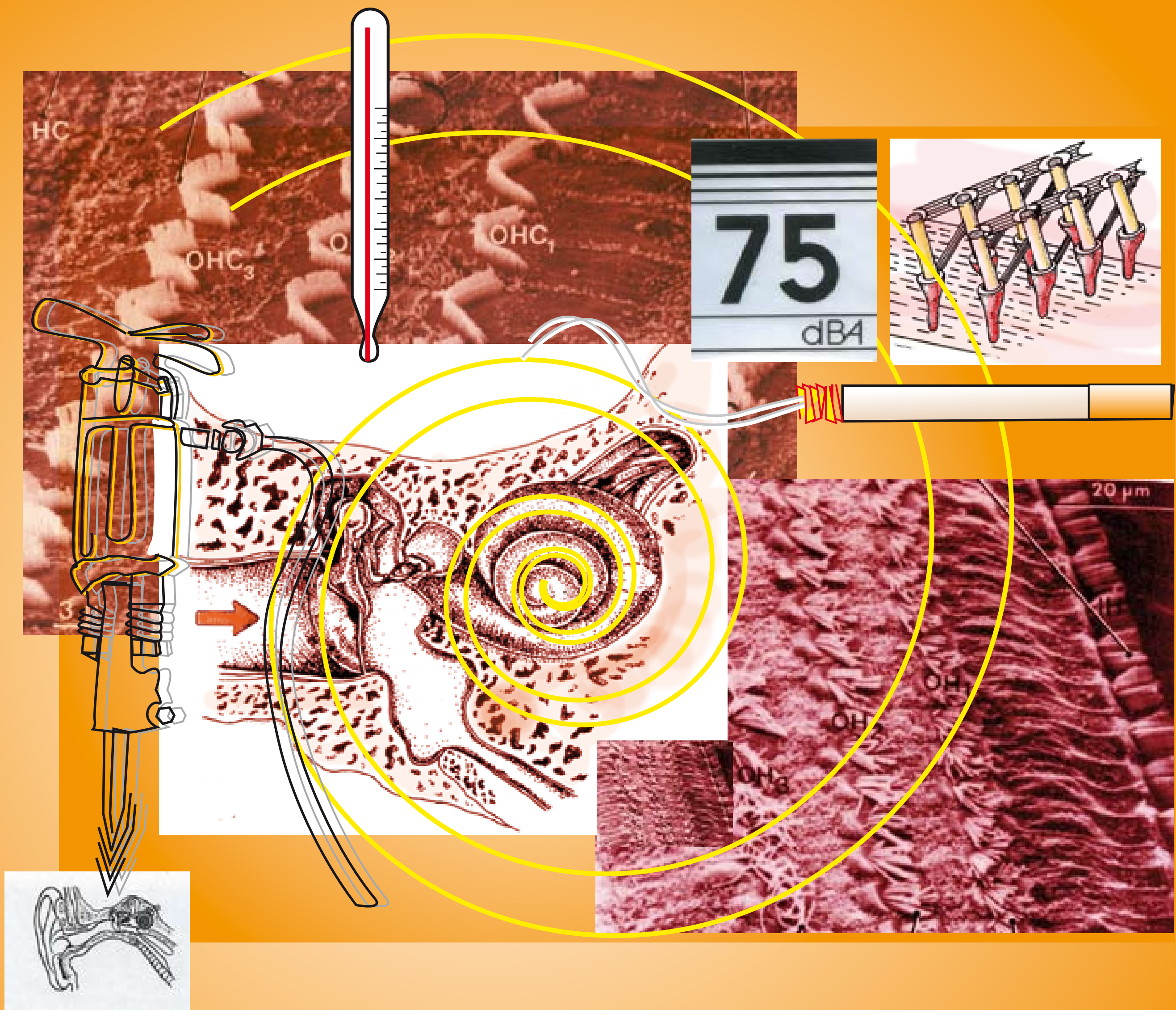
Acoustics Australia



- Non-noise contributors to hearing loss
- Adaptive optimisation for telephony
- Custom-moulded earplugs
- History of environmental noise measurement

Australian Acoustical Society

Vol. 34 No. 3 December 2006

SignalCalc ACE

QUATTRO

BSWA TECH

Everything that ACE-I has & more:
Sound Power,
Demodulation,
Acoustic Intensity,
Rotordynamics,
Quality Control
IRIG-B Time Code,
Stepped Sine and with MIMO,
Multiple Input Multiple Output
Single to Multi-Plane Balancing
Shock Response Spectrum, TEDS,
and more ....!

QUATTRO

*** 2 to 4 Input Channels**
*** 0 to 2 Output Channels**
*** 1 Tachometer channel standard**
*** 24 bit similtaneous**
*** Max Sample Rate 204.8 kHz**
*** DC to 40 kHz or 93 kHz,**
*** > 120 dB Dynamic Range**
*** Coupling AC, DC, Diff, SE, ICP**
*** Anti Alias - 100dB protection**
*** Inputs Crosstalk < -100 dB**

and **INTRODUCING a new line of**
MEASUREMENT MICROPHONES.
BSWA Tech *microphones & accessories are available in Australian & NZ.*

High quality, calibrated electret prepolarized microphones to class 1 & 2 & preamplifiers.

Accessories available:

- *ICP power sources,*
- *a portable sound level calibrators,*
- *a USB powered 2 channel measurement soundcard,*
- *a 12 speaker dodecahedral sound source,*
- *compact light weight 2 channel power amplifiers.*
- *an impedance tube providing 125 Hz to 3200 Hz range and*
- *a self contained Tapping Machine sound source for foot fall measurements.*

For more information phone: **02 9975 3272**
or visit: ***www.kingdom.com.au***

KINGDOM PTY LTD

AA 03/05

Acoustics Australia

Acoustics Australia General Business
(subscriptions, extra copies, back issues, advertising, etc.)

Mrs Leigh Wallbank
P O Box 579
CRONULLA NSW 2230
Tel (02) 9528 4362
Fax (02) 9589 0547
wallbank@zipworld.com.au

Acoustics Australia All Editorial Matters
(articles, reports, news, book reviews, new products, etc)

The editors, Acoustics Australia
School of Physics
University of New South Wales
Sydney 2052 Australia
61-2-93854954 (tel)
61-2-93856060 (fax)
aaeds@phys.unsw.edu.au
www.acoustics.asn.au
AcousticsAustralia@acoustics.asn.au
www.acoustics.asn.au

Australian Acoustical Society Enquiries see page 144

Acoustics Australia is published by the Australian Acoustical Society
(A.B.N. 28 000 712 658)

Printed by
Cliff Lewis Cronulla Printing
91-93 Parraweena Rd,
CARINGBAH NSW 2229
Tel (02) 9525 6588
Fax (02) 9524 8712
email: matt@clp.com.au
ISSN 0814-6039

Vol 34 No 3 December 2006

CONTENTS

PAPERS

Cover illustration: Heidi Hereth

Message from the President

I would like to publicly thank Neil Gross for his efforts and leadership over the last two years as President. Neil leaves the Society in a position of financial strength and growth in professional standings. It has been a pleasure to work with Neil both as a Councillor and as Vice President. His professional attitude to the position and his manner in being open to advice and discussion is a role model I aim to follow.

Over the term of my presidency, I would like to focus on improving ways of value adding to the societal experience.

Many view membership only for the access to an excellent journal and the national conferences, however the Society offers far more. The divisions run many activities designed to inform and educate its members by providing forums for members to meet and discuss local issues, provide feedback to government bodies, learn about current issues and changes in regulations relative to their professional life. Feedback from the Acoustics Society is valued by regulators as it provides cross discipline consultation mechanisms.

Opportunities exist for members to become more active in the Society by: attendance at technical meetings, providing suggestions to the divisional committee on topics that would interest you, as a participant or speaker. If you have an area of interest that you would like to be explored, please contact your local divisional secretary (see the acoustics web page for details).

The Society can only effectively achieve its aims to promote and advance the science and practice of acoustics in all its branches to the wider community and provide support to acousticians through the active support of you the members.

The inaugural joint conference of the New Zealand and Australian Acoustical Societies was held recently in Christchurch New Zealand, with 200+ delegates attending. Feedback received from authors, participants and sponsors uniformly applaud the resounding success of the conference. Responses have been very enthusiastic and clearly the joint conference concept was a success for both societies.

I have been monitoring the success of the national conferences over recent times and it would appear that with the hard work of each division, the conferences are firmly entrenched as a key event in the acoustical calendar for the Australian acoustics community. The conferences are attracting larger numbers of delegates and provide a diverse range of topics and international exposure.

The Federal Council schedules conferences so each division runs a conference on a rotational division basis. The schedule takes into account other major international acoustics conferences within Australia. In 2007, the Fourteenth International Congress on Sound and Vibration in Cairns, Australia, will be held on Monday July 9 through to Thursday July 12. This is a joint AAS and ICSV conference. Past ICSV conferences have seen 600 to 700 delegates! This one is expected to be equally large. I recommend that all readers check the societies' web pages and plan on attending the conference.Let me introduce myself with a brief outline of my history and area of interests.

My name is Terrance Mc Minn and I live in Perth, Western Australia and am currently a lecturer in Building Science in the Department of Architecture/Interior Architecture at Curtin University. During my undergraduate studies in the Bachelor of Architecture, AAS past president Mr Tibor Vass sparked my interest in the field of building acoustics. My studies in Architecture allowed me to combine my interest in computing and acoustics in the days when acoustics software was either unavailable or unaffordable.

After graduating in 1979, I was employed by the Public Works Department (later to be known the Building Management Authority of WA). I worked in the Environmental Design Section mainly in the acoustics area. I was invited to join Forbes and Fitzharding Architects where I stayed for 3-year before rejoining the Building Management Authority of WA. In 1990 I was invited to take over the 'Building Science' teaching (acoustics and lighting) in the School of Architecture, Planning and Construction Management, at Curtin University. Since 1990, I have completed a Master of Science – Building Science degree in acoustics and become heavily involved in the WA Acoustics Society Division and Federal Council – taking on various divisional and federal council roles such as Divisional Secretary, Divisional Vice President, Divisional President, Federal Councillor, Web-Master, Registrar, Vice President and most recently President.

Terrance Mc Minn

From the Editors

Cricket is a pervasive acoustic phenomenon of the Australian summer. Two phenomena in fact.

A sound field with highly correlated sources is created by the ABC cricket broadcasts. Across the country, thousands of radios all radiate their version of the same signal – and implicitly invite the question "What's the score, mate?", for we are all mates when the cricket is on.

On the beach and in the park, it is often possible to demonstrate that interference nulls are virtually impossible to notice in compound signals. Even if one could adjust the overall signal strengths appropriately in search of a null, the frequency and phase response varies among receivers. So, no matter where you put your towel on the sand, there is no way to arrange cancellation of the signals from your two neighbours' radios.

Crickets of the other sort - and their cousins the cicadas - provide another quintessential sound of summer in Australia. They are uncorrelated sources, and the frequencies are only similar, not identical, so one would not expect cancellation under any conditions. What is remarkable here is how loud even a single cricket can be. Sometimes, in a eucalypt forest, the noise can be painful. Part of the reason is that the fundamental lies in the low kHz range, where our ears are most sensitive. The simple generation mechanism – essentially passing a serrated edge over a plate – has a metabolic conversion efficiency not much greater than one percent, but the input is substantial: the metabolic rate of the cricket increases roughly tenfold when it calls (Kavanagh, 1987). And in a forest there may be many crickets.

Although the songs of two male crickets don't interfere – at least not in the physical sense – interference is important in the auditory system of a female cricket, when in a field dominated by just one song.

Sound reaches the cricket's tympanum via at least two pathways, whose relative phase of arrival depends strongly on the orientation of the listening cricket to the wavefronts of the song (eg Michelson et al., 2004; Fletcher, 2005). So, for a wavelength of order 100 mm and an insect smaller than that, where do you find the "ears"?

The legs would be an obvious site, which suggests the following experiment: remove the legs from a cricket, shout "jump" and see if she can still hear you.

Season's greetings from the editors.

Fletcher, N.H. (2005) Acoustics Australia. 33, 83-88.

Kavanagh, M.W. (1987) J. Exp. Biol. 130, 107-119.

Michelsen, A., Popov, A.V. and Lewis, B. (2004) Comp. Physiol. 175, 153-164.

NON-NOISE CONTRIBUTORS TO OCCUPATIONAL HEARING LOSS

Marion Burgess

Acoustics and Vibration Unit, UNSW@ADFA, Canberra, ACT 2600

Warwick Williams

National Acoustics Laboratory, 126 Greville St, Chatswood, NSW 2067

Noise exposure at work is a major workplace occupational health problem. Legislation exists internationally and throughout Australia requiring limits to the occupational noise exposure of employees. There are clear standards specifying the noise exposures above which noise management plans to protect the hearing of the employees must be implemented. It has been acknowledged for some decades that, in addition to hearing loss, high levels of noise can cause other adverse health effects. There is now increasing evidence that the combination of non-noise factors in the work environment plus noise can lead to a greater hearing loss than would be experienced from the noise alone. This paper provides a review of the effects of the various factors and comments on their importance for consideration when undertaking occupational noise exposure assessments in the workplace.

1.0 INTRODUCTION

Noise exposure at work is one of the largest workplace occupational health problems with thousands of new and ongoing claims for occupational hearing loss per year (ASCC: 2006), not to mention the ongoing disability and handicap experienced by those affected (Access Economics: 2006). Legislation exists throughout Australia requiring limits to the occupational noise exposure of employees, for example the NSW OHS Regulation 2001 (WorkCover 2001). These exposure limits are consistent with world's best practice and although in the long term it would be of advantage to the health of the nation that the noise exposure standard be lowered, there is insufficient compelling evidence to justify such a change at this time. The introduction of 'action' levels below the exposure limits, as recommended in the European Union Directive [EC: 2003], would provide further opportunities for minimising occupational hearing loss. Exposures to high levels of noise can have effects other than hearing damage. Also there is increasing evidence that some non-noise exposures combined with noise can lead to increased risk of occupational hearing loss. The effects of these contributing factors are still under investigation by researchers around the world. This paper provides a review of the current information on the effects of these various factors and comments on their importance for consideration when undertaking occupational noise exposure assessments in the workplace.

2.0 NOISE EXPOSURE STANDARDS

The exposure limits for employees throughout Australia are specified in legislation in each State and Territory and are consistent with the 'National Standard for Occupational Noise' (NOHSC 1007: 2000). This standard currently requires that employees should not be exposed to noise levels in excess of an eight-hour equivalent continuous A-weighted sound pressure level, $L_{Aeq,8h}$, of 85 dB for continuous noise and a C–weighted peak sound pressure level, L_{Cpeak}, of 140 dB for peak or impulsive noise.

For continuous noise this means that the amount of hearing damage from an eight hour, A-weighted sound exposure level of 85dB is considered to be an acceptable risk for the working population. It is important to understand that this does not represent a safe exposure level where there would be zero percentage risk of damage to hearing. As explained in Appendix G of the Australian/New Zealand Standard (AS/NZS 1269.4: 2005), after an exposure to an $L_{Aeq,8h}$ of 85 dB over a 40 year working life, 74% of an otologically normal male population could be expected to show a mean percentage loss of hearing of 6%, while for a similar female population the figures would be 47% with a mean percentage loss of hearing of 5%. Otologically normal implies that the individuals have been screened for any other ear or possible hearing difficulties (excluding ageing).

The implication for the Australian population is that, even with compliance with the current National Standard exposure levels, a large percentage of the work force can expect to have a significant hearing loss when they retire. This is a large potential social and economic problem. Currently it is estimated that there are 3.55 million Australians experiencing hearing loss with a *"real financial cost of $11.75 billion or 1.4% of GDP"* (Access Economics: 2006. p 5). This report estimates that 37% "*is due to excessive noise exposure which is preventable*" (p 7).

While some of the variation in hearing loss can be related to individual characteristics, there is increasing evidence that some may be related to the synergistic effects of noise plus non noise exposures that in combination lead to a greater hearing loss than would be experienced from noise exposure alone.

3.0 NON-AUDITORY EFFECTS OF NOISE

Non-auditory effects of workplace noise are currently not visibly included in published statistics of workers' compensation as a perusal of the mechanism of disease classification will show (WorkCover NSW: 2000; AASC: 2006; enHealth: 2004).

Some of these non-auditory effects of noise exposure were identified by the World Health Organisation over 25 years ago (WHO: 1980) and include:-

- Annoyance
- Task distraction
- Clinical Health Effects – such as hypertension, peripheral circulatory system irregularities, ischaemic (cardiovascular) heart disease, pupillary reaction, neuro-physiological stress and mental health.
- Sleep disturbance.

These non-auditory effects, which occur for exposures to noise well below the National Standard level, are often cited as effects of higher than acceptable community noise levels (enHEALTH: 2004).

Some effects of higher level occupational noise that have been studied more recently include:

- **Noise and the Unborn Child.** Concerns about the effects of noise on the foetus during pregnancy have been investigated since the 1980s. An early study showed an increase in the risk of having a high-frequency hearing loss in children whose mothers were exposed to noise between 85 and 95 dB(A) (Lalande, Hetu & Lambert: 1986). A review of the literature undertaken for the UK Heath and Safety Executive (Hepper & Shahidullah; 1994) comments that "*low frequency sounds (250 Hz and below) which pass unattenuated through the maternal abdomen to stimulate the foetal ear may be most likely to harm hearing*" and consequently the use of the A weighting may be inappropriate. This review concluded that further studies were necessary.

During the 1990s a number of studies showed some effects, the most common being low birth weight (Hartikainen, Sorri, Anttonen, Tuimala & Laara: 1994; American Academy of Paediatrics: 1997). Contrary statements have been made by other researchers (Stanfield et al: 2000), who stated that "*in carefully controlled studies, noise exposure does not seem to be related to low birth weight or to congenital birth defects*" (p 43). However, the American Academy Of Paediatrics: (1997) in a study of the effects of noise on the foetus and the newborn in an intensive care unit concluded that "*exposure to noise during pregnancy may result in high frequency hearing loss and may be associated with prematurity and intrauterine growth retardation*" (p 726).

As there is some evidence of a confounding effect of noise on the unborn child and it would be wise for reports on a workplace noise assessment to alert management to the potential risk.

