

# OCCUPATIONAL NOISE AND ITS POTENTIAL FOR HEALTH ISSUES

## Position Paper



### PREPARED BY

AIOH Exposure Standards Committee  
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### AUTHORISATION

This Position Paper has been prepared by the AIOH Exposure Standards Committee and authorised by AIOH Council.

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## TABLE OF CONTENTS

AUSTRALIAN INSTITUTE OF OCCUPATIONAL HYGIENISTS INC (AIOH) .....	3
EXPOSURE STANDARDS COMMITTEE MISSION STATEMENT .....	3
STATEMENT OF POSITION REGARDING AIOH POSITION PAPERS .....	3
Consultation with AIOH members .....	3
Thirty-Second AIOH Council .....	3
List of Abbreviations and Acronyms .....	4
Definitions .....	4
AIOH Position on Occupational Noise and its potential for Health Issues.....	5
Key messages.....	5
Summary .....	5
1. History.....	6
2. What is noise?.....	6
3. Noise induced hearing loss .....	7
4. Ototoxins.....	7
5. Audiometric testing.....	8
6. MP3 players and other such personal portable devices with music capabilities .....	9
7. Pregnancy.....	9
8. Acoustic shock.....	9
9. AIOH recommendations for dealing with occupational noise risks .....	10
<i>Management of occupational noise</i> .....	10
<i>Prevention of noise induced hearing loss</i> .....	10
<i>Management of ototoxins</i> .....	10
<i>Audiometric testing</i> .....	10
<i>MP3 players and other such personal portable devices with music capabilities</i> .....	11
<i>Prevention of undue health outcomes during pregnancy</i> .....	11
<i>Management of acoustic shock</i> .....	12
10. References and sources of additional information .....	13

## AUSTRALIAN INSTITUTE OF OCCUPATIONAL HYGIENISTS INC (AIOH)

The Australian Institute of Occupational Hygienists Inc. (AIOH) is the association that represents professional occupational hygienists in Australia. Occupational hygiene is the science and art of anticipation, recognition, evaluation and control of hazards in the workplace and the environment. Occupational hygienists specialise in the assessment and control of:

- Chemical hazards (including dusts such as silica, carcinogens such as arsenic, fibrous dusts such as asbestos, gases such as chlorine, irritants such as ammonia and organic vapours such as petroleum hydrocarbons);
- Physical hazards (heat and cold, noise, vibration, ionising radiation, lasers, microwave radiation, radiofrequency radiation, ultra-violet light, visible light); and
- Biological hazards (bacteria, endotoxins, fungi, viruses, zoonoses).

Therefore, the AIOH has a keen interest in the potential for workplace exposures to noise, as its members are the professionals most likely to be asked to identify associated hazards and assess any exposure risks.

The Institute was formed in 1979 and incorporated in 1988. An elected governing Council, comprising the President, President Elect, Secretary, Treasurer and three Councillors, manages the affairs of the Institute. The AIOH is a member of the International Occupational Hygiene Association (IOHA).

The overall objective of the Institute is to help ensure that workplace health hazards are eliminated or controlled. It seeks to achieve this by:

- Promoting the profession of occupational hygiene in industry, government and the general community.
- Improving the practice of occupational hygiene and the knowledge, competence and standing of its practitioners.
- Providing a forum for the exchange of occupational hygiene information and ideas.
- Promoting the application of occupational hygiene principles to improve and maintain a safe and healthy working environment for all.
- Representing the profession nationally and internationally.

More information is available at our website – <http://www.aioh.org.au>.

## EXPOSURE STANDARDS COMMITTEE MISSION STATEMENT

The AIOH established the Exposure Standards Committee to provide expert guidance and comment to the exposure standards setting process at a State and National level and internationally, where appropriate, through development of AIOH Position Papers, AIOH guidance publications or comment on relevant Standards, Regulations and Codes of Practice. The Committee's remit is to confirm that the exposure standards numbers, and Standards and Codes of Practice, are changed for valid occupational hygiene and scientific reasons.

## STATEMENT OF POSITION REGARDING AIOH POSITION PAPERS

The AIOH is not a standards setting body. Through its Position Papers, the AIOH seeks to provide relevant information on substances of interest where there is uncertainty about existing Australian exposure standards. This is done primarily through a review of the existing published, peer-reviewed scientific literature but may include anecdotal evidence based on the practical experience of certified AIOH members. The Position Papers attempt to recommend a health-based exposure value that can be measured; that is, it is technically feasible to assess workplace exposures against the derived OEL. It does not consider economic or engineering feasibility. As far as reasonably possible, the AIOH formulates a recommendation on the level of exposure that the typical worker can experience without adverse health effects.

Any recommended exposure value should not be viewed as a fine line between safe and unsafe exposures. They also do not represent quantitative estimates of risk at different exposure levels or by different routes of exposure. Any recommended exposure value should be used as a guideline by professionals trained in the practice of occupational hygiene to assist in the control of health hazards.

## CONSULTATION WITH AIOH MEMBERS

AIOH activities are managed through committees drawn from hygienists nationally. This Position Paper has been prepared by the Exposure Standards Committee, with comments sought from AIOH members generally and active consultation with particular members selected for their known interest and/or expertise in this area. Various AIOH members were contributors in the development of this Position Paper. Key contributors included: Beno Groothoff and Sue Reed.

## THIRTY-SECOND AIOH COUNCIL

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## LIST OF ABBREVIATIONS AND ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AIOH	Australian Institute of Occupational Hygienists
ASCC	Australian Safety and Compensation Council (previously NOHSC/Worksafe Australia, now Safe Work Australia)
AS/NZS	Australian / New Zealand Standards
dB(A)	Decibels, A-weighted.
dB(C)	Decibels, C-weighted.
Hz	Hertz
ILO	International Labour Organization
kHz	Kilo Hertz
$L_{Aeq,8h}$	Means the eight-hour equivalent continuous A-weighted sound pressure level in decibels (dB(A)) referenced to 20 micro Pascals, determined in accordance with AS/NZS 1269.1
$L_{C,peak}$	Means the C-weighted peak sound pressure level in decibels (dB(C)) referenced to 20 micro Pascals, determined in accordance with AS/NZS 1269.1
NATA	National Association of Testing Authorities
OEL	Occupational Exposure Limit
ONIHL	Occupational noise induced hearing loss
PCBU	Person conducting the business or undertaking
PPE	Personal protective equipment
SDS	Safety data sheet
SWA	Safe Work Australia (replaced ASCC)
TLV	Threshold Limit Value
TWA	Time weighted average
WES	Workplace Exposure Standard
WHO	World Health Organization

## DEFINITIONS

- Acoustic incident: ACIF G616: 2006, Guideline-Acoustic Safety for Telephone Equipment, defines an acoustic incident as:
  - "...The receipt by a telephone user of an unexpected sound that has acoustic characteristics that may cause an adverse reaction in some telephone users. Depending on the characteristics of the sound and the user, an acoustic shock may result from the incident..."
- Acoustic shock: It follows therefore that an acoustic incident is not necessarily the same as an acoustic shock. An acoustic shock is defined by ACIF G616: 2006 as:
  - "...Any temporary or permanent disturbance of the functioning of the ear, or of the nervous system, which may be caused to the user of a telephone earphone by a sudden sharp rise in the acoustic pressure produced by it..."
- Hazard: Means potential to cause harm.
- Noise: Means any sound that is unwanted or damages health or hearing.
- Ototoxin: Any substance that may affect the structures and/or the function of the inner ear (auditory plus vestibular apparatus) and the connected neural pathways can be considered ototoxic.
- Risk: Means the probability of harm actually occurring.

