AS/NZS 1269.0:2005 'Occupational noise management-Overview' states in Section 4.0 'occupational management' that "*for some workplaces reducing noise levels may require the application of noise management policies, planning and budging over a number of years.*"

The authors view from first-hand experience is that one of the many reasons occupational noise and its management is so hard to convince some employers and employees to take seriously is on a day to day basic (even after working in workplaces with excessive noise) a person's hearing seems to be same when they wake up as when they went to sleep that evening further more unless there is some sort of temporary threshold shift there seems to be no actual change in hearing, and unlike other workplace accidents where you may be exposed to discomfort or pain noise induced hearing loss takes years to manifest. The perverse outcome of this is that people who don't take it seriously will eventually notice a change but by the time this starts to manifest the damage is already permanent.

8. Qualification of this review

This review is intended as a guide only, it is not intended to be surrogate expert advice from a professional. The reader and users should further understand that the information within this review does not attempt to cover all areas and applications and therefore there are omissions.

While all care has been taken in the preparation of this work and the information which is included is believed to be correct at the time of preparation, users of this paper should apply discretion and rely on their own judgements regarding the use of the above information. It may be necessary to obtain independent professional advice from a suitably qualified and experienced acoustician or acoustic engineer.

It is not considered appropriate for the user to simply rely on the contents of this review without reading the contents of the relative legislation, New Zealand Standards, Approved Codes of Conduct or any related documents themselves.

References

1. Statistics New Zealand Year Book., 4th July 2013.
2. J. Maue. [Online]. Available: http://oshwiki.eu/wiki/. [Accessed 5 July 2015].
3. WHO, "World Health Organization Guidelines for Community Noise 1999," 1999.
4. D. McBride, "Unpublished document," University of Otago, 2005.
5. WHO/FIOSH, Editors: B. Oelzer, C.H. Hansen, G.A. Sehrndt, "Occupational exposure to noise: evaluation, prevention and control," Geneva, World Health Organization, and Dortmund/Berlin, the Federal Institute for Occupational Safety and Health, 2001.
6. ACC. [Online]. Available: http://www.acc.co.nz/preventing-injuries/at-work/workplace-health-issues/pi00081.
7. J. Katz, Handbook of Clinical Audiology, 4th Edition, Baltimore, ML, USA: Williams and Wilkins, 1994.
8. A. Gribble, L. Mortimer and R. Smith, "NOHSAC Technical Report 7 - Occupational health and safety in New Zealand," National Occupational Health and Safety Advisory Committee, Wellington, 2006.
9. M. f. t. Environment, "Resource Management Act," New Zealand Legislation, 1991.
10. P. Thorne, "Noise Induced Hearing Loss Report – Best Practise in Noise Induced Hearing Loss Management and Prevention," Technical Report prepared on behalf of Auckland UniServices Ltd for Accident Compensation Corporation of New Zealand.
11. "Noise-Induced Hearing Loss of Occupational Origin - A Guide for Medical Practitioners," Occupational Safety and Health Service, Department of Labour, Wellington, New Zealand, 1994.
12. "Buy Quiet," [Online]. Available: https://en.wikipedia.org/wiki/Buy_Quiet. [Accessed 17 March 2016].
13. "Worksafe New Zealand - What We do," [Online]. Available: http://www.business.govt.nz/worksafe/about/what-we-do. [Accessed 5 July 2015].
14. "Noise Management at Work - Control Guide," National Occupation Health and Safety Commission (NOHSC), Sydney, 1991.
15. R. Dobie, "Prevention of noise-induced hearing loss," Archives of Otolaryngology - Head and Neck Surger, vol. 121, no. 4, pp. 385-39, 1995.
16. R. Waugh, "Do hearing conservation programs really work?," in National Seminar on Noise Management in the Workplace, Melbourne, Australi., 1993.
17. New Zealand Qualifications Authority, "NZQA Unit Standard 29315," [Online]. Available: www.nzqa.govt.nz/framework/search/results.do?type=UNIT&query=29315. [Accessed 15 3 2016].
18. "Intermediate qualifications," OHLearning.com, [Online]. Available: www.ohlearning.com/international-qualifications/qualification-levels/intermediate.aspx. [Accessed 15 3 2016].
19. "Environmental Health Officers Qualifications Regulations 1993," Ministry of Health, [Online]. Available: http://www.health.govt.nz/our-work/environmental-health/environmental-health-officers-qualifications-regulations-1993. [Accessed 17 March 2016].
20. W. N. Zealand, "Statement of Performance nd Expectations," New Zealand Government, 2014.
21. T. Driscoll, A. Mannetje, E. Dryson, A. M. Feyer, P. Gander, S. McCracken and et. al, "The burden of occupational disease and injury in New Zealand: Technical Report," NOHSAC, Wellington, New Zealand, 2004.
22. "Key Facts About Noise Induced hearing Loss," 2007. [Online]. Available: http://dol.govt.nz/PDFs/noise-induced-hearing-loss-facts.pdf. [Accessed 5 July 2015].
23. MBIE, Classified Hearing Protectors, Ministry of Business Innovation and Employment, 2013.
24. P. R. Thorne , S. N. Ameratunga , J. Stewart, N. Reid , W. Williams , S. C. Purdy , G. Dodd and J. Wallaart , "Epidemiology of noise-induced hearing loss in New Zealand," New Zealand Medical Journal, vol. 121, no. 1280, p. 33, 2008.
25. M. Jürgen, "OSH Wiki," [Online]. Available: http://oshwiki.eu/wiki/. [Accessed 5 July 2015].