- **Vibroacoustic disease.** Vibroacoustic disease is a recent area of research and is also controversial in that almost all the research findings are from the one small group and there have been few supportive studies from workers elsewhere in the world. The claim is that vibroacoustic disease is characterised by a "*pericardial thickening in the absence of an inflammatory process, and with no diastolic dysfunction*" (Castelo Branco & Alves-Perira: 2004, p 5; Holt: 2000) and is a progressive disease that develops over many years in three stages (Castelo Branco & Alves-Perira: 2004). The main cause appears to be regular exposure to areas of low frequency noise, less than 500 Hz, at amplitudes of 90 dB or greater. There also seem to be measurable effects on the respiratory system in the long term (greater than 20 years) (Reis Ferreira, Couto, Jalles-Tavares, Castelo Branco & Castel Branco: 1999). These researchers suggest that "*VAD [vibroacoustic disease] is not acknowledged as a pathological entity, and individuals who exhibit VAD clinical pictures are malingerers (if workers) or neurotic (if females and/or housewives). At best, they are considered "overly sensitive" individuals and its presence in the workplace noted*.

Vibroacoustic disease is currently undergoing extensive examination by experts with respect to its validity and recognition as a recognised condition (ATSDR: 2001) but it does appear to be an important, emerging area of the consequences of noise exposure.

4.0 NON NOISE CONTRIBUTORS TO HEARING LOSS

The major contributor to occupational hearing loss is exposure to excess noise levels (WHO: 1980 & 1997). Physiological studies of the ear clearly show the effects on the hearing mechanism when it is required to respond and react to high level sound stimuli. Continued or repeated exposure to high levels of sound will lead to permanent damage to the hearing mechanism (Sataloff & Sataloff: 1987). Criteria and exposure limits for occupational noise levels have been based on studies where noise level was determined to be the main stimulus (IS0 1999; Robinson: 1991) for the ear. Further studies however have indicated that other factors in the environment can have a confounding effect on the resultant hearing damage. This means a combination of high noise plus other non-noise factors can change the risk of hearing damage below the exposure limits. Unfortunately, for the majority of these factors the risk of damage to hearing is increased. A number of non-noise contributors have been suggested and these are discussed in the following sections.

4.1 NOISE EXPOSURE AND OTOTOXIC AGENTS

Ototoxic substance are defined "*chemical substances that have a detrimental effect on an individual's hearing*" (AS/NZS 1269.0: 2005). Morata (2003) identified groups of chemicals, such as:-

- Organic Solvents - toluene, styrene, benzene, n-hexane;
- Asphyxiants – carbon monoxide, hydrogen cyanide;
- Metals – lead, mercury; and
- Pesticides/herbicides – Paraquat, organophosphates

In addition, ototoxic effects have been identified with some medically used drugs such as the aminoglycoside antibiotics (Niall: 1998) and in particular the anti-cancer drug cisplatin (Sockalinham, Murdoch & Charles: 1999). Recently the question of a link between lead poisoning and tinnitus has been raised (Chartrand: 2004).

It has also been demonstrated that there is a synergistic effect between simultaneous ototoxic chemical exposure and noise exposure. The simultaneous exposure tends to intensify, in particular, the effects of noise, resulting in a more rapid progression of the noise injury and subsequent hearing loss (Morata, Dunn & Sieber: 1994; Cary, Clark & Delic: 1997; Fechter: 2004). This is a particular problem in industries that use organic solvents such as chemical refineries (Morata, Engel, Durao, Kreig, Dunn & Lozano: 1997), the printing industry (Morata, Fiorini, Fischer, Kreig Gozzoli & Colacioppo: 2001) and dockyards (Sliwinska-Kowalska et al: 2004). A study in a plastic factory in Japan showed that the combination of organic solvents such as styrene, methanol and methyl acetate may affect the ability to hear high frequency sounds and hearing loss even when legal limits on both were adhered to (Morioka et al: 2000). A recent study in the US (Kaufman et al: 2005) has shown an increase in hearing loss for those exposed to both jet fuel and noise.

One of the main effects of organic solvents also appears to be high frequency hearing loss (Morioka, Miyai, Yamamamoto & Miyashita: 2000). This study examined workers exposed to styrene and found that high frequency hearing loss was experienced by both noise exposed and non-noise exposed groups such that "e*ven if workers were exposed to styrene alone, their upper limit of hearing was reduced*" (p 257).

The most well known ototoxic medications are cisplatin, used as part of the treatment for some cancers, and some of the more aggressive antibiotic drugs (Niall: 1998). A recent study by Guimaraes et al [2006] has indicated from studies of aged women that the presence of progestin in hormone replacement therapy may lead to poorer hearing ability. While such medicines are known to cause hearing loss on their own, it is not yet known how they interact with simultaneous noise exposure. From the evidence cited above concerning ototoxic chemicals in the workplace, it appears probable that there will similarly be some synergistic effects between ototoxic medicines and noise exposure. However, advances in the understanding and mitigation of the side effects of such medications, including their ototoxic effects, may well reduce this risk in the future (Salvi, Ding & Jeong: 2006).

There is an active body of research in this area and although the exact extent of the problem is not fully understood the awareness of employers, occupational health professionals and employees needs to be raised. AS/NZS 1269.0, Appendix C includes an informative appendix on this topic and recommends that for those exposed to "*known or suspected ototoxic agents their noise exposure limits should be reduced as a precautionary measure*".

At this time there is insufficient evidence to recommend the introduction of a new National Noise Exposure Standard for those exposed to both ototoxic substances and noise. However there is a strong body of evidence supporting concerns about the synergistic effects. It is therefore important that the presence of ototoxic chemicals be considered as part of a workplace noise assessment. If such chemicals are a necessary part of the workplace and high levels of noise are also found the employer should be alerted to the possibility of the confounding effect even when both are below the stated exposure criteria. Until the effect is clearly quantified, it can be suggestedv that the noise exposures for such people should be reduced (USACHPPM: 2003) by allowing, for example, a 5 dB 'safety buffer'.

4.2 NOISE EXPOSURE AND SMOKING

In some studies, smoking has been found to have an effect on hearing. One explanation is that the increased need for oxygen in the body, because of the increased presence of carbon monoxide in the blood, cuts the supply of fresh oxygen in the cochlea thus affecting its efficiency. However there are conflicting findings. For example a US study, Cruickshanks, Klein, Klein, Wiley Nondahl and Tweed (1998) concluded that smokers are more likely to damage their hearing ability. However a conflicting finding has been reported more recently (Nondahl, Cruickshanks, Dalton, Schubert, Klein, Klein & Tweed: 2004).

There have been some studies investigating the combination of cigarette smoking and occupational noise. A Japanese study on workers in steel mills (Mizoue, Miyamoto, & Shimizu: 2003) showed an increased risk of high frequency hearing loss amongst those individuals who smoked. A recent Japanese study, conducted as part of on-going research by the National Institute for Longevity Sciences, has demonstrated a relationship between noise exposure and smoking (Uchida, Nakashima, Ando, Niino & Shimokata: 2005). This relationship showed an additive correlation between smoking and noise exposure and a positive dose-response effect with smoking itself, particularly with middle aged male subjects. A statistically significant increased hearing loss existed at 4 kHz compared to non-smokers. This result was mirrored in Brazil where Ferrite and Santana (2005) found that the "*joint effects of smoking, noise and ageing contribute to increased hearing impairment*" (p 52) and in the UK by Wild, Brewster and Banerjee (2005) whose analysis "*demonstrates that hearing thresholds at 3 and 4 kHz of long term cigarette smokers are significantly elevated after long-term noise exposure when compared with non-smokers with a similar work history*" (p 30).

However Palmer, Griffin, Syddall and Coggon (2004) concluded that "*the extra risk to hearing incurred by smoking in high ambient noise levels is small relative to that from the noise itself, which should be the main target for preventative measures*" (p 340). This was following their large study of over 22,000 individuals plus a review of the studies by others.

Thus at this time there appears to be insufficient evidence to justify a specific alert to the employer on the confounding effect of smoking. With the ongoing Government policies aimed at reducing the incidence of smoking in the population as a whole, it is hoped that the incidence of smoking in the overall working population in Australia will decrease.

4.3 NOISE EXPOSURE PLUS VIBRATION

Exposure to whole of body vibration may or may not be encountered at the time of exposure to high levels of audible noise. At low levels of such vibration, individuals can feel unwell, develop nausea and experience headaches. At high levels, physical damage to the body can begin to occur. There is a strong link between vibration and noise, and control of vibration is often the basis for engineering noise control. A review for the HSE by Lawton and Robinson [1989] summarised the findings and identified the limitations in the research to that time of the combined effects of vibration and noise. They also commented that "*the prospects of useful results from further research in this area are far from promising*".

Since then a correlation has been demonstrated, for example, between vibration-induced white finger and increased hearing thresholds, although the exact causal mechanism is still speculative (Szanto & Ligia: 1999). Similarly, Palmer et al [2002] found an association between finger blanching and self reported hearing loss and recommended further investigations.

In addition to the vibration transmission from direct contact with the body, there is an air-borne infrasonic link. The effect of this infrasound seems to be less clearly understood, except in extreme cases such as jet engine test areas. There is no clear indication of the effects of infrasonic vibration, at frequencies below the range of audible sound, on the hearing mechanism (Goelzer, Hansen & Sehrndt: 2001). However, while low frequency sounds are not considered to have an appreciable effect on hearing (ISO 1999), as evidenced by the A-weighting curves, it is not difficult to imagine that continuous exposure to such vibration could have a long term effect on the delicate mechanism of hearing and the vestibular system.

4.4 NOISE EXPOSURE AND ANTI-OXIDANTS.

Studies on the biological basis for noise induced hearing loss and cell death have shown the involvement of anti-oxidants and in this case the effect can be positive in that the hearing loss is reduced. Henderson and Bielefeld (2003) report on studies showing intervention with anti oxidants at the round window prior to exposure can markedly reduce the extent of damage.

Work in the area of anti-oxidants to reduce and even to prevent damage to hearing due high intensity noise has now progressed to the state where a “Hearing Pill” is available on the US market (Johnston: 2004) based on research and development work carried out by the US Navy (Kopke, Coleman, Liu, Riffenburg & Campbell: 2002). The anti-oxidant medication is not intended to be used in place of other forms of noise management. It does however offer some additional protection for specific occasions when it may be essential for personnel to enter a high noise environment, for which traditional forms of hearing protection may be inadequate or inappropriate.

4.5 NOISE EXPOSURE AND TEMPERATURE

An interesting recent development seems to indicate that heat acclimatisation may confer some protection against noise exposure (Paz, Freeman, Horowitz & Shomer: 2003). So far this work has only been studied in animals (rats) but significantly the published results appeared to show that "*heat acclimation can lead to the long-term protection of tissues in the ear from acoustic injury*" (p 369). This could be interpreted as implying that increased temperature would protect workers from hearing loss when exposed to excessive noise.

This is in contrast to earlier work conducted by (Dengerink, Trueblood & Dengerink: 1984). This work concluded that

> *“Noise exposure which occurs in elevated ambient temperature may have greater damaging effects…than that which occurs in cooled ambient temperatures. ...Persons who work in elevated temperatures may be particularly at risk” (p 408).*

In view of the conflicting findings of the limited studies to date it is clear that more research work is required in this area before any recommendations can be made.

4.6 NOISE EXPOSURE AND WORKPLACE STRESS

Stress for workers can be one outcome of psychosocial aspects of the workplace. A study on workplace stress has been undertaken for the VicHealth (2006) and identifies:

> *Three relationships are known to be important psychosocial determinants of the mental and physical health of working people: the relationship between the employee and his or her job, between the employee and other people at work, and between the employee and the organisation.*

There is increasing concern that stress can increase the risk of damage from physical hazards in the workplace. The VicHealth report (2006) states that:

> *Evidence indicates that job stress is rapidly emerging as the single greatest cause of work-related disease and injury, and as a significant contributor to the overall burden of disease in society.*

A description of stress is given by the UK Health and Safety Executive (HSE, 2006):

> “*The adverse reaction people have to excessive pressure or other types of demand placed on them.*”

While it has been accepted for some time that noise can increase stress (WHO 1980) at this time there is no clear evidence that workplace stress will increase the risk of hearing loss. However there is a strong indication that workplace stress can have an effect on the incidence of tinnitus and of the reaction referred to as Acoustic Shock (Patuzzi & Thomson: 1996; WHSQ: 2003).

Dillon and Fisher (2002) described the understanding of the mechanism of acoustic shock as the result of an ‘acoustic startle’ from an unexpected noise that may not be particularly loud. Acoustic shock is described in AS/NZS1269.0: 2005 as:

> “*Acoustic shock is a term used to describe the physiological and psychological symptoms a person may experience after having a sudden, unexpected loud sound, usually via a telephone headset or handset and usually does not result in hearing loss*”.

In practice, an acoustic incident typically acts as a trigger after the culmination of various workplace stressors. Call centres are one such type of workplace where there may be challenging performance pressures, unrealistic performance targets, anxiety, poor working conditions, irate clients and general stress. The combination of a poor psychosocial workplace plus background noise can indirectly influence the likelihood of acoustic shock (Patuzzi & Thomson: 1996; WHSQ: 2003). For example, high background noise may require the call centre worker to use a high headset signal volume, thus increasing the level of any loud and disturbing signal that may occur. Thus for workers who need to listen through headsets it is important to minimise the background noise and to ensure that the psychosocial determinants of the work environment do not increase work place stress.

Tinnitus or ‘ringing in the ears’ is common, with estimates of 17 to 20 per cent of Australians suffering from some degree of tinnitus (Vic Government, 2005). Information on tinnitus acknowledges the two way interaction between tinnitus and stress, namely tinnitus itself leads to stress and stress itself can increase the effect of tinnitus in an affected person (Hazell: 1987). In addition, there are similar links between noise in the workplace and stress (Wilson, Walsh Sanchez & Read: 1998). Thus for high noise workplaces it is particularly important not only to take steps to reduce the noise exposures but also to ensure that the psychosocial determinants of the work environment do not increase work place stress.

5.0 CONCLUSION

The current state of knowledge on a number of emerging issues that may have an impact on occupational hearing loss has been reviewed. Most of these potentially confounding factors are still under investigation by researchers around the world and there may not yet be sufficient compelling evidence to justify inclusion in the National Standard at this time. However acoustic consultants and occupational professionals should be aware of the potential effects when undertaking occupational noise assessments. In particular, the potential for synergistic effects leading to increased risk of hearing damage should be drawn to the attention of management and considered in the development of the noise management plan for the work environment.

6.0 REFERENCES

Access Economics (2006) *Listen Hear! The economic impact and cost of hearing loss in Australia*, a report by Access Economics Pty Ltd, Canberra, February

American Academy of *Paediatrics,* "Noise: A Hazard for the Foetus and Newborn" Paediatrics Vol. 100 No. 4 October 1997, pp. 724-727

ASCC (2006) *Compendium of Workers' Compensation Statistics*, Australia 2002 – 03, the Office of the Australian Safety and Compensation Council, Canberra, ACT

Australian Academy of Science (1976) *Report of a Committee on the Problem of Noise*, Report Number 20, March 1976, Canberra

Australian/New Zealand Standard AS/NZS 1269:2005 *Occupational noise management*, Standards Australia, Sydney

ATSDR (2001) Expert review of the Vieques heart study. *Summary report for the Vieques heart study expert panel review. Contract No 200 – 2000 – 10039, Agency for Toxic Substances and Disease Registry*, USA, and the Ponce School of Medicine, Puerto Rico, August 17th, 2001, www.atsdr.cdc.gov/NEWS/viequesheartreport.html

Cary, R, Clarke, S & Delic, J (1997) "Effects of combined exposure to noise and toxic substances – critical review of the literature", *Ann. Occup Hyg*, Vol 41, No 4: 455 – 465

Castelo Branco, NA & Rodriguez, E (1999) "The vibroacoustic disease – an emerging pathology", *Aviat Space Environ Med*, March; 70 (3 Pt 2): A1 – 6

Castelo Branco, NA & Alves-Pereira, M (2004) "Vibroacoustic Disease", *Noise & Health*, 6; 23: 3 – 20

Chartrand, MS (2004) Lead poisoning and Tinnitus, *Healthy Hearing*, September, <http://www.healthyhearing.com/healthyhearing/newroot/askexpert/displayquestion.as...>

Cruickshanks, K J; Klein R, Klein B E K, Wiley T L., Nondahl D M; Tweed T S (1998) "Cigarette Smoking and Hearing Loss, The Epidemiology of Hearing Loss Study". *JAMA*: 279:1715-1719

enHEALTH (2004) *The health effects of environmental noise – other than hearing loss*, a report published by the en Health Council a sub-committee of the National Public Health Partnership, Department of Health and Ageing, Canberra

Dengerink, HA, Trueblood, GW & Dengerink, JE (1984) "The Effects of Smoking and Environmental Temperature on Temporary Threshold Shifts", *Audiology* 23: 401 – 410

Dillon, H & Fisher, M (2002) "Acoustic Shock", Acoustics Australia 30 (2): 67 – 69

EC (2003) "Directive 2003/10/EC of the European Parliament and the Council, of 6 February 2003, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)", European Union, Brussels, http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_042/l_04220030215en00380044.pdf

Fechter, LD (2004) "Promotion of Noise-Induced Hearing Loss by Chemical Contaminants", *Journal of Toxicology and Environmental Health*, Part A, 67: 727 – 740

Ferrite, S & Santana, V (2005) "Joint effects of smoking, noise exposure and age on hearing loss", *Occupational medicine*, Vol 55 No1: 48 – 53

Goelzer, B, Hansen, CH & Sehrndt, GA (2001) "Occupational Exposure to Noise: Evaluation, Prevention and Control", published by the Federal Institute for Occupational Safety and Health, Dortmund, Germany, for the World Health Organisation, Geneva

Guimaraes P, Frisina ST, Mapes F, Tadros SF, Frinsia DR & Frinsia D (2006) "Progestin negatively affects hearing in aged women" Proceedings of the National Academy of Sciences, USA; 103; 14246-14249, from http://www.pnas.org/

Hartikainen AL, Sorri M, Anttonen H, Tuimala R, Laara E (1994) "Effect of occupational noise on the course and outcome of pregnancy". *Scand J Work Environ Health*. 1994 Dec; 20 (6):444-450

Hazell, JWP (1987) "Tinnitus", Churchill Livingstone, Edinburgh, UK

HSE, 2006, Health and Safety Executive, *2006 Work related stress* http://www.hse.gov.uk/stress/index.htm

Henderson D & Bielefeld E (2003) "Combined Effects: Biological requirements for noise interactions", *Proceedings of the 8th International congress on noise as a public health hazard*, Rotterdam, Netherlands, 29 Jun -3 July paper 11

Hepper PG & Shahidullah S (1994) "Noise and the foetus: A critical review of the literature", Health and Safety Executive Contract Research report 63/1994, from http://www.hse.gov.uk/research/crr_pdf/1994/CRR94063.pdf

Holt, BD (2000) *The Pericardium, Hurst's: The Heart*, ed by V Furster, R Wayne Alexander & F Alexander, McGraw-Hill Professional Publishing, New York, pp 2061 - 2085

ISO 1999 (1990) *Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment*, International Organisation for Standardisation, Geneva

Itoh, A Nakashima, T Arao, H Wakai, K Tamakoshi, A Kawamura T and Ohno Y (2001) "Smoking and drinking habits as risk factors for hearing loss in the elderly: epidemiological study of subjects undergoing routine health checks in Aichi, Japan", *Public Health* 115 (3), 192-196

Johnston, C (2004) "Pill could help sailors' hearing", <http://www.thehearingpill.com>

Kaufman, LR; LeMasters, GK.; Olsen, DM.; Succop, P (2005) "Effects of Concurrent Noise and Jet Fuel Exposure on Hearing Loss"., *Journal of Occupational & Environmental Medicine*. 47(3):212-218, March

Lawton, BW & Robinson DW (1989) "The effects upon hearing of noise in combination with other agents: A critical review of the literature", HSE Contract Research Report No 14/1989, Health and Safety Executive, UK, 1989 http://www.hse.gov.uk/research/crr_pdf/1989/CRR89014.pdf#search=%22CRR89014%22

Kopke, RD, Coleman, JKM, Liu, K, Campbell, K & Riffenburgh, RH (2002) "Enhancing Intrinsic Cochlear Stress defenses to Reduce Noise-Induced Hearing Loss", *The Laryngoscope* 112(9): 1515 - 1532

Lalande NM, Hetu R, Lambert J (1986)" Is occupational noise exposure during pregnancy a risk factor of damage to the auditory system of the foetus?",. *Am J Ind Med.* 10(4):427-35

Mizoue, T Miyamoto, T and Shimizu T (2003) "Combined effect of smoking and occupational exposure to noise on hearing loss in steel factory workers" *Occup Environ Med*; 60: 56-59.