## AIOH POSITION ON OCCUPATIONAL NOISE AND ITS POTENTIAL FOR HEALTH ISSUES

### Key messages

- Noise induced hearing loss is foreseeable and must not exceed the existing exposure standards for noise, i.e.  $L_{Aeq,8h}$  of 85 dB(A); and  $L_{C,peak}$  of 140 dB(C).
- The hierarchy of controls must be employed to limit noise exposure to less than the exposure standard.
- The use of hearing protection must be consistent with AS/NZS 1269.3; fit testing, particularly for ear plugs, is necessary.
- Risk-based audiometric testing consistent with AS/NZS 1269:4 should be undertaken.
- Other risk factors including pregnancy, exposure to potentially ototoxic substances and vibration must be considered when assessing noise exposure risk.
- Noise exposure outside work can be a significant contribution to risk, increasing exposure and reducing recovery time.

### Summary

Noise means any sound that is unwanted or damages health or hearing. Hearing loss sustained from noise exposure has a long recognised history and remains a key occupational exposure to this day. Because the risk of sustaining occupational noise induced hearing loss is foreseeable, exposure is limited under health and safety and mining legislation. This paper was compiled to give guidance on the assessment, evaluation and control of occupational exposure to noise with an emphasis on recommending a health-based occupational exposure limit (OEL).

Under the Work Health and Safety legislation, noise is considered any sound which exceeds the exposure standard for noise, i.e.  $L_{Aeq,8h}$  of 85 dB(A); and  $L_{C,peak}$  of 140 dB(C). Persons conducting a business or undertaking (PCBUs) should follow the 2015 Code of Practice “Managing noise and preventing hearing loss at work”, which provides support for complying with the regulatory noise standard.

The AIOH supports the intent of the Safe Work Australia (SWA) Work Health and Safety legislation and the concept of managing occupational noise through higher order of controls “where reasonably practicable” before settling for lower order controls (e.g. personal hearing protectors). Where personal hearing protectors are used as a method of reducing a worker’s exposure to noise, the AIOH supports the use of a quantitative fit testing system, particularly for ear plugs, to ensure that the correct level of attenuation is provided to the worker and also as a means of training workers in correct fitting procedures.

The AIOH supports the risk assessment method of including workers who are exposed to more than 50% of the TWA exposure standard for a known ototoxic chemical (without regard to protection from a respirator if worn), irrespective of whether or not they are also exposed to noise, or where workers are exposed to ototoxic substances and noise with  $L_{Aeq,8h}$  greater than 80 dB(A) or  $L_{C,peak}$  greater than 135 dB(C), to include these workers in a hearing conservation program.

The AIOH supports the statement in the Foreword of AS/NZS 1269:4 on audiometric testing, that if monitoring and evaluation of a noise management program are carried out systematically and any problems disclosed are promptly dealt with, there can be a high degree of confidence that the programs will be effective in minimising occupational noise induced hearing loss. The AIOH considers that to minimise the incidence of noise induced hearing loss an effective audiometric retest regime based on noise exposure levels could consist of:

- $L_{Aeq,8h} > 100$  dB(A) 6 monthly
- $L_{Aeq,8h} 85 - 100$  dB(A) annually
- $L_{Aeq,8h} > 82$  dB(A) 3 yearly

Reference audiometric testing should ideally be performed as a pre-employment test.

MP3 players, mobile phones and other such personal portable devices with music capabilities are frequently used during work as well as non-work periods. There is now enough evidence to demonstrate that the noise levels delivered through various headphone systems are loud enough to cause noise induced hearing loss. The uncontrolled use of personal music players in the workplace should thus be discouraged.

There is also enough evidence to demonstrate that foetuses whose mothers have been exposed to noise in excess of 85 dB(A) during their pregnancy have a higher risk of hearing loss than those whose mothers were not exposed to loud noise. PCBUs should consider job rotation after the 20<sup>th</sup> week of pregnancy for women working around intense sound levels. Care should also be taken to avoid contact between the abdomen and vibrating tools or objects.

To manage acoustic incidents/shocks and their effects and demonstrate compliance with occupational health and safety legislation call centre managements must establish the risk to the health and wellbeing of their staff from three main elements that make up a call centre. These are:

- The work environment, including systems of work; chiefly the performance monitoring of workers, training and stress management, systems for reporting and dealing with the aftermath of acoustic incidents and shock;
- Workplace design, including acoustic requirements; and
- Technical control systems; including compliance with telecommunication requirements, controlled power supply systems to prevent brown-outs and black-outs, suitable shriek rejection devices such as Volume Limiter Amplifiers, for each of the telephone operators.

## 1. History

Hearing loss sustained from noise exposure has a long recognised history with probably the earliest notation from Pliny the Elder (23-79AD) in his 'Natural History' of the noise from the excessive uproar of the falling water in the Nile cataracts and its ill effects on the hearing of the local inhabitants. Ramazzini (1633-1714) described in the 1713 edition of his treatise on the "Diseases of Workers" the hearing impairment of coppersmiths. Works by Thomas Barr (1886) on hearing loss in Scottish boilermakers and Gottstein and Kayser (1881) on German personnel in railway works, are further landmark studies aiding in the development of our modern day understanding of occupational noise induced hearing loss. The Hungarian Georg von Békésy (1899-1972) discovered the "travelling wave" by which sound is analysed and communicated in the cochlea and for which he received a Nobel Prize in 1961.

Noise triggers the production of stress hormones like cortisol, noradrenalin and adrenaline, which are dangerous to health when released over long periods of time. The release of these hormones lead to changes in blood pressure and a greater risk of heart disease, e.g. ischemic heart disease, angina pectoris and myocardial infarction (European Federation for Transport and Environment, 2008).

Because the risk of sustaining occupational noise induced hearing loss is foreseeable, exposure is limited under health and safety and mining legislation. However, noise induced hearing loss continues to be one of the most prevalent occupational diseases. In part this is because noise is present in almost all workplaces and because there is often a long latency factor which may lead to workers 'unwittingly' contributing to unacceptable risk by modifying their behaviour to well beyond what is known to be acceptable. Even in those work environments where noise is not loud, such as open plan offices and call centres, noise may affect the health and well-being of the occupants. Despite the introduction of barriers in the mid ninety-nineties in all States and Territories in Australia, the incidence of noise induced hearing loss is on the increase with, for instance, claims for deafness compensation jumping 24% in Queensland (The Courier Mail, 9 December 2010, p10).

The World Health Organization (WHO) defines a permanent hearing threshold level of 41–60 dB as a 'moderate impairment' based on the unaided hearing threshold in the better ear and averaged over the 0.5, 1, 2, and 4 kHz frequencies. It considers this hearing threshold a 'disabling hearing impairment' as at this level of impairment an individual is able to distinguish words spoken at one metre only, if they are spoken in a raised voice, and at this level of impairment hearing aids are usually required (WHO, 2009).