Morata, TC (2003) "Chemical Exposure as a Risk Factor for Hearing Loss", *JOEM*, Vol 45, No 7, July

Morata, TC, Dunn, DE & Sieber, WK (1994) "Occupational Exposure to Noise and Ototoxic Organic Solvents", *Archives of Environmental Health*, September/October, Vol 49, No5: 359 - 356

Morata, TC, Engel, T, Durao, A, Costa, TRS, Krieg, EF, Dunn, DE & Lozano, A (1997) "Hearing Loss from Combined Exposures among Petroleum Refinery Workers", *Scand Audiol*: 26: 141 – 149

Morata, TC, Fiorini, AC, Fischer, FM, Krieg, EF, Gozzoli, L & Colacioppo, S (2001) "Factors affecting the use of hearing protectors in a population of printing workers", *Noise & Health*, 4; 13: 25 – 32

Morioka I, Miyai N, Yamamoto H, Miyashita (2000) "Evaluation of Combined Effect of Organic Solvents and Noise by the Upper Limit of Hearing", *Industrial Health* 38: 252-257

Niall, PD (1998) *The Effects of Industrial Ototoxic Agents and Noise on Hearing*, unpublished thesis submitted for Master of Science in Audiological Medicine, the Institute of Layrngology and Otology University College, London

NOHSC (2000) Occupational Noise, National Standard [NOHSC: 1007(2000)] and national Code of Practice [NOHSC: 2009 (2000)], National Occupational Health and Safety Commission, 2nd Edition, Canberra

Nondahl D M, Cruickshanks K J, Dalton D S, Schubert C R, Klein B E K, Klein R, Tweed T S (2004) "Serum Cotinine Level and Incident Hearing Loss A Case-Control Study" *Arch Otolaryngol Head Neck Surg*. ;130:1260-1264

Palmer, KT, Griffin, MJ, Syddall, HE, Pannett B, Cooper, C & Coggon, D (2002) "Raynauld's phenomenon, vibration induced white finger and difficulties in hearing", *Occup Environ Med*, 59: 640 – 642

Palmer, KT, Griffin, MJ, Syddall, HE & Coggon, D (2004) "Cigarette smoking, occupational exposure to noise, and self reported hearing difficulties", Occup Environ Med, 61: 340 – 344

Patuzzi, R & Thomson, S (1996) "Acoustic Transients and Acoustic Shock in Telstra Consultants", a report prepared by the Physiology Department, University of Western Australia, Nedlands, WA

Paz, Z, Freeman, S, Horowitz, M & Shomer, H(2003) "Prior heat Acclimation Confers Protection against noise-Induced Hearing Los", 9: 363 - 369

Reis Ferreira, JM, Couto, AR, Jalles-Tavares, N, Castelo Branco, MS & Castelo Branco, NA (1999) "Airway flow limitation in patients with vibroacoustic disease", *Aviat Space Environ Med*, March: 70 (3 Pt 2): A63 – 9

Robinson, DW (1991) *Tables for the estimation of hearing impairment due to noise for otologically normal and typical unscreened populations of males and females*, Health & Safety Executive Research report No 29/1991, UK

Salvi, R, Ding, D & Jeong, H (2006) *Gene Expression in Cisplatin Ototoxicity and protection with P53 Inhibitor*, in the proceedings of the 43rd Inner Ear Biology Workshop (IEB 2006), "Hearing Rehabilitation and Innovation", September 17 – 20, Montpellier, France

Sataloff, RT & Sataloff, J (1987) *Occupational Hearing Loss*, Marcel Dekker Inc, New York

Shu-Ju Chang, Chiou-Jong Chen, Chih-Hui Lien and Fung-Chang Sung, "Hearing Loss in Workers Exposed to Toluene and Noise" doi:10.1289/ehp.8959 *Environmental Health Perspectives* http://www.ehponline.org/members/2006/8959/8959.pdf Online 26 April 2006

Sliwinska-Kowalska, M, Zamyslowska-Smytke, E, Szmczak, W, Kotylo, P, Fiszer, M, Wesolowski, W, Pawlaczyk-Luszcynska, M, Bak, M, & Gajda-Szadkowska, A (2004) "Effects of Coexposure to Noise and Mixture of Organic Solvents on Hearing in Dockyard Workers", *JOEM*, Vol46, No 1 January: 30 - 38

Stansfeld S, Haines M, Brown B (2000) Noise and health in the urban environment *Rev Environ Health*. Jan-Jun; 15(1-2):43-82.

Smaldino, JJ & Crandell, CC (2004) "Classroom Acoustics", *Seminars in Hearing*, Vol 25, No 2, May, Thieme, New York

Sockalingham, R, Murdoch, B & Charles, B (1999) "The role of otoacoustic emissions in the identificatication and monitoring of cisplatin-induced ototoxicity", *Journal of Audiological Medicine* 8(1): 1 – 17

Szanto, C & Ligia, S (1999) "Correlation between Vibration Induced White Finger and Hearing Loss in Miners", *Journal of occupational Health* 41: 232 - 237

Uchida, Y, Nakashima, T, Ando, F, Niino, N & Shimokata, H (2005) "s there a relevant effect of noise and smoking on hearing? A population-based study", *International Journal Audiology*; 44: 86 – 91

USACHPPM (2003) "Just the Facts … Occupational Ototoxins (Ear Poisons) and Hearing Loss", US Army centre for Health Promotion and Preventative Medicine, Fact Sheet 51-002-0903, Aberdeen Proving Ground, MD, USA

VicHealth, 2006, *Workplace stress in Victoria: Developing a systems approach*, Victorian Health Promotion Foundation May 2006 at http://www.vichealth.vic.gov.au/assets/contentFiles/Workplace_stress_SUMMARY.pdf

Vic Government, 2005 *Better health channel*, 2005, Tinnitus explained, Vic Government http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Tinnitus_explained?OpenDocument.

Wild, DC, Brewster, MJ & Banerjnee, AR (2005) "Noise-induced hearing loss is exacerbated by long-term smoking", *Clinical otolaryngology* 30: 517 - 520

Wilson, D, Walsh, PG, Sanchez, L & Read, P (1998) *Hearing Impairment in an Australian Population*, Department of Human Services Centre for population Studies in Epidemiology, Adelaide, SA

WorkCover NSW (2000) NSW Workers *Compensation Statistical Bulletin 1998 – 1999*, WorkCover NSW, Sydney

WorkCover (2001) *OHS Regulations 2001*, WorkCover NSW, Sydney

WHSQ (2003) "A Guide to Health and Safety in the Call Centre Industry", Workplace Health and Safety Queensland, Department of Industrial Relations, Queensland Government, Brisbane

World Health Organization (1980) *Environmental Health Criteria 12: Noise*, WHO, Geneva

World Health Organization (1997) *Prevention of Noise-Induced Hearing Loss*, report of an informal consultation held at the World Health Organization, Geneva, 28 – 30 October, Number Three in the series: "Strategies for Prevention of Deafness and Hearing Impairment"

ICA 2010

This is the fifth in a series of regular items in the lead up to ICA in Sydney in 2010.

The International Congress on Acoustics (ICA) is held every three years. The ICA 2007 in Madrid will be followed by the ICA 2010 in Sydney which is being organised by the AAS. The organising committee hopes that there will be a very good representation from Australian acousticians at ICA 2007 to show the high standard of Acoustics in our country and to encourage international participation at ICA 2010. The AAS Council is very supportive and has initiated traveling scholarships for attendance at ICA 2007 – details on www.acoustics.asn.au. Attendance at ICA 2007 offers a great opportunity to blend your interest in acoustics with an opportunity to visit the exciting and historic city of Madrid and travel in Spain and Europe.

Marion Burgess, Chair ICA 2010

ICA 2007

ACOUSTICS FOR THE 21ST CENTURY

2-7 September Madrid

The 19th International Congress on Acoustics is organised by the Sociedad Española de Acústica, SEA, and the Instituto de Acústica, CSIC, under the auspices of the International Commission for Acoustics, ICA. The Congress will be held at the Municipal Congress Centre of Madrid (Palacio Municipal de Congresos) which is an iconic building, located at the "Campo de las Naciones", a new exhibition and financial area in the city of Madrid.

The Congress Programme will consist in the presentation of Plenary Lectures, Invited Papers and Contributed Papers in Structured Sessions. One of the special features of an ICA is that it is a true congress and covers the full range of topics in acoustics. The plenary and distinguished lecture provide the opportunity for participants to learn about advances in the fields that they primarily work in as well as others they may be interested in. The topics include:

Bioacoustics, Computational Acoustics, Electro-acoustics and Audio Engineering, Environmental Acoustics, Musical Acoustics, Noise, Non-linear Acoustics, Physical Acoustics, Physiological Acoustics, Psychological Acoustics, Room and Building Acoustics, Speech and Communication Acoustics, Structural Acoustics and Vibration, Ultrasonics, Underwater Acoustics.

Contributed papers are welcomed in the full range of topics and the deadlines are:
Abstracts 1st April 2007
Full papers 15th May 2007
Early and author registration 15th May 2007

Details for the ICA and for abstract submissions are available from www.ica2007madrid.org

There will be a varied social program during the time of the ICA. Also there will be an extensive Technical Exhibition of products and services in acoustics EXPOACÚSTICA® 2007.

SYMPOSIUM ON MUSICAL ACOUSTICS ISMA2007

Barcelona 9 to 12 September 2007

ISMA 2007 to be held in Barcelona will be organised by the Department of Mechanical Engineering of the Universitat Politécnica de Catalunya; Sociedad Española de Acústica, SEA; Instituto de Acústica, CSIC, IA. Information from www.isma2007.org

SYMPOSIUM ON ROOM ACOUSTICS ISRA 2007

Seville 9 to 12 September 2007

ISRA2007 will be organised by the Instituto Universitario de Ciencias de la Construcción, IUCC; Escuela Técnica Superior de Arquitectura, Universidad de Sevilla, ETSAS; Sociedad Española de Acústica, SEA; Instituto de Acústica, CSIC, IA. Information from: www.isra2007.org

ADAPTIVE RANGE OPTIMISATION FOR TELEPHONY

Christi Wise*, Bonar Dickson, and Peter Blamey

Dynamic Hearing Pty Ltd, Chapel Street, Richmond VIC 3121, Australia

***Electronic Mail: cwise@dynamichearing.com.au**

ADRO® is a sound processing strategy implemented in a headset amplifier with acoustic shock protection for call centres. An initial experiment established the feasibility of maintaining high intelligibility of speech in ambient noise levels up to 75 dBA without amplifying speech to uncomfortable levels. In another experiment, ten normally hearing listeners compared the ADRO device with a device used in many Australian call centres. In background noise, the ADRO device provided higher speech intelligibility scores on the Phonetically Balanced Monosyllable word test than the comparison device, and was preferred in 95% of cases. These results suggest the possibility of improving communication and working conditions in call centres and other noisy environments.

1. INTRODUCTION

Headsets have developed rapidly over the last decade, and are now commonly used in call centre environments to improve comfort and productivity of the user. However, an increase of reported incidents of acoustic shock injury, which results from loud unexpected sounds, has also been noted with headset use [13]. Therefore, output limiting has become a priority. Two sets of guidelines have been developed for this reason, the Australian Communications Industry Forum G616: 2004 [1] and the Telstra TP TT404B51 [16]. Devices have been developed to protect against acoustic shock injury [e.g. 7, 8] and improve the occupational safety of call centre operators by meeting these guidelines. While acoustic shock protection is essential, sound quality, speech intelligibility in background noise and listener comfort should not have to be compromised.

Sound processing is critical in call centre environments, where background noise levels are typically between 55 and 66 dBA and the main source is general conversation between callers and co-workers [14]. Perception in speech or speech-like background noise has been shown to be the most difficult listening environment over other types of noise [11], probably due to the noise carrying a meaningful content (information masking). The negative effects of background noise on various cognitive tasks include loss of efficiency in working memory capacity [15], slower reaction times and reduced accuracy [9], and a greater degree of perceived effort for speech perception [11]. The perceived effort to understand printed text is also increased [11], indicating that the influence of speech-like background noise is detrimental to a wide range of cognitive tasks. A distorted speech signal will exacerbate the problems associated with speech perception in noise. Thus, a clear speech signal is fundamental to successful and efficient communication in call centre environments, which could also lead to improved customer satisfaction.

A digital signal processing scheme, Adaptive Dynamic Range Optimisation (ADRO), has been modified to meet the need for acoustic shock protection while providing optimised speech intelligibility at the same time. It uses statistical analysis to optimise sound in independent narrow frequency channels and a set of fuzzy logic rules to place the output signal within the comfortable and audible range of the listener [2]. The ADRO processing results in an optimized frequency response, signal dynamic range, and overall signal-to-noise ratio. The adaptation rate is also optimized so that ADRO provides linear processing on a moderate time scale, compared with most nonlinear processing schemes. ADRO has shown benefits in cochlear implants and in comparison with wide dynamic range compression hearing aids [4, 12]. ADRO has been specially adapted for telephony applications [3]. ADRO assesses the ambient noise level using the headset microphone and adjusts the output level and frequency response for the received signal based on this information.

This paper reports two experiments. The first experiment explored the feasibility of using ADRO processing in a headset amplifier for call centres. Loudness perception and speech intelligibility were assessed, with and without ADRO processing. The second experiment was a blind comparison between the ADRO device and a device currently used in many Australian call centres. Speech intelligibility and subjective preferences were evaluated.

2. FEASIBILITY OF ADRO FOR TELEPHONY

All testing was carried out in an audiometric test booth, with dimensions 2.7 m x 2.45 m x 2.1 m, and a reverberation time of 0.22 seconds. The setup of the room is shown diagrammatically in Figure 1. Input speech material was filtered according to the send filter specification in ITU P.48 as shown in Figure 2 [10].

Four normally hearing adults ranging in age from 21 to 30 years were recruited for the experiment. Participants were tested prior to the experiment to ensure that they had normal hearing bilaterally (pure tone thresholds ≤ 25 dB HL at octave intervals from 250-4000 Hz). Participants sat in the middle of the room with 4 speakers as noise sources at 1 metre from the listener's head. The noise was the National Acoustics Laboratory Restaurant Noise recording with a long term spectrum similar to the Hoth spectrum recommended by IEEE 269-2002 as shown in Figure 3. Tests were performed in quiet and with noise levels of 55, 65, and 75 dBA (diffuse free field as measured at head location of participant). The input speech material to the headset was female City University of New York (CUNY) sentences [5] at a

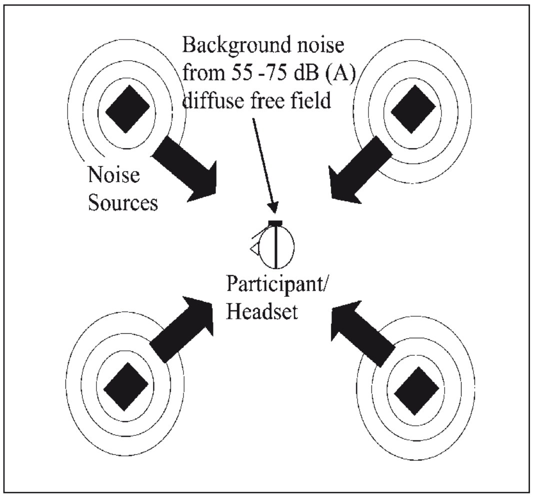


FIGURE 1 General test setup in the audiometric test booth used in the current study

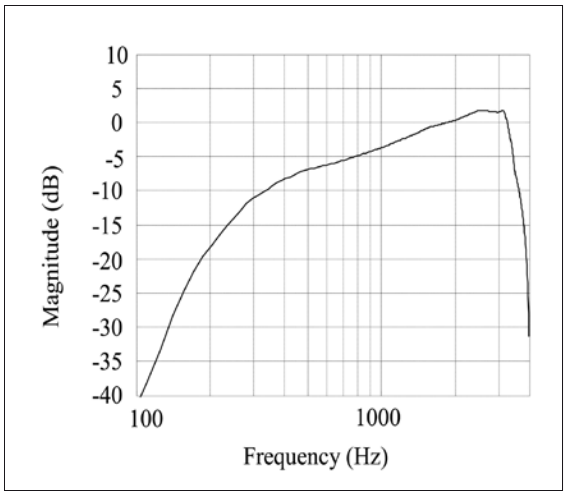


FIGURE 2 ITU Recommendation P.48 IRS send filter magnitude response [10] used for the input material in the current study

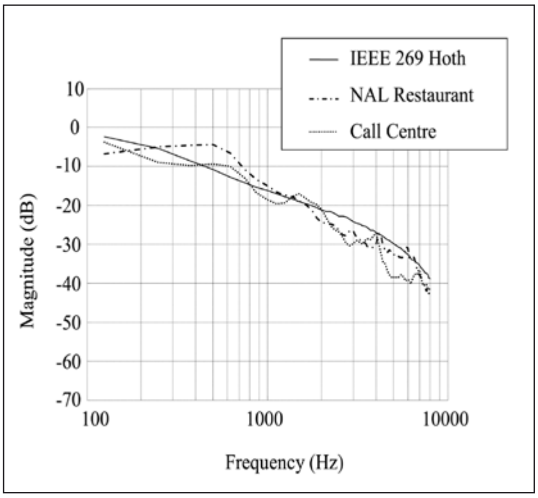


FIGURE 3 Ambient noise spectra showing IEEE 269 Hoth, NAL restaurant, and simulated call centre noise as used in the current study

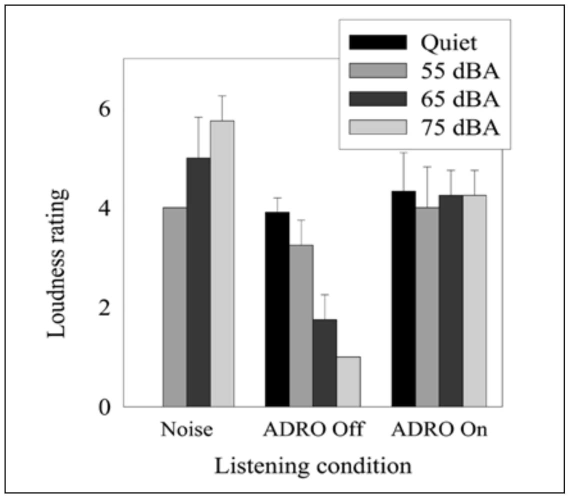


FIGURE 4 Loudness ratings averaged across subjects

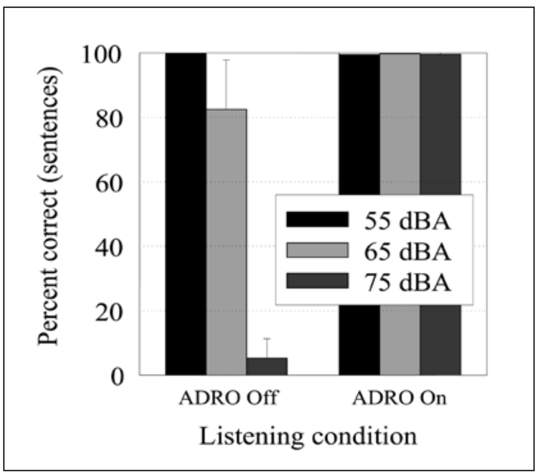


FIGURE 5 Speech intelligibility scores in percent correct for City University of New York sentences in various levels of noise for ADRO-ON and ADRO-OFF conditions

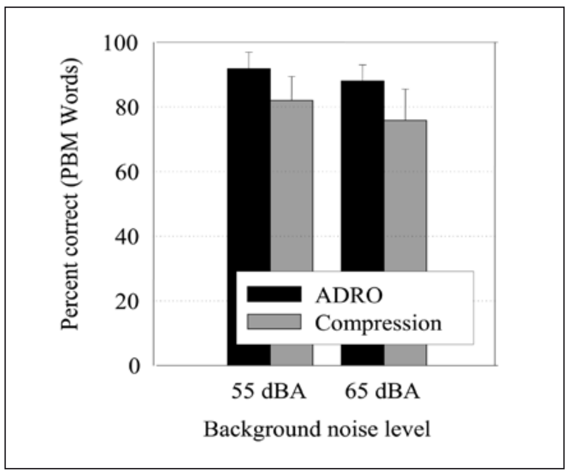


FIGURE 6 Speech intelligibility scores for Phonetically Balanced Monosyllable words in 55 and 65 dBA of pseudo call centre background chatter

nominal input level to produce 73 dB SPL RMS at the eardrum reference position on a Brüel & Kjær head and torso simulator (Ear Simulator IEC711 ITU-T Type 3.3) for both ADRO-ON and ADRO-OFF conditions and did not change throughout the experiment. In the ADRO-OFF condition, the headset amplifier operated as a linear amplifier with flat frequency response and no ambient noise adjustment.

Participants placed the Plantronics Supra Monaural H51-TT3 headset comfortably on their right ear for testing. Initially, loudness ratings were taken according to a 7 point loudness scale (Appendix) with 0 being inaudible and 7 being uncomfortably loud [6]. The CUNY sentences were presented through the headset with background noise from the speakers at four levels (off, 55, 65, and 75 dBA). Participants were asked to give loudness ratings for the background noise alone and for speech in the ADRO-ON and OFF conditions in each level of noise.

Secondly, CUNY sentences were presented through the headset with background noise levels of 55, 65, and 75 dBA to evaluate speech intelligibility. One list containing 10 sentences was presented for each noise level in both ADRO conditions (ON and OFF), so a total of 6 lists were presented. Scores were calculated by counting the number of words correct for each list. The order of presentation of noise levels and ADRO conditions, and the assignment of CUNY sentence lists were randomized across participants.

Loudness Ratings

The loudness ratings averaged across participants are shown in Figure 4. The loudness ratings for noise range from Comfortable to Loud but OK. Without ADRO processing, the perceived loudness of speech decreased as noise level increased. With ADRO processing on, speech was maintained at a constant and comfortable loudness, regardless of the level of noise.

Speech Intelligibility

The ADRO-OFF results in Figure 5 establish how difficult this task is without any processing. The CUNY sentence scores decreased from 100% in 55 dBA of noise to 5% in 75 dBA of noise. This is consistent with the perceived loudness of the speech which decreased from comfortable but slightly soft to very soft as shown in Figure 4. The CUNY sentence scores remained close to 100% in all noise conditions with ADRO-ON, consistent with the constant comfortable loudness ratings. A non-parametric Kruskal-Wallace test was used to assess the statistical significance of the differences between ADRO-ON and ADRO-OFF conditions because of the obvious ceiling effect in the ADRO. The differences were statistically significant for the 65 dBA and 75 dBA conditions ($p<0.05$).

3. BLIND COMPARISON OF DEVICES

In the second experiment, the ADRO device was compared with a headset amplifier commonly used in call centres throughout Australia. The comparison device uses compression and selective filtering to control the loudness of speech and other sounds. For most signals the time constants are in the order of 100 ms. For high level sounds the attack time of the algorithm is much faster, in the order of 5 ms in order to protect the listener against acoustic shock. The comparison device can also adapt two notch filters to remove high-pitched tones in the frequency range from 1 kHz to 4 kHz. The device settings were as shown in Table 1. The settings for the comparison device are those most commonly used in several Australian call centres with the Plantronics H51 headset. They were chosen to maximize speech intelligibility in background noise, within the capability of the comparison device.

The participants for this experiment were eight adults with normal hearing, ranging in age from 25 to 45 years. Participants were tested to ensure that they had pure tone thresholds ≤ 25 dB HL at octave intervals from 250-4000 Hz. The room set up was the same as in the previous experiment as shown in Figure 1. The diffuse noise conditions of a call centre were simulated using 4 speakers as noise sources at 1 metre from the participant's head, with simulated call centre background chatter as the output, according to test methods specified in TT4 [16] and shown in Figure 3. Tests were performed with noise levels of 55 and 65 dBA (diffuse free field as measured at head location without subject). A Plantronics Supra Monaural H51-TT3 headset was used with both headset amplifiers. The input signal to both amplifiers was ITU P.48 IRS Send filtered, 0.3 – 3.4 kHz bandwidth, at -20 dBV RMS [10] as shown in Figure 2. All participants were instructed to place the headset comfortably on their right or left ear for testing, with the microphone two finger-widths from the corner of their mouth. The volume control was set at maximum level on both devices. At this volume setting, the long-term average output level for a sample of speech measured using a Brüel & Kjær head and torso simulator (Ear Simulator IEC711 ITU-T Type 3.3) was equal for the two devices in quiet conditions.

The input speech material for the first part of the experiment was NAL Phonetically Balanced Monosyllable (PBM) Words. Eight PBM word lists equivalent in their performance/intensity (PI) functions were used for speech intelligibility and subjective comparison testing (2 devices x 2 noise levels x 2 lists). Noise levels, list sequence, and starting condition were randomized. The first 5 words were practice items, and the remaining 25 words were test items. The score was the percentage of completely correct whole word answers.

A paired comparison procedure was also used to assess listener preference for the ADRO and compression devices. The listening material consisted of 20 samples of continuous speech (10 male and 10 female voices) heard through the headset in the presence of 55 dBA of simulated call centre background noise. The participants used an A/B switch box to switch as many times as they needed to reach a preference judgment. The order of speech samples and the assignment of processing strategy to switch positions A and B were chosen randomly for each trial and counterbalanced across participants. Each participant compared the two devices once for each voice, making a total of 20 judgments for each participant.

Speech Intelligibility

The speech intelligibility results with PBM words are shown in Figure 6. A two-way analysis of variance showed a significant difference between processors ($F(1, 60) = 38.24$, $p<0.001$) and between noise levels ($F(1, 60) = 7.9$, $p<0.01$). The interaction between processor and noise level was not significant ($p=0.485$). The error rates for the PBM word test for ADRO were 9% and 12 % in 55 and 65 dBA noise levels respectively. This is in accord with the TT4 guideline [10] which specifies a 10% or less error rate in 55 dBA background noise.

Listener preferences

The paired comparison of continuous discourse with 55 dBA simulated call centre background chatter resulted in the majority of participants choosing ADRO in 95% of cases as their preferred listening strategy. The comparison headset was chosen a total of 8 times out of 160 choices. This result was significantly different from chance ($p<0.001$).

4. DISCUSSION

We did not expose the participants in this study to the risk of acoustic shrieks for obvious reasons. A comparison of the device performance from this point of view is more appropriately done by instrumental measurement. The manufacturers of both the ADRO device and the comparison device state that they are G616 compliant and suitable for TT4 compliant operation. The ADRO processing in a headset amplifier with acoustic shock protection maintained good intelligibility and comfortable loudness under adverse listening conditions, while protecting users' hearing with signal limiting. It is likely that the independent optimization of listening level in each frequency channel of the headset contributed to the robustness of the speech intelligibility scores in noise. The typical transfer function of a telephone line (Figure 2) and the typical ambient noise spectrum (Figure 3) slope in opposite directions, resulting in a variation in the effective signal-to-noise ratio for the listener at high and low frequencies. ADRO's frequency shaping of the headset output tends to overcome this problem. The linear operation of ADRO has also been shown to provide improved intelligibility in noise compared to the non-linear operation of compression in hearing aids [4]. In addition, the ambient noise adjustment built into the ADRO amplifier provided an automatic volume control function to keep the signal-to-noise ratio at an adequate level without exceeding the safe output levels built into the device.

In difficult listening situations with 65 and 75 dBA of noise, CUNY sentence scores with ADRO processing on were significantly higher than with ADRO off. There was a ceiling effect for both ADRO on and off conditions in noise at 55 dBA.

The PBM words have less redundant information than the CUNY sentences, and provided a more sensitive intelligibility test. In particular, the acoustic cues for consonant identification are often at a much lower sound level than the vowels, and are easily misheard in background noise.

The PBM word test results indicated that the imposition of safe output levels in both devices had a measurable adverse effect on speech intelligibility under typical noise conditions for device settings that are commonly used in Australian call centres. This limitation of speech intelligibility was observed when the comparison device was set to minimal limiting and maximal volume: the condition likely to provide maximum speech intelligibility in noise. The ADRO device provided significantly greater robustness and halved the error rate relative to the comparison device. This difference is likely to correspond to a measurable difference in the accuracy of call center operators' work and reduced call resolution time.

The ADRO amplifier provided comfortable listening levels in all ambient noise levels up to 75 dBA, and was preferred 95% of the time over the comparison device in a blind paired comparison. These results show that use of the ADRO amplifier is likely to add to the comfort and job satisfaction of call centre operators.

5. ACKNOWLEDGMENTS

The authors would like to thank Jane Steinberg for her contribution to this research. The research was conducted with the approval of the Human Research and Ethics Committee of the Royal Victorian Eye and Ear Hospital (03/529H).

ADRO® is the registered trademark of Dynamic Hearing Pty Ltd.

6. REFERENCES

[1] Australian Communications Industry Forum G616:2004 "Guideline: Acoustic Safety for Telephone Equipment."

[2] Blamey, P.J., James, C.J., Wildi, K., McDermott, H.J., Martin, L.F.A. Adaptive dynamic range optimization sound processor. Australian Patent Application PCT/AU99/00076, International Patent Application WO 00/47014, filed Feb. 5, 1999, and published Aug. 10, 2000. (1999)

[3] Blamey, P.J., Dickson, B., Steele, B.R., Steinberg, J.M. Method & apparatus for adaptive sound processing parameters. International Patent Application PCT/AU2004/001691, filed Dec. 13, 2004. (2004)

[4] Blamey, P.J. Adaptive dynamic range optimization (ADRO): A digital amplification strategy for cochlear implants and hearing aids. *Trends in Amplification* 9(2): 77-98, 2005

[5] Boothroyd, A., Hanin, L., Hnath, T. "A sentence test of speech perception: Reliability, set equivalence, and short term learning." *Speech & Hearing Report RCI.* New York: City University of New York. (1985)

[6] Cox, RM, Alexander, GC, Taylor, IM, and Gray, GA. "The Contour Test of loudness perception". *Ear and Hearing,* 18: 388-400 (1997)

[7] Dillon, H., Fisher, M. "Acoustic Shock." *Acoustics Australia.* 30(2):67-70. (2002)

[8] GN Netcom 8210 White Paper, Retrieved on Nov 8, 2005, from the World Wide Web: http://www.gnnetcom.com/NR/rdonlyres/A0D6518D-807E-484F-B450-7FC858A8C4AB/0/GN_8210_factsheet_UK_EMEAindd.pdf (n.d.)

[9] Hallgren, M., Larsby, B., Lyxell, B. Arlinger,S. "Evaluation of a cognitive test battery in young and elderly normal-hearing and hearing-impaired subjects." *J Am Acad Audiol*., 12: 357-370. (2001b)

[10] International Telecommunications Union-T, P.48 "Specification for an Intermediate Reference System." (1993)

[11] Larsby, B., Hallgren, M., Lysxell, B., Arlinger, S. "Cognitive performance and perceived effort in speech processing tasks: Effects of different noise backgrounds in normal-hearing and hearing-impaired subjects." *Int J Audiol*., 44, 131-143. (2005)

[12] Martin, L.F.A., Blamey, P.J., James, C.J., Galvin, K.L., Macfarlane, D. "Adaptive dynamic range optimisation for hearing aids." *Acoustics Australia* 29, 21-24. (2001a)

[13] Milhinch, J.C. Acoustic Shock Injury [unpublished report]. Melbourne, Australia: Milhinch Audiology. (2001)

[14] Patel, J.A., Broughton, K. "Assessment of the Noise Exposure of Call Centre Operators." *Ann Occup Hyg*., 46(8), 653-661. (2002)

[15] Pichora-Fuller, M., Schneider, B., Daneman, M. "How young and old adults listen to and remember speech in noise." *J Acoust Soc Am.* 97(1), 593-608 (1995)

[16] Telstra Specification TP TT404B51: "Specification: Headset & Limiting Amplifier, Acoustic Protection." Issue 3.1 (2001)

7. APPENDIX

LOUDNESS SCALING INSTRUCTIONS

In this task, we want you to rate the loudness of various sounds according to the scale printed below. You will be presented with three types of sounds; some with a voice talking in quiet, some with a voice talking with noise in the background and some with just the background noise. Please rate the overall level of loudness for the various types of sounds. The quality or clearness of the speech when presented with the noise is not important in this task, just rate the overall loudness of the speech and the noise. The task will be repeated several times.

LOUDNESS RATING CATEGORIES

7. UNCOMFORTABLY LOUD
6. LOUD, BUT OK
5. COMFORTABLE, BUT SLIGHTLY LOUD
4. COMFORTABLE
3. COMFORTABLE, BUT SLIGHTLY SOFT
2. SOFT
1. VERY SOFT
0. INAUDIBLE

TABLE 1 Device settings

	ADRO Processing	Compression Processing
Software Version:	1.10a	1.9
Rx Volume:	Max	Max
Tx Volume:	Mid	Mid
Tx Mute:	Off	Off
Other:	Terminal setting: A	Config menu settings: Rx input gain: mid Tx volume: mid Headset profile: Limiter setting: 1

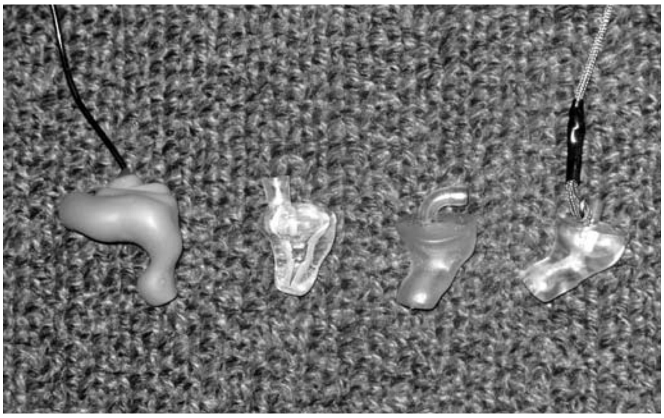
CUSTOM-MOULDED EARPLUGS

Warwick Williams

National Acoustic Laboratories

Chatswood, NSW

Custom-moulded earplugs are often presented as the ultimate in hearing protector technology and attenuation ability. This analysis compared the performance of custom-moulded devices to off-the-shelf earplugs and earmuffs and found that, while custom devices performed better than the 'average' earplug, they were not as good as the 'average' earmuff. The suggestion is made that the standard hearing protector rating specification of SLC80 may not be applicable to custom-moulded devices and perhaps a more individual rating should be used.



INTRODUCTION

For better or worse hearing protectors are a well recognised tool in the management of noise exposure in the workplace [1, 2, 3]. Quite appropriately these same sources clearly emphasise that the use of hearing protectors is seen as the last step in the occupational noise exposure management process – elimination of the hazard is always preferable to the use of personal protective equipment. This said, hearing protectors do have a legitimate role in the reduction of noise exposure in those workplaces where long term solutions are in the process of being implemented or there are no other practicable solutions.