Our current understanding of noise and its effects on people recognises that exposures from other workplace hazards may have further undue effects on hearing loss and workers' health. For instance, a wide variety of chemicals and medication may, alone or in concert with noise, result in hearing loss (European Agency for Safety and Health at Work, 2009). These substances are called ototoxins (oto = ear, toxin = poison). There is evidence that exposure to hand arm vibration and noise produces greater hearing loss than noise alone. There is also sufficient evidence to demonstrate that noise greater than  $L_{Aeq,8h}$  85 dB(A), be it at work or during leisure activities, has a negative effect on the development of the foetus. The rapid increase in the number and size of call centres over the last ten years has introduced new hazards to call centre telephone operators through the rather large number of acoustic and acoustic shock incidents reported to date.

The popularity of personal stereos such as MP3 players enabling users to listen for many hours, often at high volumes, adds to the incidence of noise induced hearing loss. Access Economics' report "Listen Hear" of 2006 states that 37% of all hearing losses are noise induced from both occupational and leisure activities. Australian Hearing's "Binge Listening" report from May 2010 found that among owners of personal stereos 53% describe their usual volume as loud to very loud.

## 2. What is noise?

The above definition of noise is the most encompassing one but the literature shows variations to the definition, e.g. "noise is unwanted sound" or "noise is damaging sound". The 2015 National Code of Practice "Managing noise and preventing hearing loss at work" includes a reference to the damaging effects of noise on health by stating that "**Noise** means any sound that is potentially harmful to the health or safety of a person" but no longer includes the "unwanted" component of noise.

Under the Work Health and Safety legislation noise is considered any sound which exceeds the exposure standard for noise:

- a) the  $L_{Aeq,8h}$  of 85 dB(A);
- b) the  $L_{C,peak}$  of 140 dB(C),

and which is determined at a worker's ear without taking into account any protection that may be provided to the person by the use of personal hearing protectors.

The (A) after the decibel symbol dB means that the sound level measuring instrument must use an A-weighting filter. This filter interprets the measured sound as if perceived by the human ear. The ear's sensitivity differs at different frequencies, i.e. it is rather insensitive at low frequency sounds but very sensitive at higher frequency sounds (Figure 1). The ear's interpretation of sounds also varies with different levels of loudness. At higher sound pressure levels, i.e. >100 dB, the sensitivity variation between lower and higher frequencies is less pronounced than at lower sound pressure levels resulting in a flatter curve, indicated by the (C) weighting, than the A-weighting. The A and C weighting were derived from research conducted by Fletcher and Munson in the 1930s of a sample of young males to establish the sensitivity of the ears to different frequencies and loudness of sounds. This has led to what are now known as the equal loudness contours and which are standardised in ISO 226:2003. The A-weighting was initially destined for measuring sounds up to 65 dB and the C-weighting for sounds greater than 100 dB. However, over time the A-weighting was found to be adequate for all sounds of a non-impulsive nature. The C-weighting was introduced to ensure the microphone characteristics of sound measuring instruments all meet the C-weighting contour and therefore measure impulsive sounds the same.



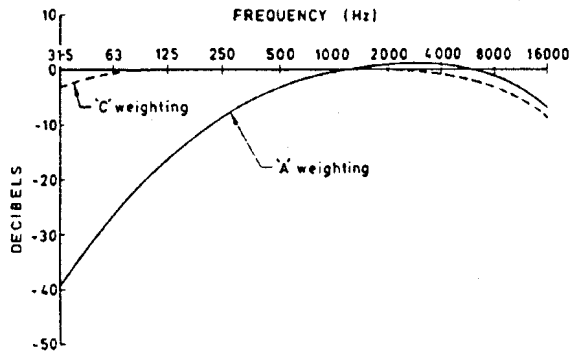


Figure 1: The A and C-weighting curves

Source: Powell & Forrest (1988)

In the above noise exposure standard there is an absence for the protection of the health and wellbeing of those workers whose exposure to noise will never exceed the exposure standard but whose health and wellbeing may nevertheless be affected by unwanted noise. To accommodate such situations, the 2015 Noise Code of Practice states; “Risks of adverse health effects can be minimised by keeping noise levels below: 50 dB(A) where work is being carried out that requires high concentration and effortless conversation, or 70 dB(A) where more routine work is being carried out that requires speed or attentiveness or where it is important to carry on conversations. These levels include noise from other work carried out within the workplace”.

### 3. Noise induced hearing loss

Noise induced hearing loss generally develops slowly over a long period of time (usually several years) resulting from regular exposures to loud noise. Acoustic trauma on the other hand causes a sudden change in hearing ability as a result of a single, or a few, sudden loud bursts of noise, usually of an explosive or impact nature. The typical characteristics of noise induced hearing loss are:

- It is always sensory neural, affecting the hair cells in the cochlea
- It is typically bilateral
- It may be asymmetric, e.g. from gunshots, sirens or driving trucks
- The first signs are indicated on the audiogram by a notching at 3000 – 4000 or 6000Hz.

The main implication of noise induced hearing loss is impaired speech discrimination, i.e. the affected person can hear well but has difficulty understanding communication due to a diminished ability to hear the high pitched consonant sounds, such as th, sh, pf, s, t, k, c, in words, leading to diminished quality of life, social isolation and often depression.

Severe noise induced hearing loss may increase the risk of accidents for the affected person.

Occupational noise induced hearing loss (ONiHL) is so significant in Australia that in 2008 the Australian Safety and Compensation Council (ASCC) - currently known as Safe Work Australia - declared ONiHL as one of eight priority diseases which must be addressed by regulators and industry. The ASCC’s April 2006 report “Work-related noise induced hearing loss in Australia” estimates that about 1 million employees in Australia are exposed to hazardous levels of noise (in the absence of hearing protection), which accounts for about 16% of adult onset hearing loss (ASCC, 2006). The occupational groups most affected are blue collar workers such as labourers, trades persons and plant or machine operators. Hogan *et al* (2009) in an analysis of the 2003 Australian Survey of Disability, Ageing and Careers found among other things that people with hearing loss were less likely to be found in highly skilled jobs and were over represented among low income earners. The conclusion that can be drawn is that ONiHL not only affects the sufferer’s quality of life and increases the chance of becoming involved in workplace accidents, but also affect their career prospects.

### 4. Ototoxins

In the workplace environment a wide variety of chemicals may, alone or in concert with noise, result in hearing loss. Of the workplace chemicals five major classes have been confirmed as being ototoxic; i.e. solvents; nitriles; pharmaceuticals; heavy metals and chemical asphyxiants (European Agency for Safety and Health at Work, 2009). In addition, organic solvents have been well recognised for their neurotoxic effects on both the central- and peripheral nervous systems of exposed people in the workplace.

Strictly speaking, ototoxicity refers to toxic damage to the sensory or secretory epithelia of the labyrinth and the auditory nerve, i.e. the pathology within the temporal bone. Toxicity in the central auditory pathway is referred to as neurotoxicity. Toxicity affecting the eighth nerve is referred to as cranial nerve toxicity (Groothoff, 2006).