The main attenuation parameter for hearing protectors in Australia is the well recognised SLC80 (Sound Level Conversion) or attenuation that is applicable to approximately 80% of the users at any one time. This has been further simplified through the use of the Classification System for selecting hearing protectors [4, 5]. Employing the SLC_{80} method for the determination of appropriate hearing protectors involves two noise exposure measurements, both A- and C-weighted, and some minor calculation while the Classification Method requires only the A-weighted noise exposure – a simplification for the end user.

When selecting hearing protectors for use, the main parameters to be considered are the required attenuation, comfort and the ability to communicate and/or hear warning signals. The attenuation performance and communication ability are self-explanatory but comfort is critical because no matter how well a device performs, if individuals will not wear it, it is ineffective. Comfort is a very difficult parameter to define [6]. An important consideration often not considered is the consistency of attenuation. This consistency should be expected by the wearers and be independent of the actual attenuation specification. Consistency in this case is interpreted in terms of the variation in attenuation obtained between different test subjects. In practice it is represented by the variance of the attenuation results of a specific protector or, similarly, the standard deviation of the results.

Thus if individuals are being supplied with hearing protectors as their main tool against noise exposure, consistent performance of the hearing protector is extremely important. If the performance of the device varies significantly individuals may have a tendency to not wear them. This can particularly be the case in lower noise environments [7].

When considering the range of different hearing protectors available, any that offered some form of personal fitting procedure would seem to be preferable as they would tend to minimise fitting variability. This view would be enhanced when endorsing statements are made such as:

"Custom moulded earplugs ... are made-to-measure to the individual's auditory ear canal. The [resulting] plug provides the sealing, while an additional acoustic filter determines the actual attenuation required" [8];

and

"Custom moulded HPDs [Hearing Protection Devices] are comfortable and cannot be worn incorrectly" [9] (p 18).

In general the advertising around custom-moulded hearing protectors emphasises better performance because of the personalised aspect. It is intended in this work to look closely at the performance of custom-moulded earplugs and the suitability of the traditional single figure rating system.

Custom made devices are made by either one of two processes. The first are made on site in a single process where by some manner a moulding material is injected into the ear and ear canal. This mould is then turned into a permanent earplug. The second process is one where an ear impression is taken and sent off site to a manufacturing facility where a permanent earplug is produced, using the impression, from a more durable material than that used for taking the original impression.

As well as having a personalised physical fit many devices also have a personalised acoustic fit. This is where an acoustic filter is inserted into the plug with the intention of matching the attenuation characteristics of the plug to the noise spectrum experienced by the individual. The emphasis at all times is that the devices are personally tailored and individually fitted by an experienced operator in order to better fit the device to the user's ear and to match the attenuation of the device to the users noise exposure.

METHOD

The data used for the analysis was taken from hearing protector testing that had been carried out in accordance with the requirements of combined Australian/New Zealand Standard AS/NZS 1270:2002 Acoustics – Hearing protectors [10]by laboratories accredited by the National Association of Testing Authorities, Australia. In fact most of the basic data can be gathered from the information that is required to be supplied with the sale of the devices as described in AS/NZS 1270. Devices tested before the introduction of the 1999 and 2002 versions of the Standard have not been included in this analysis as they were tested with a smaller number of subjects (minimum 15). The number of test subjects in the later versions of the standard is set at a minimum of 20 for earplugs. (The difference between the 1999 and 2002 versions of the Standard was only in the mechanical testing procedure)

The attenuation of a hearing protector is determined by exposing individual test subjects to one-third octave bands of pink filtered noise at seven octave band centre frequencies from 125 to 8k Hz and determining the subjects occluded (wearing the protector) and unoccluded (not wearing the protector) hearing threshold level difference. This threshold difference is the attenuation of the device. With the test procedure as used in Australia, the tester is not permitted to assist the test subject to fit the protector. The test subject may only use the instructions as provided by the supplier of the devices thus it is termed an inexperienced subject-fit test.

The SLC is calculated as described by Waugh [11]; the SLC_{80} as described in *AS/NZS 1270, Appendix A* [10]; and the mean standard deviation of the device by taking the average of the standard deviations of the attenuations for the seven octave bands. The mean individual SLC (*mi*SLC), mean individual SLC_{80} ($miSLC_{80}$) and individual standard deviation (*i*SD) are a proposed new procedure and are calculated as detailed by Williams [12]. The *mi*SLC is, as suggested by the name, the mean of the individual overall attenuation calculated from the octave band attenuation experienced by the test wearer. The *i*SD is simply the standard deviation of the *i*SLC values while the *mi*SLC80 is the *mi*SLC minus the *i*SD (ie $miSLC_{80} = miSLC - iSD$).

The main difference between the SLC_{80} and the $miSCL_{80}$ is essentially that the SLC_{80} uses the mean and standard deviations of the octave band results for the final calculation while the $miSLC_{80}$ uses the mean individual performance and the standard deviation of the mean.

The devices chosen for this analysis are current and commercially available on the Australian market.

RESULTS

Table 1 summarises all of the calculated parameters for ten custom-moulded ear plugs. Several of the devices were produced by the same manufacturer but were fitted with different filters to provide a specific attenuation. For example, one particular plug may be produced with three filters in order to provide a range of protectors with Classification ratings of 3, 4 and 5 respectively. Each of these plugs would be indicated as being a separate device. For commercial reasons the name and/or manufacturers of the respective devices have not been supplied.

Device	SLC	SLC_{80}	Mean SD	*mi*SLC	iSD	$miSLC_{80}$	Min	Max	Range
A	19.0	15.0	4.2	18.3	3.1	15.2	14.1	25.1	11.0
B	21.5	17.5	4.4	20.9	3.1	17.8	17.1	26.8	9.7
C	22.9	18.8	4.8	22.5	3.6	18.9	17.7	30.0	12.3
D	24.6	20.3	4.8	24.1	3.7	20.3	16.0	30.7	14.7
E	29.0	23.6	5.8	28.4	4.9	23.6	21.2	36.5	15.3
F	30.6	25.0	5.7	29.7	4.2	25.5	22.6	38.1	15.5
G	30.5	22.1	8.0	29.2	7.3	21.9	12.7	45.5	32.8
H	29.6	23.0	6.9	29.0	6.3	22.8	12.8	37.5	24.7
I	27.7	20.4	7.7	26.9	6.8	20.1	14.5	36.6	22.1
J	27.9	23.2	4.7	27.3	4.1	23.3	18.6	32.7	14.1
Average			5.7		4.7				
Average for all plugs			7.8		(4.2)				
(Average for all muffs)			6.2		(3.3)	*Note: All figures are expressed in dB*			

Table 1: A summary of the parameters calculated from the available test data for custom-moulded earplugs. 'Min' is the minimum individual attenuation (iSLC) measured for a particular device while 'Max' is the maximum and 'Range' is the difference between the Max and Min. All figures expressed in dB. ($miSLC_{80} = miSLC - iSD$)

The *"Average for all plugs"* figures is the average *'Mean SD'* and *iSD* respectively for earplugs (including two custom-moulded pairs) that were tested in accordance with AS/NZS 1270:2002 [10] by National Acoustic Laboratories over the years 2002 to 2004 [7]. Thus they present standard deviation values that could be considered typical for earplugs in general. A similar situation also applies to the "*Average for all muffs*" figures.

DISCUSSION

If it is accepted that consistency of performance can be adequately represented by standard deviation, then the overall performances of the custom-moulded devices are more consistent compared to the general results obtained for tests of many earplugs. This is shown by the average 'Mean SD' for custom-moulded plugs being 5.7 dB while for all plugs it is 7.8 dB and the average iSD being 4.7 dB compared to 6.2 dB for all plugs. However, the custom-moulded plugs do not perform as well as the average for all ear muffs, which have average values for mean SD and iSD of 4.2 dB and 3.3 dB respectively. The best earplugs have an iSD of 3.1 dB while for the best earmuffs it is as low as 1.4 dB.

While most devices performed with standard deviations around the average value some performed very poorly. This is reflected in the range of *i*SLC attenuations provided, which varied by 9.7 dB, from 17.1 to 26.8 dB, for the most consistent performer to a variation of 32.8 dB, from 12.7 to 45.5 dB, for the worst. Even for the best result a range of attenuation of 9.7 dB around the mean of 20.9 represents a variation in performance of around 46%.

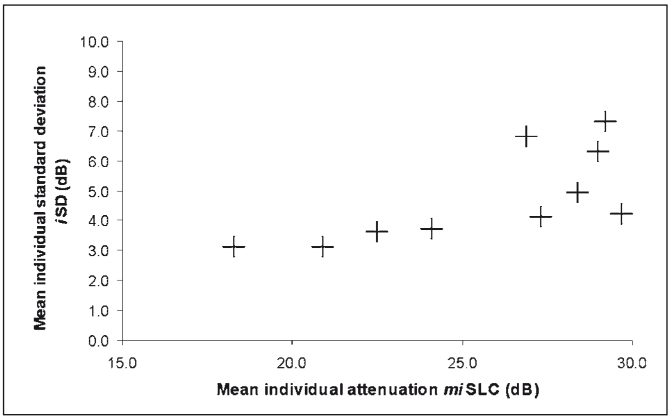


Figure 1: Individual standard deviation (iSD) (dB) versus the mean individual attenuation (miSLC) (dB) for ten, commercially available custom-moulded earplugs.

Figure 1 graphs the distribution of the individual standard deviations (iSD) (dB) versus the mean attenuation (miSLC) (dB). The majority of the devices behave as would reasonably be expected in that they have very similar standard deviations. This is reasonable because it could be presumed that the variations for each device tested would come from similar sources and hence yield a consistent value. Three devices obviously fell well away from range exhibited by the majority of the plugs tested. It should be noted that these are three devices produced by the same company but with different 'filters' to better personalise their performance to the clients requirements. It can only be speculated that the cause of these larger than average standard deviations may be due to a particular production technique or fitting procedure.

One question to pose is that rather than produce an overall attenuation performance figure for custom-moulded earplugs should we be paying more attention to the 'personalised' feature of these devices and somehow look more at a personal performance measure more related to the individual and their personalised device? It may be possible that currently by mixing two processes, ie personalising the fit but including a 'standardised' filter, there is a degree of uncertainty introduced into the process. Perhaps it would be better to fit a personalised device to an individual and more accurately measure the insertion loss they experience when the device is in use. This would then be more accurately described as a personally fitted earplug.

This now leads to an important point. Is there a real need for a parameter such as SLC80 for a personalised hearing protector? And, if for some persuasive argument the SLC80 is retained, does it have any relevant meaning?

Some occupational health and safety jurisdictions require that for a hearing protector to be legitimately applied as part of an occupational noise management programme it must have been tested in accordance with AS/NZS 1270. This implies the rating to have been measured as the result of a statistical performance amongst a specified minimum number of suitable test subjects. Since the SLC80 measure is a population statistic strictly it does not apply to the individual even though this is frequently conventionally done.

If we are using a personally specific device perhaps the implementation of a standardised personal 'insertion loss' test would be of more value than trying to fit the characteristics of personalised devices to an unsuitable 'population' measure. A better rating may simply be the iSLC, calculated from the individual's measured attenuation at each octave band for overall attenuation as demonstrated here by the use of miSLC, iSD and miSLC80 [12]. If the octave band method of specification must be used then the same octave band attenuations can be employed.

CONCLUSION

An overall analysis indicates that overall custom-moulded earplugs do perform more consistently than earplugs in general, with the average individual standard deviation for custom-moulded devices being 4.7 dB while it is 6.2 dB for earplugs in general. However, they still are not as consistent as the general performance for earmuffs that have an average individual standard deviation of 3.3 dB.

This analysis also suggests that the current method of specification of custom-moulded earplug performance using the SLC80 figure may not be entirely satisfactory and perhaps another more individualised rating is required.

REFERENCES

[1] NOHSC (1991) Noise Management at Work Control Guide, National Occupational Health and Safety Commission, second edition, Sydney

[2] WorkCover (1996) Code of Practice for noise management and protection of hearing at work, WorkCover NSW, Sydney 1996

[3] NOHSC (2004) National Code of Practice for Noise Management and Protection of hearing at Work [NOHSC: 2009(2004)], 3rd Edition, Canberra

[4] AS/NZS 1269.3 Australian/New Zealand Standard AS/NZS 1296.3: 2005 Occupational noise management, Part 3: Hearing protector program, Standards Australia, Sydney

[5] Williams, W (1999) The classification system for hearing protectors, J Occup Health Safety – Aust NZ 15(5): 471 – 474

[6] Broughton, KA (1995) Comfort Aspects of Ear Protection, Physical Agents Group, Technology and Health Science Division, Health and Safety Executive, UK

[7] Williams, W & Dillon, H (2005) Hearing protector performance and standard deviation, Noise & Health, 7; 28: 51 – 60

[8] Hearing Tech Pty Ltd (2006) Choosing the best hearing protection, <http://www. ferret.com.au/articles/b0/0c01b4b0.asp>

[9] Joyce, K (2006) Applying customisation to hearing protection, Safety Solutions, March 2006

[10] AS/NZS 1270 Australian/New Zealand Standard AS/NZS 1270:2002 Acoustics – Hearing protectors, Standards Australia, Sydney, 2002

[11] Waugh, D (1976) Investigation of sound level conversion as a means of rating ear protector performance, Journal of the American Industrial hygiene Association, April 1976: 239 – 245

[12] Williams, W (2005) A Variation to the Sound Level Conversion Measure of Hearing Protector Performance, Acoustics Australia Vol 33, No 2: 51 - 55

CHANGES AND CHALLENGES IN ENVIRONMENTAL NOISE MEASUREMENT *

Philip J Dickinson

Massey University Wellington, New Zealand

Many changes have occurred in the last seventy years, not least of which are the changes in our environment and interdependently our intellectual and technological development. Sound measurement had its origins in the 1920s at a time when people were still traveling by horse and cart or on steam trains and few people used electricity. The technology of electronics was in its infancy and our predecessors had limited tools at their disposal. Nevertheless, they provided the basis on which we rely for our present day sound measurements. Since then we have come far, but we still await a solution for the lack of accuracy we have come to accept.

THE BEGINNINGS

Harvey Fletcher, first President of the Acoustical Society of America. Courtesy Emilio Ségré Archives

In the early part of last century, the study of sound was given a large boost by the American Telephone and Telegraph (AT&T) Company's research headed by Harvey Fletcher at Western Electric to improve reception in the telephone. The Western Electric Laboratory as the name suggests was engaged primarily in electrical research and development. Acoustics was only a small facet of its work and the development of acoustical measurements occurred on the back of electrical developments. The Laboratory had been engaged for many years in the development of a means to measure an a.c. voltage. This was not easy and the Laboratory had to utilize a root mean square in order to always achieve a positive value for the moving coil meters then in use. In those days the unit for resistance was 1 mile of standard cable, which varied with frequency and temperature, and for measurement of a.c. power to make it independent of frequency and temperature, it was convenient to use a power (or logarithmic) series for its description based on the power developed by a one volt sinusoid across a mile of standard cable. This measure was called the Transmission Unit TU (Martin 1924)

Harvey Fletcher (whom this author is very privileged to be able to have called a friend) studied the reactions of (it is believed) 23 of his colleagues to sound in a telephone earpiece generated by an a.c. voltage. He came up with the idea of a "sensation unit" SU, based on a power series compared to the voltage that produced the minimum sound audible. Harvey initially called this the "Loudness Unit" (Fletcher 1923) but later changed his mind following his work on loudness with Steinberg (Fletcher and Steinberg 1924). As a ratio it was not really a unit, but nevertheless was called one, following the use of the "Transmission Unit". With the AT&T development of the Wente microphone (Wente 1917), an instrument to measure sound in sensitivity units could be developed based on an arbitrary sound pressure close to that simulated by Harvey Fletcher's voltage that produced the minimum audible sound for his research subjects. The idea of an "intensity level" meter was born – as was the idea of an acoustical society: The Acoustical Society of America founded in 1928 holding its first meeting in May 1929 (ASA 1929). Harvey Fletcher (Fig. 1) was its first president.

In the mid 1920s there were suggestions of renaming the Laboratory after Alexander Graham Bell who had recently died, and on February 8th 1924 AT&T and Western Electric created the Bell Telephone Laboratories or Bell Labs as it was called from then on. In 1927 there was a further suggestion to call the Transmission Unit the "Bell", but after some consultation with telephone engineers in France who objected to the word because it was too close to the French word "Belle" (Marsh 2005), Bell Labs decided to call the Transmission Unit the "Bel" with a tenth of it called the "Decibel" (Martin 1929). Later, of course, by international convention "deci" and "bel" are always lower case, with the bel abbreviation as "B" – hence our use of dB in electrical work. The Director of Research at AT&T – H. D.

* This is an invited paper, modified from a historical paper in the Proceedings of the Australian Acoustical Society Conference, 2005. Editor Terrance McMinn.

Arnold – had led the development of the vacuum tube and electronic amplification was becoming available to measure small values of power, which is of course proportional to the square of the voltage. In such work, a logarithmic measure was also quite useful in that when amplifiers and attenuators are connected in series, power levels could be added or subtracted arithmetically.

During the 1920s, quite independently there were similar studies being carried out in Europe with similar results, except that the Europeans (with the exception of the British) used a naperian logarithm series that resulted in development of the "neper" – the natural logarithm of a power ratio. It is understood this pre-dated the decibel (Lang 2005), but this author has been unable to find any reference to the development of a valve-voltmeter or wattmeter utilizing nepers and it is interesting to note that Georg von Békésy in his experiments in hearing (Békésy 1960) used the decibel for his research at the Royal Hungarian Institute for Research in Telegraphy. Professor Erwin Meyer of the University of Göttingen preferred the decibel for all his work in the 1930s, and his colleague Arnold Schock wrote a small book on Acoustics in which only the decibel was used (Bruel 2005). Békésy later worked in the Department of Telegraphy and Telephony at the Royal Institute of Technology in Stockholm and this may account for the use of the decibel in Scandinavia after World War II

The first sound level meters were large, consisting of a condenser microphone, an amplifier with thermionic valves and a valve-voltmeter with a logarithmic scale covering the voltage range of one sensation unit split into 10 segments. Almost immediately it was found that something had to be done to the meter to make the movement of the needle readable and some damping was inserted so that the needle would move over the whole scale in 1 second. The (logarithmic) scale had a range of one bel divided into decibels with a reference level of 10-16 watts/cm^2 (Fletcher 1953). At the same time, the first audiometers started to appear with voltage settings linked to sensation units (Fletcher 1923A). Speech clarity and hearing studies were the main acoustics focus and sound level meters and audiometers were research instruments only for comparison studies. There were no standards to give the reference power or voltage – indeed some researchers used 10-13 watts/m^2 and some used 10-12 watts/m^2 (GenRad 1963) – and accuracy was questionable. So the next step was to try to get some order and a standard by which everyone could work. Such a standard was not to appear until circa 1936 when the Acoustical Society of America published the first embryo standard for sound level meters. (ASA 1936).

In conjunction with CBS and NBC, Bell Labs explored the way to describe audio power levels in recording and broadcast studios and developed the "volume unit" VU based on a reference power level of 1 milliwatt into an impedance of 600 ohms. The metric was labeled dBm and a standard produced in the late 1930s (Chinn et al 1940)

At a time when electronics was in its infancy and the choice of materials very limited, a good structural base had been set for the development of acoustics research in an era of a relatively quiet environment for most people. There were very few cars on the road and even fewer aircraft to upset the noise environment. The main transportation was by steam train supplemented by horse and cart in country areas and by the omnibus and bicycle in towns. Certain industrial processes such as stamp mills were abominably loud and the noise in textile factories and mills much more than experienced today. In general, however, the home and school were quiet places, but children were still employed in factories and Harvey Fletcher even in those days noted the large number of children with hearing loss (Fowler and Fletcher 1926).

THE DEVELOPMENTAL YEARS - 1935 TO 1959

The early work of Fletcher and Wegel (Fletcher and Wegel 1922) and Fletcher and Munson (Fletcher and Munson 1933) into auditory thresholds and sensitivity, clearly showed that the reading on a sound level meter did not represent a measure of how loud or intense the subject sound might be. Something was needed in the meter's circuitry to give a measure of loudness. Initial work produced the A, B and C frequency weightings (ANSI 1961). Sometime in this period – this author has been unable to find out exactly when – the decibel became the official measure for sound pressure level. It is popularly attributed to Harry Olsen, the Chief Engineer of RCA who, when talking about electrical sound recording, said he could see no difference between acoustical watts and electrical ones (Wallis 2005). Whatever the source, by the end of World War II, the decibel was in general use for the description of sound. Rapid developments in electro-technology, as a result of the War effort, spawned a number of companies producing sound level meters in the late 1940s and the formation of the International Electrotechnical Commission which in 1953 formed Technical Committee 29 to develop and establish performance standards for acoustical instrumentation (Rasmussen 2005). ISO Technical Committee TC 43 was also formed around this time and the decibel adopted by them also (Rasmussen 2005). It became possible to buy sound level meters off the shelf enabling researchers to study environmental noise and develop ways of describing it (Fig. 2).

Fig 2. An early sound level meter used by the author [GenRad 1963]

Quite surprisingly, little thought initially was given to maintaining accuracy of measurement, and acoustic calibrators were not part of the measurement regime until the 1960s.

Indeed, from personal experience, in some countries the use of acoustic calibrators was not introduced until the 1990s. Early calibrators were simply a box with a diaphragm onto which tiny ball-bearings were dropped from a fixed height by inverting the box (Fig. 3). By use of a spacer bar, the sound level meter was set up with the microphone 4 inches away. It was not accurate, but better than nothing.

Fig. 3. Falling ball calibrator, Courtesy Cirrus Research.

THE AGE OF SURVEYING - 1950 TO 1975

Following World War II and the introduction of jet aircraft into commercial travel, environmental noise levels rose to such an extent that people started to complain. Military air bases in particular faced confrontation from local residents for making too much and quite unnecessary noise. Some air bases responded by placing large notices at their boundary saying "Listen to the Sound of Peace and Security" or "Hear the sound of safety" etc. Whereas the military might well get away with the noise, commercial airports were much more vulnerable and moves were made to restrict the noise emission to reasonable levels (Fig. 4).

In order to find out what was a reasonable level of noise (as judged by government, of course) surveys were made around some of the major airports of the day, (e.g. the Wilson Report, 1963). In each, the occupiers of certain picked residences were interviewed about their reactions to the noise outside which latter was measured very simply with a short series of instantaneous measurements of A-frequency weighted sound pressure level (although it is believed no survey ever admitted it). Relating the respondents survey answers to the given noise level outside seemed often to have political overtones for in general the study came up with a relationship between the residents' reaction and the environmental noise involving some obscure metric that no one could measure and hence prove the researchers or the government wrong. And with the obscure metric, compatible land use policies were developed (Galloway & Bishop 1970) with which the local territorial authorities were expected to comply, whereas no control was placed on the airports or airfields to reduce the noise emission.

Relating the respondents survey answers to the given noise level outside seemed often to have political overtones. For example: The surveys around London (Heathrow) Airport produced a relationship called the noise and number index NNI where:

$$\text{NNI} = \text{Average Perceived Noise Level (PNdB)} + 15 \log_{10} (\text{Number of flights}) - 80.$$

Fig. 4. One of the noisiest aircraft at London (Heathrow) Airport: A de Havilland Trident.

This was readily accepted by the British Government and regulations involving maximum levels permitted by aircraft were introduced into law in the late 60s. Noise insulation grants were given to residences receiving (or at least predicted to be receiving) more than 35 NNI. Everyone was led to believe the government had accurate figures for the noise exposure, but not only could the local people not measure the noise in PNdB, neither could the government officers. They (We) simply made an A-frequency weighted measurement in decibels and added 13. A system of noise monitoring stations were set up around the airport with noise limits in PNdB that the aircraft were obliged not to exceed. The monitoring stations were set up very carefully in prominent positions and this author recollects the pilots were very worried about being prosecuted for making more noise than the limit. They all kept very carefully to the allocated flight tracks, little realizing that this was all the monitoring system was set out to accomplish. It, too, only took A-frequency weighted readings in dB and added 13. The outdoor microphone systems were prone to corrosion and several (somewhat questionable) methods were used to keep out the wind and the rain – all of which must have rendered the system way out of calibration. At one major airport, not in England, hydrophones were used to overcome these problems. Several other countries came up with their own aircraft noise measures, and monitoring systems, and it is believed all used metrics in which no-one outside of government could measure – and nor could the government officers, but this was never publicised!

Not all noise surveys targeted major airports. The reaction to noise in a number of major cities was also surveyed. The Greater London Survey was one of the first noise surveys, predating the airport noise surveys, and differed from almost all the rest by the introduction of a metric that the general public themselves could measure – the "percentile level" – but then it did not include a (government) sensitive facility such as a major airport. From the author's own recollections, the metric stemmed from a meeting over morning tea between four British representatives at an ISO meeting in Paris circa 1955 including Peter Parkin, George Vulkan and Hugh Humphries. Who raised the question cannot be remembered, nor who answered, but on being asked "What do you think would be the best way to describe the background noise level?" someone answered "The level that is there 90% of the time." The others thought this a very good idea and one of them suggested that the noise that is there for 10% of the time was the nuisance noise. Unfortunately they were not mathematicians and termed the measure the "Percentile Level". This stuck for some years until someone dared to suggest that the L90 was mathematically the 10th percentile level and the L10 the 90th percentile level. At the time, few people listened, but eventually the measure became known as the "Centile Level". Although a very poor measure of community reaction (Schultz 1982) it was all that was really possible with an instantaneous reading sound level meter and the methodology was simple. Although obsolete in modern day technology, the measure still lingers on in a very few places that favour industry being able to make whatever noise it likes as long as it is for not longer than just under 10% of the time.

Importantly the US Federal Aviation Administration FAA and the International Civil Aviation Organization ICAO introduced noise certification for all new aircraft entering service in Europe and the United States after 1972. Again politics was involved in that the first step (to Stage 2 or Chapter 2 aircraft noise certification) would be achievable by 75% of the civil aircraft then extant. A next step (to Stage 3 or Chapter 3) was to be achieved by 1976 and gradually introduced throughout the world. Although some airlines still employed Chapter 2 aircraft well into the 1990s the overall result is that aircraft individually are much quieter than they were and public reactions noticeably reduced. For example at Wellington International Airport New Zealand, in the 1980s there were hundreds of complaints every month about aircraft noise. Today with adherence to good airport noise management, and a workable national standard (NZS 6805:1992) aircraft noise exposure is only a tenth of what it was, and complaints are very few. Some monthly records each year register no complaints at all.

University research benefited also in having government research money readily available for studies into people's reactions to noise, and a multitude of frequency weightings appeared to describe the sound produced by different sources. Indeed, until a stop was called internationally in 1973, more than a hundred different frequency weightings had been produced for sounds ranging from those of different types of jet aircraft to that of noise in pipes or the barking of different types of dog. None were significantly better than the original A-frequency weighting and so by international agreement all were dropped by ISO and IEC except for the A-frequency weighting. One other – the C-frequency weighting – was temporarily retained to provide a lower and upper cut-off frequency when measuring peak levels so as to avoid recording any high levels of sound outside the audio-frequency range. Modern sound level meters now employ a Z-frequency weighting to provide such cut-off frequencies (IEC 61672)

Yet perhaps the greatest advance during this age was the development in the sound recording industry. The new plastics allowed the development of the reel to reel tape recorder to quite sophisticated levels with Ampex, Grundig, and above all Nagra producing some exceptional recording machines that could be used in conjunction with the instantaneous reading sound level meters to store sounds for future analysis. However it was a little known company called "Soundstream" led by Dr Thomas Stockham that arguably produced the most important advance in acoustics since the work of Harvey Fletcher in the early 1920s – that of the flash card and digital recording and analysis. Sadly Tom died trying to protect his invention from piracy by big business, but the advantages he gave to the acoustics industry was a quantum leap forward at a time when computers were in their infancy and RAM almost an unknown quantity.

The world at last had a reliable way of measuring environmental sound and well researched guidelines for planning the home environment to protect residents from the adverse effects of too much noise.

Perhaps the most useful (measurement) development of this time was that of a true time-average-level based on short Leq measurements (Holding 1985). The computer, of course, had made this possible and from then on high grade sound level meters used computer chips capturing sound exposure in Pa2.s and then converted it to whatever unit or decibel measure was desired. It became possible to log sound level measurements at one second intervals over several hours and obtain a time history of the sound. We now benefit greatly from this, but at a cost: A number of major companies could not keep up with the pace and went into liquidation.

As the development of the computer advanced, so did that of the sound level meter. Electronically the sound level meter advanced to be capable of doing almost anything one wanted, but then other concerns came to the fore.

THE AGE OF UNCERTAINTY - 1995 TO 2005

Two things caused much concern in this particular decade. The international Institute of Metrology pointed out that to conform with Standard International convention the SI unit should be the neper and not the decibel. This resulted in much heated discussion and no conclusion could be drawn at the ISO/TC43 meeting in 2003 although the decision was taken that some existing draft standards should continue to employ decibels (ISO 2003).

The meeting did conclude however that for field quantities, the quantity should be written as:

$L_F = 10 \log [F^2/F0^2]$ dB and not as

$L_F = 20 \log_{10} [F/F_0]$.

Not until the 31st meeting in Toronto was the problem resolved. Almost unanimous agreement was reached that the decibel would remain the descriptor for sound (ISO 2005).

The other concern was a directive by ISO and IEC that in reporting all measurements there must be a statement of percentage uncertainty. It is difficult enough for a testing laboratory using carefully controlled environmental conditions to put such a value on its measurements, but for measurements outside it is almost impossible. The problem is always the microphone, how it receives the signal and how it sends on the response to the central processing unit of the meter. When we have a fixed signal and calibrator in a controlled environment we can expect accuracy rather better than a dB.

For field measurements it is a totally different matter: the variability of many environmental noises and the effects of wind make fractions of a dB impossible, and variations of 5 dB or so typical. (Kerry & Craven 2001) This is probably one reason for the retention of the decibel as the metric rather than the Pa2.s. It is not that we have to measure in decibels with all its inherent complications, but stating the uncertainty of a sound measuring system ± 1 dB, clearly sounds much better than ± 26% .

THE CHALLENGING YEARS AHEAD

Now in the 21st century, technology has progressed almost beyond our wildest dreams. We have sound measurement instrumentation we would never have thought possible a decade or two ago. We can log sound in third octave bands at intervals of a few milliseconds and immediately read off reverberation times across the entire spectrum, or we can log sound levels at one second intervals over long periods of time and analyse any period at will. We can also store raw data to give measurement results in any metric we like, all with instant graphs in wonderful colours, and have an audio play back as well, if we wish. We can operate a sound level meter by remote control from a thousand miles away while watching the activity through a telelink, and synchronise the recordings of a multitude of noise monitors. We can also record in several channels at once incorporating sound pressure, particle velocity and phase in three dimensions. The new "Microflown" system (Microflown 2002) gives a measure of velocity. Drawbacks remain: the microphone has not reached the precision available in the other parts of the sound level recording systems. Nevertheless, acoustics must still be considered one of the less accurate sciences. We can measure the light from a star millions of kilometres away, we can measure the time for light to travel a distance less than a tenth of a millimetre, we can measure the heat output of a candle more than a kilometre away – all to an accuracy of 3% or better, but it is difficult or impossible to measure sound levels in the field with comparable precision.

REFERENCES

American National Standards Institute 1961 S1.4 'Sound level meters'.

Acoustical Society of America 1929 J. Acoust. Soc. Am. Vol. 1.

Acoustical Society of America 1936 'American Tentative Standards for Sound Level Meters Z24.3-1936 for Measurement of Noise and Other Sounds' J. Acoust. Soc. Am. Vol. 8, pp 147-152.

Békésy, G. 1960 'Experiments in Hearing' McGraw Hill.

Bruel, P. 2005 Pers. comm., 14 June.

Chinn, H A, Gannett D K, & Morris R M. 1940 'A new standard volume indicator and reference level' Proceedings of the Institute of Radio Engineers, Vol. 28, 1-17.

Fletcher, H. 1923a 'The use of the audiometer in prescribing aids to hearing'. Transcriptions. College of Physicians of Philadelphia Vol. 45 p 489.

Fletcher, H. 1923b 'Physical measurements of audition and their bearing on the theory of hearing' J. Franklin Inst., Vol. 196, pp. 289-326.

Fletcher, H. 1953 'Speech and Hearing in Communication' Van Nostrand 1953.

Fletcher, H. and Munson, W.A. 1933 'Loudness, its definition, measurement and calculation'J. Acoust. Soc. Am. Vol. 5 pp 82-108.

Fletcher, H. and Steinberg, J.C. 1924 'The dependence of the loudness of a complex sound upon the energy in various frequency regions of the sound' Phys.l Rev Vol. 24 pp 306-317.

Fletcher, H. and Wegel, R.L. 1922 'The frequency-sensitivity of normal ears' Phys. Rev. Vol. 19 pp 553-565.

Fowler, E.P. and Fletcher, H. 'Three million deafened school children' J. Am. Med. Assoc. Vol. 87 pp 1877-1882.

General Radio, 1963 'Handbook of Noise Measurements'

Galloway, W.J. and Bishop, D.E. 1970 'Noise Exposure Forecasts: Evolution, Evaluation, Extensions and Land Use Interpretation'

Holding, J. 1985 Ph.D Thesis Sheffield University

International Electrotechnical Commission 2005 'Sound level meters' Standard IEC 61672, Geneva.

International Organization for Standardization 2003 Resolution 2. Report of the 30th meeting of ISO TC/43 'Acoustics' Berlin.

International Organization for Standardization 2005 Report of 31st meeting of ISO TC/43 'Acoustics' Toronto, Canada. Pers. comm., William Lang.

Kerry, G. and Craven, N. 2001 'Beyond verification – The role of measurement uncertainties in environmental noise measurements' Proc. UK Institute of Acoustics, February.

Lang, W. 2005 Pers. comm., 13 June.

Martin, W.H. 1924 'The transmission unit and telephone transmission reference systems'. Bell System Tech. J., Vol. 3 pp. 400-408.

Martin, W.H. 1929 'Decibel - The name for the Transmission Unit'. Bell System Tech. J., Vol. 8 pp. 1-2

Bree, H.E. 1997 Ph.D. thesis. University of. Twente. www.microflown.com

Standards New Zealand 1992 'Airport noise management and land use planning' NZS 6805.

Rasmussen, K. 2005 Pers. comm. 15 June.

Schultz, T. 1982 'Community noise rating' Applied Science Publishers, Barking, England.

Wallis, A.D. 2005 Personal communication 6 June.

Wente, E.C. 1917 'A condenser transmitter as a uniformly sensitive instrument for the absolute measurement of sound intensity,' Phys. Rev. Vol. 10. Pp. 39-63.

Committee on the Problem of Noise (UK) 1963 'Noise' (The Wilson Report) London.

CRITIQUE OF ISO 354 (ACOUSTICS – MEASUREMENT OF SOUND ABSORPTION IN A REVERBERATION ROOM)

Byron Martin, CPEng, MAAS

Mechanical Engineering, the University of Adelaide, South Australia

The University of Adelaide has an acoustics facility in which transmission loss, absorption and sound power measurements are regularly performed. The facility is used for teaching, research and external consulting. A recent series of sound absorption tests performed there used ISO 354 as the test procedure.

Three sections in the "standard" were considered to be too vague to be easily understood: section 7.2.2 Averaging, the definitions of m_1 and m_2 in 8.1.2.1 and 8.1.2.2 respectively, and equation (8) in 8.1.2.3

AVERAGING.

In section 7.2.2, two methods are stated as being possible for averaging the reverberation times; ensemble averaging and arithmetic averaging. Ensemble averaging averages the decay curves and the resultant "averaged" reverberation time is used in the calculations. I have two difficulties with this method: First, the time domain synchronisation of each decay curve should be within 1% of the shortest decay time. In our lab that would be about 15 ms, otherwise errors will occur in the time domain averaging. Second, while this method does produce an average, on most analysers no variance is calculated. I believe that an average value requires knowledge of the variance to be useful. In fact, the "standard" includes a section (8.2.2) on the use of the reverberation time standard deviation in determining the repeatability of the measurements.

This quote concerns arithmetic averaging: "the single decay curves shall be evaluated first and the resulting reverberation times shall be averaged using arithmetic averaging". The theory relating reverberation time T to the sound absorption uses the decay rate, i.e. a quantity proportional to the reciprocal of reverberation time. A more accurate estimate of sound absorption would be obtained from the arithmetic average of 1/T rather than that of T. In this case the standard deviation can also be easily calculated and the published equation (10) for the relative standard deviation would be replaced with:

$$\varepsilon_{20}(1/T)/(1/T) = \sqrt{\frac{2.42 + 3.59/N}{fT}} \qquad \text{(a)}$$

If knowledge of the repeatability of the measurements of acoustic absorption is required, then arithmetic averaging of the individual decay rates is the best way to proceed.