**Table 1: Occupations exposed to noise and ototoxic substances**

Occupation	Noise	Ototoxic agent
Aircraft maintenance workers	✓	✓
Printing industry workers	✓	✓
Industrial and house painters	✓	✓
Dry-cleaners	✓	✓
Boat builders	✓	✓
Furniture makers	✓	✓
Refinery/fuel product workers	✓	✓
Vehicle/aircraft re-fuellers	✓	✓
Fire fighters	✓	✓
Fire arm instructors	✓	✓
Rural/agriculture workers	✓	✓

The most common routes of entry into the body of these substances are via inhalation or skin absorption and to lesser extent, ingestion, due mainly to poor personal hygiene practices at work, or inadequate higher order control measures. Because of the variability in interaction between some 700 ototoxic chemicals identified to date it is difficult to derive a “safe” method of risk assessment. At present a prudent way to accommodate this issue in risk assessments is to include workers who are exposed to more than 50% of the TWA for the known ototoxic chemical (without regard to the possible protection from a respirator worn), irrespective of whether or not they are also exposed to noise, and to include these workers in a hearing conservation program. This system is advocated in the 2015 Code of Practice “Managing noise and preventing hearing loss at work” in Chapter 5.7 “monitoring hearing”. The Noise Code of Practice also states that monitoring of hearing with regular audiometric testing is recommended where workers are exposed to:

- Ototoxic substance at any level and noise with  $L_{Ae,8h}$  greater than 80 dB(A) or  $L_{C,peak}$  greater than 135 dB(C);
- Hand-arm vibration at any level and noise with  $L_{Ae,8h}$  greater than 80 dB(A) or  $L_{C,peak}$  greater than 135 dB(C).

## 5. Audiometric testing

The PCBU has specific obligations under the Work Health and Safety Regulation (s58) to manage the risks of hearing loss associated with noise at the workplace by ensuring that the noise to which a worker is exposed at work does not exceed the exposure standard and by providing audiometric testing to a worker who is frequently required to wear personal hearing protectors to protect the worker from the risk of hearing loss associated with noise that exceeds the exposure standard. The PCBU then must provide audiometric testing for the workers; - within three months of the worker commencing work and in any event at least every 2 years.

The 2015 Code of Practice “Managing noise and preventing hearing loss at work” states that audiometric testing and assessment of audiograms should be carried out by a competent person in accordance with the procedures in AS/NZS 1269.4:2014 – Occupational noise management – Auditory assessment.

Clause 7.1 “General” of AS/NZS 1269.4 states that audiometric testing should be made available to all persons likely to be exposed to noise above the exposure criteria as set by the relevant statutory authorities or by the organisation’s noise policy, whichever is the lower, or ototoxic agents as listed in Appendix C of AS/NZS 1269:0. Audiometry is desirable because there are uncertainties in hearing protector programs, e.g. error in noise exposure measurements and variability in the effectiveness of hearing protectors. Audiometry may assist in the early detection of inadequacies in the hearing protector program and therefore enables early remedial action to be taken (AS/NZS 1269:4).

It is therefore a generally accepted/recommended practice that as part of the program’s monitoring and reviewing process, auditory re-testing is conducted and noise assessments carried out to check for variations in exposure levels from previous levels. At the same time hearing protector use should be reviewed and refresher training given.

The minimum standard of audiometric testing envisaged by AS/NZS 1269.4 “Auditory Assessment” consists of pure tone air conduction audiometry which it considers adequate for the implementation of a hearing conservation program in industry.

AS/NZS 1269:4-1998 introduced the method advocated by Macrae (1996) which reduces the test-retest variability and enables detection of an average threshold change of 5 dB. The method has been maintained in the 2005 and 2014 editions of AS/NZS 1269:4. It involves the averaging of thresholds across frequencies and across repeated tests, with the headphones removed and re-fitted between tests. The method is based on



averaging the thresholds at 3, 4 and 6 kHz, the frequencies most likely to be affected in the early stages of noise exposure, across two tests. Tests are to be conducted with an audiometer in a room, which must comply with the background conditions specified in Appendix C of AS/NZS 1269:4 (2014). This can be a problem in many industrial settings, as these background conditions cannot be met without installing a sound proof booth. Other problems that may affect the tests lie in the placement of the headphones over the ears or in the way the test signals are presented to the worker to be tested. Care must be taken to ensure that the microphones are placed directly opposite the ear canals and the headphone stays securely in place.

AS/NZS 1269.4 uses two types of audiometric testing, namely, *reference audiometry*, to determine a person's hearing threshold (baseline) as accurately as practicable and *monitoring audiometry* to determine a threshold shift from the baseline results. The frequencies for both tests are the same, i.e. 500, 1000, 1500, 2000, 3000, 4000, 6000 and 8000 Hz.

## 6. MP3 players and other such personal portable devices with music capabilities

MP3 players are often used on the way to and from work to block out the outside world and frequently also during work. Most of us had to endure the metallic hissing sounds coming from somebody's MP3 player on public transport despite the person being several metres away. At the volumes they can produce the user is likely to be at risk of sustaining noise induced hearing loss with regular use. The "Binge Listening" report from 2010 found that among owners of personal stereos 53% describe their usual volume as loud to very loud (Australian Hearing, 2010). Despite these admissions and recognising the connection between exposure to loud noise and hearing loss, many of the users do not see themselves as personally at risk or downplay their risk in relation to their social activities (Australian Hearing, 2010). It has been demonstrated that the use of ear-bud speakers can produce noise levels in the ear of up to 120 dB(A) and the allowable eight-hour equivalent exposure is then exceeded in just 8 seconds. By allowing the use of MP3 players or any other such personal portable devices with music capabilities in the workplace, the PCBU fails to comply with the regulatory limits by; a) not maintaining control over the level of noise exposure of the worker, and b) willingly putting the worker's hearing at risk of sustaining noise induced hearing loss.

## 7. Pregnancy

There is a body of research that shows that children whose mothers were exposed to loud noise (85 – 100 dB(A)) during their pregnancy have a higher risk of hearing loss than those whose mothers were not exposed to loud noise as noise travels well through the abdominal wall into the uterine environment (ILO, 2004; Groothoff, 2005). The studies also indicated an increased risk of low birth weight, premature birth, stress and increased blood pressure. The foetal cochlea is structurally ready to function as early as the twentieth week of pregnancy. Complete maturation of the hearing mechanism is achieved by the last trimester. This phase of maturation seems to correspond to a period during which the cochlea would appear to be particularly sensitive to damage caused by sound or chemicals (Campo & Crockart, 1991) and can be defined as a "critical period" for the cochlea of the human foetus (Campo & Crockart, 1991). In pre-term babies the hearing mechanism is, in part, still developing after birth (TNO, 2000). Noise levels inside incubators are in the order of 80 dB(A) and pre-term babies are exposed 24 hours a day, sometimes over long periods and sometimes with the added effects of antibiotic treatment, which may be ototoxic (amino glycosides).

The 2009 report from the Institut National de Santé Publique du Québec, "Effects of Workplace Noise during Pregnancy" found that; concerning the 8 effects from noise on pregnancy, biological plausibility is deemed good for sound levels  $\geq 85$  dB(A), or at lower levels if the task at hand requires great concentration or significant mental effort. Otherwise, plausibility is deemed average and, in such cases, evidence strength is modified for spontaneous abortion and weight deficiencies for gestational age.

For workplace noise exposure, sufficient evidence was found of an increased risk (27%) for weight deficiencies with regards to gestational age. Increased risks are also suspected for 4 other effects on pregnancy; spontaneous abortion (6%), pre-term birth (13%), pre-eclampsia (12%) and gestational hypertension (42%). No conclusions could be drawn on the risks associated with stillbirth, congenital anomalies, low birth weight and hearing loss in children.

Industries where pregnant women may be exposed to high noise levels include; mining, construction, metal manufacturing, transport, music entertainment, defence forces and law enforcement.

## 8. Acoustic shock

Call centres are basically office type environments in which (usually) large numbers of telephone operators conduct their work selling products, conducting surveys, providing a service and/or answering enquiries from callers. They do this by using headsets to communicate with clients and at the same time doing things like inputting data into computer systems. Perhaps the most important distinction between a call centre and other workplaces is that there is no visual (e.g. eye), or tactile (e.g. handshake) contact between the telephone operator and clients and therefore the business is conducted at a purely auditory level. Occasionally call centre telephone operators experience acoustic incidents such as sudden loud shrieks, crackling, clicking, piercing or howling tones through their headsets.

The signals in modern telephones are limited to 120 dB SPL or 123 dB Peak (AS/ACIF S004: 2004). These levels are well below those considered to cause damage to hearing, depending on the duration of exposure, but certainly not cause acoustic trauma with which acoustic shock is often confused. The 'normal' voice level may be disrupted by a sudden and extraneous noise that causes a sharp increase in the headset noise level and temporary hearing loss, tinnitus, dizziness and nausea may result. However, there are investigated instances where the experienced headset noise was not loud but more a crackling type noise and which resulted in the operator reporting and displaying symptoms consistent with acoustic shock. Telephone operators who experienced an acoustic shock often report symptoms like; initially being startled, followed by nausea, vomiting, dizziness and tingling or burning sensation at the affected side of the face and tongue with sometimes the neck shoulder and arms affected as well, headache and feeling anxious and teary for some time afterwards.

The severity outcome of the experience is generally the result of a combination of the unwanted and unexpected interference on the telephone line and the operator's psychosomatic (stress from work pressures and environment) and physiological responses (startle reflex of middle ear muscles) to the acoustic incident. Effects may range from simple annoyance to incapacity to continue to work, often for periods ranging between a few hours to never again being able to do work involving the use of headsets.

## 9. AIOH RECOMMENDATIONS FOR DEALING WITH OCCUPATIONAL NOISE RISKS

### *Management of occupational noise*

Noise, be it excessive or not, is an insidious danger to peoples' health and the preservation of hearing and must be taken seriously by those creating it as part of their business activities. All states and territories have adopted the National Standard [NOHSC: 2009(2000)] and regulated workplace noise in their workplace health and safety or mining legislation. The national Work Health and Safety legislation has adopted the current noise exposure levels as the exposure standard.

PCBUs should follow the 2015 Noise Code of Practice "Managing noise and preventing hearing loss at work", which provides support for complying with the regulatory noise exposure standard. In addition, the Australian/New Zealand Standard series AS/NZS 1269 "Occupational noise management" provides extensive information on all facets of noise management including; competency of assessors, instrumentation, assessment, evaluation of results and noise management. By following the guidelines stated in the 2015 Noise Code of Practice and the relevant parts of AS/NZS 1269 a PCBU should, in most cases, be able to demonstrate compliance with the noise exposure standard and thus the prevention of occupational noise induced hearing loss at work.

AS/NZS 1269 states that the use of hand held sound level meter measurements, made by a competent person, are preferred to measurements using a personal sound exposure meter (PSEM - dosimeter). There are pros and cons for the use of either a hand held sound level meter or a dosimeter. Confounding factors in using either type of instrument can be overcome by using a competent occupational hygienist.

### *Prevention of noise induced hearing loss*

Modern health and safety legislation requires all obligation holders to identify the risks to workers and control the identified risks through the hierarchy of controls. Ultimately the Courts apply the "reasonably practicable" standard, i.e. 'is, or was it at a particular time, reasonably practicable to comply with the PCBU's duty to ensure health and safety, taking into account and weighing up all relevant matters', in its determination whether or not compliance with the duty of care requirement was achieved in the particular case before it.

The AIOH supports the intent of the 2011 Work Health and Safety legislation and the concept of managing occupational noise through higher order of controls "where reasonably practicable" before settling for lower order controls. Since personal hearing protectors do not control workplace noise it follows that the use of personal hearing protectors must only be used as an interim measure or last resort, until higher order controls can be implemented.

Where personal hearing protectors are used as a method of reducing a worker's exposure to noise, the AIOH supports the use of a quantitative fit testing system, particularly for ear plugs, to ensure that the correct level of attenuation is provided to the worker and also as a means of training workers in correct fitting procedures. A number of types of electronic fit testing devices are currently available and include:

The VeriPRO system from Howard Leight (<http://www.howardleight.com/veripro>)

3M™ E-A-Rfit™ Validation System (<http://tinyurl.com/7dsfo7e>)

FitCheck from Michael & Associates ([www.michaelassociates.com/index.php/p/f/](http://www.michaelassociates.com/index.php/p/f/)).

### *Management of ototoxins*

The AIOH supports the risk assessment method of including workers who are exposed to more than 50% of the TWA exposure standard for a known ototoxic chemical (without regard to protection from a possible respirator worn), irrespective of whether or not they are also exposed to noise, to include these workers in a hearing conservation program.

Exposure limits for chemical substances are stated in Safe Work Australia's Hazardous Substances Information System (HSIS) which can be accessed at: <http://hsis.safeworkaustralia.gov.au/>. Safety Data Sheets (SDS) generally do not provide any information regarding ototoxicity. However, workplaces in industries listed in Table 1, using known or suspected ototoxic chemical substances, should be looking for information on the chemical's general toxicity, neurotoxicity and nephrotoxicity as most of the chemicals that affect the auditory system also are potentially neurotoxic and / or nephrotoxic.

Because of the absence of specific ototoxic information in SDSs it is recommended that workers in any of the occupations listed in Table 1 be included in annual audiometric testing programs. Other workers whose industry is not listed in Table 1, but who are working with substances which are either suspected or confirmed ototoxic, should also be included in such programs. Reviewers of audiometric test program data should be alert to the possible additive or synergistic effects between the exposure to noise and ototoxins. Where necessary they should suggest reducing exposure to one or both agents. PCBUs of workers exposed to noise and/or ototoxic substances should ensure that information on the ototoxins and their effects are included in training sessions. (Groothoff, 2006).

### *Audiometric testing*

The AIOH supports the statement in the Foreword of AS/NZS 1269:4 that if monitoring and evaluation of a noise management program are carried out systematically and any problems disclosed are promptly dealt with, there can be a high degree of confidence that the programs will



be effective in minimising occupational noise induced hearing loss. [**Note:** a noise management program is the same as a hearing conservation program].

A noise management program manages the risk of noise induced hearing loss in workers exposed to noise that may be excessive. The PCBU should have a system in place whereby the hearing ability of the workers is known at the commencement of their employment through a reference audiometric test as this is the benchmark against which future hearing tests are compared. If the program is shown to be effective, it may provide the PCBU with a defence against future claims or litigation of alleged occupational noise induced hearing loss sustained by a worker during employment at the workplace.