DEFINITIONS OF m (THE POWER ATTENUATION COEFFICIENT).

In section 8.1.2.1, m_1 is calculated "in the empty reverberation room during the measurement" – I presume that this means during the measurement of the reverberation times for the empty room, i.e. without the test sample.

Then in section 8.1.2.2 m_2 is defined in exactly the same way – but I presume that it should be during the measurement of the reverberation times with the test sample in the empty room.

CALCULATION OF THE EQUIVALENT SOUND ABSORPTION AREA, EQ (8).

The equation in the "standard" used for calculating the sound absorption (8) is a reduced form of the theoretically rigorous:

$$S\bar{\alpha} = \frac{55.25V}{c}\left[\frac{1}{T_{60}} - \frac{(S'-S)}{S'T'_{60}}\right] \qquad \text{(b)}$$

The difference between equation (b) and equation (8) is the term:

$$\frac{S}{S'T'_{60}} \qquad \text{(c)}$$

where S' and T' refer to the empty room

This term is not negligible; if the sample is 10 m^2 and the room ~200 m^2 then the term reduces 1/T' by 5%. This is demonstrated in the table, taken from one of our recent tests.

In one of the bands the difference is a factor of 6. Even in bands where the absorption is >0.5 the difference is ~5% which exceeds the published standard's requirement for reproducibility.

Band	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600
eq(b)	0.04	0.02	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.08	0.11	0.20	0.51	0.87	0.61
eq(8)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.05	0.08	0.17	0.48	0.84	0.58

AAS News

ANNUAL COUNCIL

At the annual meeting, held in conjunction with the Annual Conference in Christchurch, New Zealand, Terry McMinn was elected as President and Neil Gross as the Vice-President. Byron Martin continues as Treasurer. The importance of the web page for communication within and without the AAS was acknowledged by the agreement that each Division would appoint a webmaster to run their page on the national site for their Division – they would be responsible for preparing and uploading the information.

Name Change for Sustaining Member

Council is considering changing the name "Sustaining" to "Sponsor" or "Corporate". Concern has been expressed that it could be assumed from the title that Sustaining Members have expertise in acoustics. Any comments on this issue should be addressed to generalsecretary@acoustics.asn.au

Discontinue membership of FASTS

The AAS has been a member of FASTS, the Federation for Australian Scientific and Technological Societies, almost since its inception in 1985. This organisation is a lobby group which represents 60,000 working scientists and technologists, and promotes their views on a wide range of policy issues to Government, industry and the community. The societies which make up FASTS represent the professional interests of scientists and technologists in Australia. The President is an ex officio member of the Prime Minister's Science, Innovation and Engineering Council (PMSEIC), and this allows FASTS to contribute to discussions at the highest levels in policy-making in Australia. FASTS has three formal objectives: to encourage scientific dialogue between industry, government, and the S&T community; to promote public understanding of science; and to foster close relations between the societies. In recent years FASTS has had considerable influence at the policy making level of government. Council is willing to reconsider this decision if there is support for continuation from the AAS membership. Further information on FASTS can be found on www.fast.org. Any comments on this issue should be addressed to generalsecretary@acoustics.asn.au

Education Grant 2006.

One award of $2500 was made to Ralph James and Shane Chambers from the Bioacoustics Research Group, School of Physics, University of Western Australia (UWA). They aim to quantify the effect of the attenuative processes on inshore shallow water acoustic propagation These results will be used to assess whether dysfunction of cetacean sonar is a possibility at classic 'whale trap' topographies; gently shelving sandy beaches. Their award will be used to purchase additional items of equipment to further this study.

Education Grant 2007.

Council has taken two actions in regard to the education grant for 2007. One is to make a substantial increase the allocation for 2007 to $15,000. The other is for Charles Don and John Davy to review the guidelines to ensure they reflect the aim of the grant. The revised guidelines and submission details will be available from www.acoustics.asn.au early 2007 and the grant will be announced at the AAS AGM to be held in November 2007.

AAS Traveling grant award

In the first round applications for the AAS traveling grant, Jer Min Chen, PhD student UNSW, has been awarded a traveling grant to assist attendance at both the ICA and ISMA meetings in Spain in 2007. He has been studying the role of vocal tract in saxophone playing by measuring the vocal tract acoustical impedance during performance. He will be presenting a paper on vocal tract interactions in saxophone performance. The second round of applications for the travelling grant is now open with the deadline for submission end of February; details from www.acoustics.asn.au

Excellence in Acoustics Award 2007

The Council is appreciative of the continued support by CSR Bradford Insulation of this award. Council acknowledged the role played by Marion Burgess in chairing the selection committee since the inception of the award and is pleased that John Dunlop has now taken over this role. It was agreed that, although it means the selection process will need to be brought forward, the award would be presented at the ICSV14 during July 2007. Submission details will be available from www.acoustics.asn.au early 2007

Education initiative

The lack of suitable opportunities for education in acoustics has been identified as a major problem for the acoustic consulting firms. Following the discussion at the 2005 Conference a small committee comprising Neil Gross, Matthew Harrison, Matthew Stead and Marion Burgess has looked into various options. It was agreed at the outset that any course must be able to be undertaken in distance mode. A program based on the Diploma in Acoustics managed by the UK Inst of Acoustics (IOA) was considered the most appropriate to meet the identified needs. Negotiations with the IOA continued through most of the year and resolution achieved shortly before the Council Meeting. Both the AAS and the Australian Association of Acoustical Consultants (AAAC) are delighted that this first step has been reached. The IOA has accepted the cooperative nature of this undertaking and provided the course material for the General Principles of Acoustics Unit in the first instance. While the basic concepts are the same, this course material needs updating and modification to be applicable for Australian conditions. The AAAC has agreed to provide the funding for the costs for the first IOA test and tutorials. The AAAC has also agreed that a member company in each state will provide facilities and oversee the undertaking of the experimental work associated with this module and to supervise the test. This first unit will be offered via the Short Course program of the University of New South Wales at the Defence Force Academy. The next stage will be to provide additional units covering community and occupational noise, building acoustics, vibration, legal aspects etc based on the IOA program but updated to meet Australian requirements. In the longer term, the necessary steps will be taken to ensure that successful completion of these units will be considered for advanced standing for students seeking to undertake a formal post graduate University course. The first unit will be offered from February 2007 and anyone interested should contact avunit@adfa.edu.au for more information.

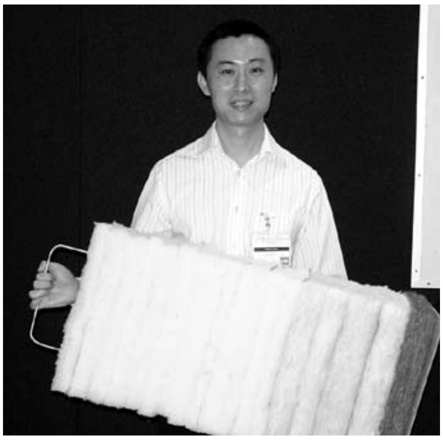
ICA Young Scientist Awards

These prestigious awards are primarily to assist young scientists to participate in the ICA congress in Madrid in 2007. Candidates must be relatively early in their professional careers (typically a maximum of 15 years of active career), but can be either undergraduate or postgraduate students, postdoctoral or young acousticians. Submissions are due by March 15, 2007 and the details are given on www.icacommission.org. Note that the submitted papers should be also accompanied by a letter of reference from an "Officer" of the candidate's local acoustical society and such requests should be addressed to generalsecretary@acoustics.asn.au

ICA Early Career Award. The ICA Early Career Award is presented to an individual who is relatively early in his/her professional career (about 10-15 years of active career), and who has been active in the affairs of Acoustics through the National Society and has contributed substantially, through published papers, to the advancement of theoretical or applied acoustics or both. The Award consists of an honorarium, a Certificate and a Medal on the recommendation of the ICA Early Career Award Committee. The nomination and selection procedure is given on www.icacommission.org. Any member wishing to nominate themselves or others should contact generalsecretary@acoustics.asn.au

CSR Bradford Insulation Excellence in Acoustics Award 2006

The Annual Excellence in Acoustics Award, sponsored by CSR Bradford Insulation, aims to foster and reward excellence in acoustics. The entries from members of the Australian Acoustical Society (AAS) are judged on demonstrated innovation from within any field of acoustics. The prizes are a trophy and a gift to the value of $2,500 for the winner and a certificate and gift to the value of $500 to the runner up.



Dr Jingfeng Xu holding an example of the multiple layers to achieve the anechoic performance.

The first challenge for the two judges from the AAS and two judges from CSR Bradford Insulation was to short list from the range of entries. All were of a high standard and this was not an easy task. The two short-listed were then asked to make a short presentation to the four judges and to answer questions.

The winning entry was from Dr Jingfeng Xu on “Flat walled multi-layered anechoic linings: optimization and application”. Dr Xu now works for Arup Acoustics but much of the technique used was developed during his PhD studies. Most linings for anechoic, or low reverberation rooms, use wedges of sound absorbing material to provide the required performance. Such linings are expensive and it has been realized for some decades that the use of multiple layers of flat lining, each with differing acoustic properties should be able to achieve the same outcome. Selection of the appropriate materials and thicknesses for the layers has been a difficult and tedious task. Xu has applied multi-objective evolutionary algorithm (MOEA) to optimize this process. Using the various properties of different sound absorbing materials and other criteria including minimizing overall cost, the optimization can be achieved in a matter of minutes. This technique has already been applied in the construction of an anechoic room for the MARCS auditory laboratory at the University of Western Sydney and a hemi-anechoic room for the School of Electrical and Information Engineering at the University of Sydney. The required anechoic performances down to 250 Hz and 100 Hz respectively have been achieved with a huge saving in the overall construction costs compared with the use of wedges for lining.

Ken Williams and Dean Gillies demonstrating the capabilities of the “Noise Camera”

Acoustic Research Laboratories (ARL) were awarded the runner up prize for their "Noise Camera". This is an automated system designed to identify and record engine brake noise and to obtain a visual identification of the offending vehicle. The identification of the brake noise from the general traffic noise is based on analysis of the modulation in the signal. The system brings together leading edge audio and video technology in one instrument capable of being calibrated to Australian and International standards for sound level meters and octave analysers.

The Excellence in Acoustics Awards were presented by Ray Thompson from CSR Bradford Insulation during the dinner at the first Australasian Conference on Acoustics held in Christchurch, New Zealand in November 2006. Unfortunately Jingfeng Xu was unable to attend but advised he would use the prize to assist with commercialising his design. Ken Williams accepted the prize on behalf of ARL and said that it would be spent on the purchase of an EPROM programmer to be used in further development work.

The AAS is delighted that CSR Bradford Insulation will support the Excellence in Acoustics Award for 2007 and the details for submissions is available from the AAS website, www.acoustics.asn.au

2006 State of the Environment Report

2006 State of the Environment Report has been released. This is the third such report. The independent Committee was chaired by Bob Beeton and other members include Ms Kristal Buckley, Professor Gary Jones, Ms Denise Morgan, Professor Russell Reichelt, Mr Dennis Trewin and Mr Sean Sullivan. The report is available from www.deh.gov.au/soe/2006/index.html. The themes, or sections, for the report are Atmosphere; Biodiversity; Coasts and oceans; Human settlements; Inland waters; Land; Natural and cultural heritage ; and Australian Antarctic Territory.

It is interesting to note that in the introduction to the 62 pages section on Human Settlement, it is stated that human settlements: "... *constitute an environment in their own right—the built environment—delivering amenity and liveability to resident and visitor populations.....Secondly, human settlements are a source of pressure on the rest of the (natural) environment...*" However in this entire section there are only 2 mentions of the word noise, namely as an effect of infill housing "*... such as privacy, wind flow and ventilation, environmental noise, and shading*" and one of multiple objectives in a table on Elements of an urban sustainability framework is *“Reduce environmental noise”* but with no interim target identified as is the case for many of the other objectives.

Air Met and Allara on the Move

Air Met, agents for Quest noise and vibration instrumentation, and their sister company Allara Instrument Hire have moved their Sydney office to 17-23 Myrtle St, North Sydney and have opened a new office in Mackay at Unit 3, 73 Wood St, Mackay. For all sales and service enquiries phone Air Met on 1800 000 744 or fax 1800 000 774 or for rental enquiries phone Allara on 02 9954 6552 or fax 02 8904 1825. Their www page remains as www.airmet.com.au and www.allara.com.au and email for general enquiries sales@airmet.com.au and hire@allara.com.au

New logo for Pyrotek

Pyrotek
Soundguard noise control

This clearly identifies the Pyrotek imprimatur on the well-known Soundguard soundproofing label, which till now has been marketed successfully as an entity in its own right. The move is aimed at making clear to customers who seek soundproofing, aluminium, foundry, glass, steel or specialty metal solutions that they can source all these needs from the one company. Pyrotek has a 30 year history in Australia of developing and manufacturing its Soundguard range of noise control materials for the industrial, commercial, building and marine industries. More details at www.soundguard.com.au.

Divisional News

VICTORIAN DIVISION

The final Victoria Division technical meeting for 2006 was a dinner held on Dec-06 at the Malvern Valley Golf and Reception Centre with 27 members and friends present. Graeme Harding, as invited speaker, spoke about human responses to noise. It is important that we distinguish between the "hearing" and human "processing" of sounds, aspects neglected by acousticians, and preferred to be not recognized by lawyers and legislators. Our sense of hearing is the only one that processes sounds while we sleep. Primitive people living in caves could sleep with others snoring and the wind blowing, yet hear the twig snap under the sabre tooth tiger, or the baby crying. Today, though we can die from smoke inhalation and burning, the smoke alarm will wake us.

Through experience our brains become programmed to learn which noises are benign or acceptable, which have yet to be assessed, and which are warnings of danger. We hear a train coming in the distance and rationalize that it won't come through the house, and continue sleeping; but we are not so sure about the recognizably different noises of trucks and aircraft. People used to living next to a busy road have no difficulty sleeping, though noise measurements and criteria indicate the likelihood of sleep disturbance. Noise from acoustically treated machinery can be "too quiet" for those who want to know that it is operating satisfactorily, but "too noisy" when it is associated with undesirable activity.

These, and other hearing paradoxes depend on, and are explained by our degrees of adaptation to different noises. Several questions and some discussion followed. In conclusion, on behalf of all present, Norm Broner thanked Graeme for his interesting and challenging observations.

Louis Fouvy

QLD DIVISION

The Queensland Division Christmas Party and Technical Meeting took place on Tuesday 12th December 2006. The event was held at the Byblos Bar and Restaurant, at Portside Wharf (Brisbane's new Cruise Ship Terminal). 35 members and guests attended.

The speaker was Geoff Macpherson from Queensland DPI and Fisheries, Cairns. His presentation on "*Acoustic issues related to mitigation of depredation by toothed whales on Coral Sea longline catches and the potential for mitigation of tilapia infestation using sound*" was very well received. Geoff gave an interesting presentation of some of his current acoustic interests and clearly conveyed his enthusiasm for a topic that would not generally be touched upon in the ordinary run of airborne acoustics and land based engineering noise and vibration control. Geoff described the use of hydrophone arrays to monitor the position of vocalising marine mammals in the vicinity of fishing vessels and fishing gear as a means to minimise loss of catch. The presentation included some graphic illustrations of the extent of the marine mammal depredation problem for Australian fisheries with accompanying sound effects. He then gave a brief exposition of his most recent project (with sound effects), which looks to exploit the acoustic behaviours of cichlid fishes ("tilapia") as a means to impact these highly invasive exotic pests, which are causing major problems for native fish populations across northern Australia.

After his talk, the most winners of the various Queensland Education awards were announced. This year the Category I award was split between Dave Claughton from ASKCE/Griffith University for his project "*Dynamic Measurement of Tyre/Road Noise*" and Chris Wong Chou from UQ Mechanical Engineering "*Integrating the MLSSA package into the undergraduate acoustics course at University of Queensland*". The Category II awards for outstanding coursework went to Alexander Mackintosh of UQ and Helena Wu of QUT. Dave Claughton's and Helena Wu's bursaries were the inaugural awards of a Queensland Division bursary for their respective institutions.

This year the Division elected to extend the award program by making a one-off grant of \$2063.00 to the University of Queensland, Division of Mechanical Engineering to purchase a MLSSA card which will be used as part of the undergraduate engineering acoustics teaching program. (The card is an updated version of a similar system which has been in use at UQ over many years).

The Division 1 Acoustics Bursary is awarded as part of the Queensland Science Contest which is an annual event conducted by the Queensland Science Teachers Association. The 2006 Division 1 Bursary of \$360 was awarded to Kathryn Zealand, a Year 10 student at Brisbane Girls Grammar School for a study entitled "The Singing Tube". This was an extensive and outstanding investigation of the "Rijke tube" thermo-acoustic phenomena, which would have done credit to a student at undergraduate level.

Matt Terlich and Ian Hillock

WA DIVISION

Western Australian

A good turnout of thirty two members and guests attended the Carine Tavern on 24th August for our combined one-day seminar and AGM. "Structured-informal" and "neat-casual" contributed to an informative, relaxed and enjoyable day. Michael Cake (DEC) outlined the findings of the attitudinal community survey about noise impacts on health and wellbeing, overall attitudes and coping with noise. Dick Langford (LAS) spoke of the design of environmental noise regulations, from the original WA regulations of 1974 to their complete replacement in 1997, and of the balance between legal and technical requirements in modern legislation. Jim McLoughlin (SVT) and Michael Cake presented comparisons of industrial noise modelling using ENM and SoundPlan in accordance with EPA Guidance No. 8, fostering much discussion on the performance of acoustic models.

Moving below the waves, Iain Parnum & Miles Parsons (CMST) explained techniques for examining seafloor habitats and fish aggregations. Remote observations of the seafloor and water column with single/multi-beam echo-sounders, combined with video, was shown to be an efficient way to monitor the state of the coastal marine environment. Chaoying Bao and Derek Bertilone (DSTO) explained sonar array problems caused by the appearance of grating lobes in beam-former response, then demonstrated with modelling and data the effectiveness of adaptive beam-forming in suppressing this effect. Alexander Gavrilov and Binghui Li (CMST) presented results of analyses of long-term sonar monitoring in WA, with strong indicators for identification of ice rifting and breaking events and locations along the eastern Antarctic coast.