The PCBU should also have a system in place whereby workers' hearing is retested at regular intervals through monitoring audiometric tests. AS/NZS 1269:4 provides guidance for retesting and states that where there is no significant change in threshold shift or the work situation it may be sufficient to retest at yearly intervals but high risk groups may require more frequent testing. Practical experience with a range of industries indicates that audiometric tests are mostly conducted every two years.

The importance of an effective audiometric test regime may be demonstrated by the results of a longitudinal study conducted between 1990 and 2004 by Rabinowitz *et al* (2007) of 6217 industrial workers and which, among others, found that workers with higher ambient noise exposures sustained less hearing loss than co-workers in less noisy areas i.e. ambient noise exposures between  $L_{Aeq,8h}$  82 and 85 dB(A). The authors attribute this difference, to a large degree, to the differential use of hearing protection in noisier versus less noisy work environments, i.e. workers in higher noise exposure areas may be more bothered by the noise levels and consequently more conscientious about the use of hearing protectors than their co-workers in lower noise exposure areas. The problem in these lower noise work areas is that despite a risk of sustaining noise induced hearing loss, the use of hearing protection is legally not required and their use therefore often not implemented or enforced by workplace managements.

The AIOH considers that to minimise the incidence of noise induced hearing loss an effective retest regime based on noise exposure levels could consist of:

$L_{Aeq,8h} > 100$  dB(A) 6 monthly

$L_{Aeq,8h}$  85 – 100 dB(A) annually

$L_{Aeq,8h} > 82$  dB(A) 3 yearly

Reference audiometric testing should ideally be performed as a pre-employment test but where this is not the case, as soon as possible after the commencement of employment. The test shall be conducted immediately after a period of not less than 16 hours of quiet, i.e. noise exposures less than 75 dB(A), as this is unlikely to result in a temporary threshold shift. The worker shall be made fully aware as to why the test is performed and the procedures of the test shall be explained to the worker.

Monitoring audiometric testing should be performed within 12 months of the initial reference audiogram. Monitoring audiometric testing should be scheduled well into the work shift. The purpose is to detect threshold shift which may be temporary or permanent. A temporary threshold shift may be an early indicator of the likelihood of permanent threshold shift occurring in the exposed worker.

Audiometric testing should be conducted by a competent person to avoid misinterpretation of results. The initial reference test should ideally be conducted by an audiologist or ear nose and throat specialist as they are qualified to establish the many different causes of hearing loss possible. An audiologist is trained to operate an audiometer and would not have received the training or education to be able to differentiate between different causes of hearing loss.

Occupational noise management programs should take into account possible exposures to those agents for which there is human or animal evidence of ototoxicity (AS/NZS 1269.0). Workers who are exposed to more than 50% of the TWA exposure standard for a known ototoxic chemical (without regard to protection from a possible respirator worn), irrespective of whether or not they are also exposed to noise, should be included in a hearing conservation program.

### ***MP3 players and other such personal portable devices with music capabilities***

There is now enough evidence to demonstrate that the noise levels delivered through various headphone systems are loud enough to cause noise induced hearing loss. Fligor and Cox (2004) measured noise levels generated by headphones from commercially available personal stereo devices and found that the free field equivalent sound pressure levels at maximum volume ranged between 91 and 121 dB(A). The situation is worrying enough for Worksafe WA to issue a safety and health alert (2008) about personal music players in the workplace. The document raises a number of factors to consider, i.e. they can be distracting and may in certain circumstances fully isolate the wearer from all external noise, including those that may need to be heard by the worker. As the devices are capable of producing noise levels in the 90 to 120 dB range there is the potential for noise induced hearing loss (Worksafe WA, 2008).

By allowing the use of the devices in the workplace the PCBU does not comply with the obligations to ensure health and safety at work by failing to comply with the regulatory limits by:

- a) not maintaining control over the level of noise exposure of the worker, and
- b) willingly putting the worker's hearing at risk of sustaining noise induced hearing loss.

It follows therefore that the uncontrolled use of personal music players in the workplace should be discouraged.

### ***Prevention of undue health outcomes during pregnancy***

There is enough evidence to demonstrate that fetuses whose mothers have been exposed to noise in excess of 85 dB(A) during their pregnancy have a higher risk of hearing loss than those whose mothers were not exposed to loud noise. The Dutch "Arbobeids regel 1.42 (1997)" states that exposure to sound pressure levels above 80 dB(A) and peak sound pressure levels above 200 Pa (140 dB) must be avoided as the foetus is



sensitive to damaging sound. Direct contact with ultrasound through a solid or liquid medium may have damaging effects on the foetus by causing tissue damage which in turn may lead to other issues. In the “Arbobeids regel 1.42 (1997)” a temporary threshold value of 110 dB(A) is set for ultrasound above 20 kHz. The ACGIH Physical Agents TLV Committee has noted that an 8-hour TWA exposure of 115 dB(C) or a peak exposure of 155 dB(C) to the abdomen of a pregnant worker beyond the fifth month of pregnancy may cause hearing loss in the foetus. This peak level equates to noise exposures generated by discharging firearms with larger than a .22 calibre round and pregnant women should be excluded from discharging firearms after 20 weeks gestation (Navy Environmental Health Centre, 2006).

PCBUs should consider job rotation after the 20<sup>th</sup> week of pregnancy for women working around intense sound levels. Care should also be taken to avoid contact between the abdomen and vibrating tools or objects.

### ***Management of acoustic shock***

Call centres are workplaces like any other workplace and thus fall under the jurisdiction of health and safety legislation. To manage acoustic incidents/shocks and their effects and demonstrate compliance with occupational health and safety legislation, call centre management must establish the risk to the health and wellbeing of their staff from three main elements that make up a call centre. These are:

- The work environment, including systems of work; chiefly the performance monitoring of workers, training and stress management, systems for reporting and dealing with the aftermath of acoustic incidents and shock;
- Workplace design, including acoustic requirements; and
- Technical control systems; including compliance with telecommunication requirements, controlled power supply systems to prevent brown-outs and black-outs, suitable shriek rejection devices such as Volume Limiter Amplifiers, for each of the telephone operators.

Where these are adequately addressed it is most likely that stress levels in telephone operators will be reduced to acceptable levels, that is, levels which do not interfere with, or otherwise affect, the way the work is intended to be conducted and have no detrimental effects on the operator’s health.

### ***Performance monitoring***

Most industry employers have moved away from close worker monitoring and control as the long-term negative effects on workers’ job satisfaction affect product output and worker / management relations. Despite these known negative aspects, the call centre industry has embraced close monitoring of its workers as its primary tool to control all aspects of their activities and human resources management. Close monitoring however, leads to loss of control over one’s work which has very serious implications for the individual worker’s long-term psychological and physiological health and wellbeing. Workers and their representatives should therefore be consulted about the monitoring systems, their purpose, and the setting of targets because of the risks to their health and safety (Groothoff, 2005).

### ***Managing stress***

Negative stress can be reduced by providing some freedom in deciding when to take a lunch break and short breaks from telephone duties and doing other duties during breaks away from the phones. Mini breaks, such as getting a glass of water or a toilet break not only provide some relief from telephone work, they also provide relief for the eyes and voice and allow the muscles and body parts that have been inactive due to a prolonged sitting posture to overcome fatigue. Call centre management should systematically look for what the problems are and what systems need to be put in place to overcome the problems.

### ***Reporting***

Call centres, like other workplaces, must have a traceable reporting system for all incidents including acoustic incidents. Such a system must include reporting; the time and date of the incident, a description of the noise including a way of indicating the loudness and other characteristics, the duration of exposure, the activities carried out at the time, symptoms experienced immediately and later, follow-up e.g. referral to audiologist, details of headset and equipment used and whether or not this equipment has been isolated. Other information may be required depending on the needs of the call centre.

### ***Controls***

Control measures include telephone systems complying with AS/ACIFS004 of 2004, including the incorporation of acoustic shock protection devices, provision of information, instruction, training and supervision to both operators and their supervisors. There should also be a policy of no mobile phone use in the call centre. Since the technology to prevent acoustic shock has improved to a stage where it could be reasonably expected that, if properly executed, the effects on telephone operators can be minimised to experiencing annoyance rather than incapacity to continue work, or worse, devastation it would be reasonable to expect that call centre managements incorporate such systems. Failing to do so could be seen as a failing in the employer’s obligation or duty of care.

### ***Acoustic Workplace design***

AS/NZS 2107:2000, in Table 1 under 5, “Office Buildings” states the recommended “satisfactory” and “maximum” design sound levels in  $L_{Aeq}$ , dB(A), for call centres, i.e. a Satisfactory level of 40 dB(A) and Maximum level of 45 dB(A), and reverberation time between 0.1 and 0.6 s, in the unoccupied state but with building systems operating. Panels or screens between desks should be of an acoustic quality in accordance with AS/NZS 4443-1997. The sound absorption coefficient should not be less than 0.6 and the sound transmission class (STC) rating not less than 20.

Surveys conducted by the Health and Safety Laboratory of the UK HSE in 15 call centres, found a mean background noise level of 62 dB(A) with a maximum of 66 dB(A) (HSE 2001) in the occupied state. Ambient noise levels around  $L_{Aeq,8h}$  70 dB(A) have been reported as a problem for easy and effective communication with customers and efforts should be made to reduce such ambient noise levels.

## 10. REFERENCES AND SOURCES OF ADDITIONAL INFORMATION

Specific references used in the production of this position statement include:

- Access Economics (2006). *"Listen Hear", the economic impact and cost of hearing loss in Australia*, Access Economics Pty Ltd, Canberra, ACT.
- Australian Hearing (2010). *Binge Listening; Is exposure to leisure noise causing hearing loss in young Australians?* National Acoustics Laboratories, Sydney.
- Australian National Occupational Health and Safety Commission (NOHSC), (2003). *Noise - Annual Situation Report 2003*, Commonwealth of Australia (available online at: [www.safeworkaustralia.gov.au/.../NoiseAnnualSituationReport2003.pdf](http://www.safeworkaustralia.gov.au/.../NoiseAnnualSituationReport2003.pdf) accessed 31/1/11).
- Australian Safety and Compensation Council (2002). *Compendium of Workers' Compensation Statistics, Australia 2001 -2002* (available online at: [www.nohsc.gov.au/PDF/Statistics/Compendium2002.pdf](http://www.nohsc.gov.au/PDF/Statistics/Compendium2002.pdf) accessed 12/2/2005).
- Australian Safety and Compensation Council (2006). *Work-Related Noise Induced Hearing Loss in Australia, April 2006*, Canberra.
- Australian Standard AS/ACIF S004:2004. *Voice Frequency Performance Requirements for Customer Equipment*, Australian Communications Industry Forum, Milsoms Point, NSW.
- Australian Standard AS/ACIF G616:2006. *Acoustic safety for telephone equipment*, Australian Communications Industry Forum, Milsoms Point, NSW.
- AS IEC 61672.1-2004. *Electroacoustics-Sound level meters, Part 1: Specifications*, Standards Association of Australia, North Sydney.
- Australian Standard AS IEC 61672.2-2004. *Electroacoustics-Sound level meters, Part 2: Pattern evaluation tests*, Standards Association of Australia, North Sydney.
- Australian Standard 1259-1990. *Sound Level Meters, Part 1: Non-Integrating and Part 2: Integrating-Averaging*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 1269.0-2005. *Occupational Noise Management Part, 0 Overview*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 1269.1-2005. *Occupational Noise Management Part, 1 Measurement and Assessment of Noise Immision and Exposure*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 1269.2-2005. *Occupational Noise Management Part, 2 Noise Control Management*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 1269.3-2005. *Occupational Noise Management Part, 3 Hearing Protector Program*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 1269.4-2014. *Occupational Noise Management Part, 4 Auditory Assessment*, Standards Association of Australia, North Sydney.
- Australian Standard 1270-1999. *Acoustics - Hearing Protective Devices*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 2107:2000. *Acoustics-Recommended Design Sound Levels and Reverberation Times for Building Interiors*, Standards Association of Australia, North Sydney.
- Australian Standard 2822, (1985). *Acoustics-Methods of Assessing and Predicting Speech Privacy and Speech Intelligibility*, Standards Association of Australia, North Sydney.
- Australian/New Zealand Standard 4443: (1997). *Office Panel Systems - Workstations*, Standards Association of Australia, North Sydney.
- Babisch, W (2005). *Noise and Health*, Environmental Health Perspectives, Vol 113, No 1, Jan 2005.
- Bureau Beroepsziekten (1997). *Arbobeleidsregel 1.42.*, FNV, Amsterdam.
- Burgess, M & W Williams (2006). *Non-Noise Contributors to Occupational Hearing Loss*, *Acoustics Australia*, Vol 34, December (2006) No 3.
- Campo, P & JC Crockart (1991). *Auditory Risks run by the fetus in pregnant women exposed to noise*, Unpublished, Health and Safety Executive Translation Services.
- Eden, D & R Piessie (1991). *Real World Attenuation of Hearing Protectors*, Proceedings, Westprac IV' 91 Conference.
- European Agency for Safety and Health at Work (2009). *Combined Exposure to Noise and Ototoxic Substances*. European Observatory Literature Review. (available online at: [http://osha.europa.eu/en/publications/literature\\_reviews/combined-exposure-to-noise-and-ototoxic-substances](http://osha.europa.eu/en/publications/literature_reviews/combined-exposure-to-noise-and-ototoxic-substances) Accessed 27/11/12).
- European Federation for Transport and Environment (2008). *Can you hear us?* (available online at: [http://www.transportenvironment.org/sites/te/files/media/2008-02\\_traffic\\_noise\\_can\\_you\\_hear\\_us.pdf](http://www.transportenvironment.org/sites/te/files/media/2008-02_traffic_noise_can_you_hear_us.pdf) Accessed 27/11/12).
- Fisher, M (2001). *Psycho Acoustic and Audio Signal Processing Aspects of Acoustic Shock Protection*. Proceedings of Risking Acoustic Shock Seminar, Fremantle, Western Australia.
- Fletcher, H & WA Munson (1933). *Loudness, Its Definition, Measurement and Calculations*, J.Acoust. Soc. AM. 5, 82-108.



- Fligor, BJ & LC Cox (2004). *Output Levels of Commercially Available Portable Compact Disc players and the Potential Risk to Hearing*, Ear and Hearing, Lippincott Williams & Wilkins, USA.
- Groothoff, B (2005). *Whole body vibration exposure at work and pregnant women*, March 2005, Occupational Health Unit, Workplace Health and Safety Queensland, Brisbane.
- Groothoff, B (2005). *Health Effects from Noise in Open Plan Office Areas*, August 2001, Occupational Health Unit, Workplace Health and Safety Queensland, Brisbane.
- Groothoff, B (2005). *Acoustic shock in call centres*, Proceedings Acoustics Australia, Busselton Western Australia.
- Groothoff, B (2006). *CES 11, Advanced Noise Topics Workshop*, Proceedings Australian Occupational Hygienists Conference, Gold Coast, Queensland.
- Groothoff, B (2010). *Introduction to Noise and Vibration, their Effects and Control in the Occupational Environment*, Queensland University of Technology, Faculty of Health Science, Brisbane.
- Guo, J & P Gunn (2004). *Occupational Noise Control In Australia – Its Policy and Management*, Worksafe Western Australia, Perth, WA.
- Hassall, JR & K Zaveri (1979). *Acoustic Noise Measurements*, Brüel & Kjær, Denmark
- Health and Safety Laboratory (2001). *Advice Regarding Call Centre Working Practices, LAC 94/1*, Health and Safety Executive, UK.
- Hinke, K (2001). *Acoustic Shock in a Danish Call Centre: A follow up investigation*, Proceedings of Risking Acoustic Shock Seminar, Fremantle, Western Australia.
- Hogan, A, K O'Loughlin, P Miller, H Kendig, H (2009). *The health impact of hearing disability on older people in Australia*, J Aging Health, 2009, Dec; 21(8): 10980-111.
- Institut National de Santé Publique du Québec (2009). *Effects of Workplace Noise during Pregnancy* (available on; [http://www.inspq.qc.ca/pdf/publications/1040\\_BruitTravailGrossesseSynthese.pdf](http://www.inspq.qc.ca/pdf/publications/1040_BruitTravailGrossesseSynthese.pdf), accessed on 7/2/2011).
- International Standard ISO 226:2003. *Acoustics – Normal equal-loudness-level contours*, 2003, Geneva.
- International Standard ISO 1999 – 1990. *Acoustics - Determination of Occupational Noise Exposure and Estimation of Noise Induced Hearing Impairment*, 1990, Geneva.
- Kjellberg, A & U Landstrom (1994). *Noise in the Office: Part I-Guidelines for the Practitioner*, Journal of Industrial ergonomics, Elsevier B.V. Amsterdam.
- Kjellberg, A & U Landstrom (1994). *Noise in the Office: Part I-The Scientific Basis (Knowledge Base) for the Guide*, Journal of Industrial ergonomics, Elsevier B.V. Amsterdam.
- Kochkin, S (2007). *The Impact of Untreated Hearing Loss on Household Income*, Better Hearing Institute, available online at: [http://www.betterhearing.org/pdfs/M7\\_Hearing\\_aids\\_and\\_income\\_2006.pdf](http://www.betterhearing.org/pdfs/M7_Hearing_aids_and_income_2006.pdf) accessed 31/1/11).
- Laroche, C "Effects of Workplace Noise during Pregnancy", available online at: [http://www.inspq.qc.ca/pdf/publications/1040\\_BruitTravailGrossesseSynthese.pdf](http://www.inspq.qc.ca/pdf/publications/1040_BruitTravailGrossesseSynthese.pdf) accessed 31/1/11)
- Lidström, I (1990). *Pregnant women in the workplace*. Seminars in Perinatology, Vol 14, No4 August 1990, pp 329 – 333.
- Macrae, J (1996). The Role of Audiometry in Occupational Noise Management, Journal of Occupational Health and Safety – Australia and New Zealand, 12(5):571-576. CCH Australia, North Ryde, N.S.W, Australia.
- Milhinch, J & J Doyle (2000). *Acute Aural trauma in Users of Telephone Headsets and Handsets*, Proceedings of Audiological Society of Australia National Conference, June 2000.
- Milhinch, J (2001). *Audiological Rehabilitation of Injured Workers*, Proceedings of Risking Acoustic Shock Seminar, Fremantle, Western Australia.
- Navy Environmental Health Centre (2006). *Reproductive and Developmental Hazards: a Guide for Occupational Health Professionals; Technical Manual NEHC-TM-OEM 6260.01A April 2006*, Portsmouth, Virginia 23708-2103.
- Patuzzi, R (2001). *Acute Aural Trauma in Users of Telephone Headsets and Handsets*, Proceedings of Risking Acoustic Shock Seminar, Fremantle, Western Australia.
- Paul, J (2004). *Healthy beginnings: Guidance on safe maternity at work.*, International Labour Office, Geneva
- Powell, RF & MR Forrest (1988). *Noise in the Military Environment* Brassey's Defence Publishers, Richard Clay Ltd, Chichester, Sussex, UK.
- Queensland Government (2008). *Noise Code of Practice 2004*, Goprint, Brisbane (available online at: [http://www.deir.qld.gov.au/workplace/resources/pdfs/noise\\_code2004.pdf](http://www.deir.qld.gov.au/workplace/resources/pdfs/noise_code2004.pdf) accessed 31/1/11).
- Royster, JD & LH Royster (1990). *Hearing Conservation Programs*, Lewis Publicists Inc. Michigan.
- Rabinowitz, PM, D Galusha, C Dixon-Emst, MD Slade & MR Cullen (2007). *Do ambient noise exposure levels predict hearing loss in a modern industrial cohort?* Occup. Environ. Med. 2007;64;53-59; originally published online 14 Sep 2006; doi:10.1136/oem.2005.025924.
- Safe Work Australia (2011). *Work Health and Safety Act*. Canberra, ACT



Safe Work Australia (2011). Work Health and Safety Regulation. Canberra, ACT

Safe Work Australia (2015). Code of Practice; Managing noise and prevention of hearing loss at work, Canberra, ACT

Sataloff, J & RT Sataloff (2006). *Occupational Hearing Loss*, Taylor & Francis Group, London.

Slivak v Lurgi (Australia) Pty Ltd (2001). 205 CLR 304 cited in Bluff & Johnstone (2004) The relationship between Reasonably Practicable and Risk Management (WP 27 ANU National Research Centre for OHS Regulation)).

Telstra (1995). *Telstra Office Accommodation, Policies and Guidelines (Draft)*, Melbourne.

The Courier Mail (2010). *Here come the iGens*, 26 February 2010, News limited, Brisbane.

Timmins, P (2008). *Getting Heard: Effective Prevention of Hazardous Occupational Noise*, Australian Safety and Compensation Council, Canberra.

Workplace Health and Safety Queensland (2003). *A guide to health and safety in the call centre industry*, (available online at: <http://www.qpsu.org.au/callconnect/whs.pdf> accessed 31/1/11).

WHO (World Health Organisation) (2009). *Grades of hearing impairment*, (available online at: [http://www.who.int/pbd/deafness/hearing\\_impairment\\_grades/en/index.html](http://www.who.int/pbd/deafness/hearing_impairment_grades/en/index.html) accessed 31/1/11).

Worksafe WA (2008). *9/2008 Personal music players in the workplace*, Safety Alert, DOCEP, WA, Perth.