Lunch and the AGM provided an interlude, then for a hoot we listened to Rob Bullen (WM) who was in town and had our necks swivelling with a live demo of the Barn Owl Directional Noise Monitoring System. The finale was a duet from Robert Wilkins and Jie Pan (UWA), presenting the preliminary findings of a research project on violin acoustical attributes from the perspective of a violinmaker and an acoustical engineer respectively.

Murray Limb

Vale Richard (Dick) Langford (1937-2006)

Richard (Dick) Langford was working in the mining industry in the early 70's when he developed an interest in occupational and environmental acoustics. In 1974 he accepted a newly created position as an environmental noise specialist with the Tasmanian government. In this role he was responsible for developing an environmental noise management regime and introducing environmental noise regulations, and chaired the State Noise Advisory Committee.

In 1986 Dick moved to WA to join the (then) Environmental Protection Authority. There he played a leading role in the development of the environmental noise regulations which represented a significant shift in focus for the State. Many young Western Australians remember Dick for having guided their education in environmental noise through lecturing at university and training courses.

Retirement from the government in 2000 was an opportunity for Dick to form a consultancy that provided a more relaxed lifestyle, allowing him to spend more time on one of his passions, model steam trains (the photograph shows him kitted-out for a full head of steam!). Dick consulted to industry and government, helping guide development of environmental noise regulations in the Northern Territory and development of amendments for the WA regulations. His contribution in these States will continue to be felt for many years.

Dick had a long involvement with the Australian Acoustical Society, having served as WA State Secretary and Chairman. Only two days after presenting a lively talk on the history of WA's environmental noise regulations at the WA Division seminar, Dick died suddenly from a heart attack on 26 August 2006. He leaves behind a loving wife Noelene, daughter Kate and son Peter. He will be sorely missed.

Murray Limb

FASTS

FASTS AGM Dinner

At the FASTS AGM Dinner on 20 November 2006, the guest speaker was Jenny Macklin. A full transcript of her talk is available from www.alp.org.au. Since then there has been a change in the leadership of the federal opposition and FASTS have welcomed the appointment of Senator Kim Carr as Shadow Minister for Industry, Innovation, Science & Research and Stephen Smith MP as the Shadow Minister for Education and Training. The President of FASTS, Professor Tom Spurling said "science and education are central to Australia's future prospects accordingly, we look forward to working with Senator Carr and Mr Smith to ensure these portfolios are at the top of Labor's priorities heading into an election year."

Business Council of Australia

The Business Council of Australia has released a new discussion paper on innovation "New Pathways to Prosperity" (available from www.bca.com.au). This paper was written for the Council by a University of NSW based group called the Society for Knowledge Economics and follows on from a BCA discussion paper of March 2006 which was called New Concepts In Innovation.

Most of the contents of the new paper will be very familiar to those who follow policy discussion around innovation. One comment is that not all the points are actually 'innovation' but are generic business and market efficiency issues. The paper advocates five key pointers:

1 Recognise innovation as a critical national priority, and align efforts by governments and business to boost innovation.
2 Strengthen linkages and collaboration between all elements of Australia's innovation system.
3 Implement specific policy and investment measures to strengthen Australia¹s research networks and institutions.
4 Enhance policy focus and strategic investment in education and training to improve the innovation capabilities and culture of our people.
5 Undertake continuing micro-economic reforms to improve and sustain a business environment suitable for innovation.

Public Support For Science And Innovation

This draft Productivity Commission research report has been released for comment with final report expected in March 2007. It is a massive report (over 700 pages long) that will take quite some time to absorb. The President of FASTS, Professor Tom Spurling has said the report provides an intelligent, refreshing and realistic rethink of science and innovation policy. "The report does us all the considerable service of stating the obvious; that a major benefit of public support for science and innovation is ensuring national preparedness for emerging economic, social and environmental challenges such as climate change, drought or low carbon energy…. FASTS strongly supports the Commission's finding that the Co-operative Research Centres (CRC) program should be improved by reinstating the original policy objectives of translating research into broad social, environmental and economic benefits rather than a focusing public support on industrial research alone. The Commission is right to question the value of public sector research doing the job of industry R&D especially if there aren't the business receptors for such research. Rethinking how best to encourage industry R&D though improvements to the tax concession and more agile CRC-type arrangements are important and sensible suggestions,"concluded Professor Spurling.

Standards Australia

Productivity Commission Report

Mr John Tucker, CEO of Standards Australia, said the Productivity Commission's report into Standards Australia, makes a series of demanding recommendations while acknowledging that Standards Australia had "embarked on a significant plan to address key issues of concern." "The report recognises the challenges faced by Standards Australia and the reform agenda being implemented to address them. Many of the recommendations, including increased partnership arrangements, greater emphasis on project management and better use of technology, were already part of the reforms being undertaken by Standards Australia. For the past two years Standards Australia has been going through a major reform process focussing our attention on greater involvement with other standards development organisations. An important role for Standards Australia in the future will be the continued accreditation of other organisations to develop Australian Standards".

The report is available at www.pc.gov.au/study/standards/index.html and the key recommendations in the report include:

- Standards Australia continuing as Australia's peak non-government standards development body;
- Continued adoption of International Standards ahead of Australian Standards, wherever appropriate;
- Increasing the transparency of the justification for new or amended Standards;
- Maintaining or increasing current Federal funding for consumer and industry involvement in international standardisation activities;
- Increased participation by consumer groups in the ISO consumer policy group;
- Improving the balance of interests represented on committees including increasing representation from small business, consumer and other community groups;
- Reducing the barriers to volunteer participation by reducing the cost of involvement;
- Strengthening Standards Australia's appeals and complaint mechanisms.

Transformation Program

Standards Australia has announced its next step in its Transformation Program following extensive consultation with stakeholders, government and staff. This Program gives effect to recommendations from the Cameron Ralph Report, the strategic planning process and our financial statements, all of which make one thing clear – Standards Australia has to adapt.

The recommendations in the Productivity Commission's Final Report released yesterday mirror these sentiments. In particular, the Productivity Commission's Report recommended that Standards Australia continue reforms to ensure:

1 a stronger commitment to on-time delivery of projects;
2 stronger project management and secretarial support;
3 optimised technology solutions;
4 enhanced performance management mechanisms; and
5 greater partnering and co-funding arrangements.

Among the methods to achieve these is the intention to "increase interest in committees by supporting and acknowledging contributions, reviewing the committee constitution and selection processes". This will be a worthy undertaking and it is hoped that support will be provided by members of the Acoustical Society who may be invited to participate. Membership of these

One concern is the greater emphasis on delivery of projects in a timely, professional and cost effective manner. It is hoped that the need to carefully consider the technical content of standards is not overlooked nor are standards deleted from the records just because they are not bringing in income

Sunsetting Of Standards

To ensure Standards are maintained and kept up to date, Standards Australia's Sector Boards have agreed on setting a review cycle for Standards including a 'sunset' provision. This move will see Australian Standards reviewed within a maximum of five years after their date of publication. The Technical Committee responsible for the Standard will carry out this review, or where the Committee has been disbanded using a review panel comprising a representative and balanced group of nominating organisations. Reviews can also be triggered by other factors, e.g. a special request of a representative group of users or regulators. The review will result in the Standard either being reconfirmed for a further five-year period, or a revision to be undertaken. Where the Standard is no longer necessary it will be withdrawn. The timeframe for revisions will be limited to three years after which the Standard will be automatically withdrawn.

The AAS acknowledges that there is a need to review, revise and update Standards but it is concerned about the limitations of process in view of the cross referencing to acoustics in such a wide range of standards that are not in the scope of the main Acoustics committees. Council has written to Standards Australia seeking consultation prior to the removal or revision of any Standard that has any relationship to noise and vibration.

Standards And Legislation

Working out where a Standard appears in legislation can be a challenge - particularly since there are often differences in requirements across the different states and jurisdictions. To help locate the Standards and the legislation they appear in, Standards Australia has entered into an agreement with the legal and government regulation search engine, Australasian Legal Information Institute (AustLII). Under the agreement AustLII has developed search capabilities to allow users on the Standards Australia website to search for references to Australian Standards in legislation and case law. Stage one of this facility is now available free on the Standards Australia website. Further enhancements are being developed to enable searching by subject title and on trade lines. It should be noted that Codes that are referenced in legislation, such as the Building Code of Australia and the Food Standards Code are not included in this search facility.

Members

Tom Candalepas (Vic), Glen Copelin (QLD), Michael Hayne (QLD), James Heddle (QLD), Michael Lanchester (QLD), Valeri Lenchine (SA), Ross Leo (NSW), Sue Riddler (NSW), Karel Ruber (NSW)

Future Meetings

ICSV14 incorporating AAS Annual Conference

9-12 July 2007, Cairns

The 14th International Congress on Sound and Vibration (ICSV14), sponsored by the International Institute of Acoustics and Vibration (IIAV) and the Australian Acoustical Society (AAS), will be held at the Cairns Convention Centre in Cairns, Australia, 9-12 July, 2007. The ICSV14 is part of a sequence of congresses held annually around the world and was last held in Australia in Adelaide in 1997.

Key note papers will be presented by:

- Professor Jeremy Astley, ISVR, University of Southampton, UK, 'Predicting and reducing aircraft noise'
- Professor Ilene Busch-Vishniac, Johns Hopkins University, US, 'The challenges of noise control in hospitals'
- Associate Professor Svante Finnveden, MWL, Royal Institute of Technology, Sweden, 'Two observations on the wave approach to SEA'
- Professor Colin Hansen, The University of Adelaide, Australia, 'Optimisation of active and semi-active noise and vibration systems'
- Professor Jeong-Guon Ih, Korea Advanced Institute of Science and Technology (KAIST), Korea, 'Acoustic holography based on the inverse-BEM for the source identification of machinery noise'
- Associate Professor Kimihiro Sakagami, Kobe University, Japan, 'Recent developments in applications of microperforated panel absorbers'
- Professor David Thompson, ISVR, University of Southampton, UK, 'But are the trains getting any quieter?'

Theoretical and experimental research papers in the fields of acoustics, noise and vibration are invited. Abstract submissions are due – deadline is 15 February. The full papers (8 pages) have a deadline of 31 March which is also the last date for the early bird registration rate. All papers submitted by Australian and New Zealand authors will be peer reviewed, to meet with the academic requirements in our countries.

The exhibition will be a major component of the congress. In addition to booth displays, there are a number of possibilities for sponsorship.

For further information on the conference go to http://www.icsv14.com/

ICA 2007, Madrid

2-7 September

The 19th International Congress on Acoustics is organized under the auspices of the International Commission for Acoustics, ICA. The Congress Programme will consist in the presentation of Plenary Lectures, Invited Papers and Contributed Papers in Structured Sessions.. The unique feature of an ICA congress is that it comprises sessions on all aspects of acoustics. The extensive range of fields can be seen from the ICA web page, www.ica2007madrid.org. Abstracts are due by 1 April 2007. The full paper manuscripts (no more than 6 pages) will be due by 15th May 2007 which will also be the deadline for the early bird registration fee.

The Congress will be held at the Municipal Congress Centre of Madrid (Palacio Municipal de Congresos). This is an iconic building, located at the "Campo de las Naciones", a new exhibition and financial area in the city of Madrid. It is very easily accessed both from the city centre and the Barajas International Airport.

During the week of the ICA 2007 MADRID an International Technical Exhibition of Products and Services in Acoustics EXPOACÚSTICA® 2007 will be held. The participation of the most prestigious companies in the field is expected.

ISMA 2007

Symposium on Musical Acoustics will be held in Barcelona from 9-12th September 2007. This will be organized by the Department of Mechanical Engineering of the Universitat Politécnica de Catalunya; Sociedad Española de Acústica, SEA; Instituto de Acústica, CSIC, IA. Details from www.isma2007.org

ISRA 2007 Symposium on Room Acoustics will be held in Sevilla from 9-12th September 2007. This will be organized by the Instituto Universitario de Ciencias de la Construcción, IUCC; Escuela Técnica Superior de Arquitectura, Universidad de Sevilla, ETSAS; Sociedad Española de Acústica, SEA; Instituto de Acústica, CSIC, IA. Details from: www.isra2007.org

INTER-NOISE 2007, Istanbul

28-31 August

Inter-noise 2007 will be held at the Convention and Exhibition Centre in Istanbul. From the centre there is convenient access to the scenic and historic aspects of Turkey. The city may be even more lively than usual as the Turkey Grand Prix will be in Istanbul on the preceding weekend.

The theme of Inter-Noise 2007 Congress is "Global Approaches to Noise Control" and papers of specific relevance to this theme are especially encouraged. Technical papers in all areas of noise control may be submitted for inclusion in the technical program. Special structured sessions covering a wide range of relevant topics are being organized. Three plenary lectures will be presented and there will be a technical exhibition during the time of the conference. The social program will include opportunities for viewing some of the sights of Istanbul.

The deadline for abstracts is January 31 and the full papers will be due May 31. More details from www.internoise2007.org.tr/

Meetings Reports

Acoustics 2006
Noise of Progress

The first joint Annual Conference of the Australian and New Zealand Acoustical Societies was held in Christchurch from 20 to 23 November 2006 with the theme the Noise of Progress. Of the almost 200 registrants, three quarters had travelled across the 'ditch' from Australia. Many arrived on Sunday to a bitterly cold day. Come the opening of the conference on Monday the sun shone on the aptly named Clearwater Lake, a feature of the conference venue. This venue is within a new estate area comprising a golf course which was also a great attraction for some of the participants. Those coming from drought declared Australian, with severe water restrictions in most residential areas, enjoyed just looking at the abundance of green grass around the venue.

The conference commenced with a plenary address which was an overview of underwater acoustics given by Chris Tindle from the University of Auckland. The plenary on the second day was given by Michael Vorlander from Aachen University on building acoustics from prediction to auralisation. Over 87 contributed papers were given in the three parallel sessions for the two and a half day conference. All of these papers had been through the review process before acceptance and this no doubt contributed to the high standard of the content and the presentation. The conference proceeded with good quality audio visual facilities in each room. The session topics were broad ranging and included building acoustics, aircraft noise, active control, underwater acoustics, occupational noise, wind farms, building code, road noise, room acoustics, environmental noise, electroacoustics and industrial noise.

The dinner in the Christchurch Town Hall commenced with a spirited explanation of the design and acoustics by Sir Miles Warren and Dr Harold Marshall. The excellent acoustics was aptly demonstrated by the music from the string quartet and the clarity with which announcements from the stage were understood. This was followed by a most enjoyable dinner which was also the time for the presentation of the various awards and prizes. The Presidents prize for the best paper went to Marin Keane, University of Auckland, for his paper on Improving the Upright Piano. There was no award for the 2006 education prize. Ray Thompson, CSR Bradford, announced the Excellence in Acoustics award winner Dr Jingfeng Xu and runner up Acoustics Research laboratories (more details on these submissions are given below). After such a good evening there were a few who did not make it to the buses on time for the Tuesday morning technical tours. Tuesday evening was the Exhibitors reception complete with BBQ meal. Neil Gross was the winner of the golf ball chip competition and came away with a noise cancelling headset.

The conference was certainly a great success and there is already talk of the next joint conference. Stuart Camp and his committee were warmly thanked for their work to bring such a successful conference to fruition.

Marion Burgess

Active 06

The Sixth International Symposium on Active Control of Sound and Vibration, Active 2006, was held from the 18th to 20th September in Adelaide by the SA Division in collaboration with the University of Adelaide. The conference was deemed a huge success by all who attended and the organising committee received numerous communications from delegates thanking the organisers. The organising committee is particularly grateful to all those who took part in the conference and the sponsors who made the event possible. The companies that sponsored the event were Bruel and Kjaer, Texcel, HW Technologies, Acticut International, Kingdom and Polytech.

The conference reception was held at the SA Art Gallery, where delegates were entertained by the South Australian chapter of the Australian Girls Choir and treated to drinks and canapés. The following evening the conference banquet was held at the Stamford Grand Hotel in Glenelg. The famous H-type Adelaide trams were loaded with champagne and used to transport delegates back and forth to Glenelg. So that none of the international delegates left Australia without having seen a kangaroo, a tour of the Adelaide Zoo including drinks and canapés was arranged for the Tuesday evening. The conference concluded on Wednesday with a BBQ held on the University grounds, where delegates got a chance to eat some genuine Australian cuisine, including some of our macropodidae national icon.

The conference featured 73 technical papers on a range of topics written by 149 authors from 17 countries. Two papers of note were those which won prizes; James Mabe of Boeing Phantom works was awarded the best paper prize for his paper on 'Boeing's morphing aerostructure for jet noise reduction', and Noah Schiller of Virginia Polytechnic Institute and State University was awarded the best student prize for his paper on 'A high authority / low authority strategy for coupled aircraft-style bays'. There were five keynote speakers: Sen Kuo (Northern Illinois University, Illinois, USA), Marty Johnson (Virginia Tech, Virginia, USA), Scott Sommerfeldt (Brigham Young University, Utah, USA), Jie Pan (University of Western Australia) and Paolo Gardonio (Institute of Sound and Vibration, Southampton, UK). All the keynote speakers presented their latest findings in the area of active control of sound and vibration. Steve Elliott (Institute of Sound and Vibration, Southampton, UK) presented a special paper on the natural feedback mechanisms within the inner ear which sparked a lot of interest.

The SA division of the AAS wishes to thank INCE for the opportunity to hold this conference.

Mike Kidner and Carl Howard
Active 2006 Chairmen

Book Reviews

Noise Control from Concept to Application

Colin Hansen

Taylor and Francis, 2005, 419pp, soft cover ISBN 0 415 35861 2, hard ISBN 0 415 35860 4, approx cost hard cover A$200, soft cover $112, e-book for net library only $220:

As stated in the preface, this book covers material similar to that of the well known "Engineering Noise Control" by Bies and Hansen, which is a valuable reference book for engineers working with noise and vibration. This book however deals with the material at a different level, stripping away all but the essential mathematical equations and derivations and even removing the more modern techniques like active control. For each topic and concept a short description, with figures where appropriate, is followed by examples and their solutions. Where applicable there is a reference to the appropriate chapter in Bies and Hansen for more detailed mathematical derivations.

The book starts with chapters on fundamentals, noise criteria and instrumentation. These are followed by chapters dealing with sound sources, propagation, sound absorbing materials, partitions, enclosures and mufflers.

The strengths of this book are in the clear, concise explanations of the concepts and the examples, which show how to undertake the calculations to apply that concept. These are valuable for the reader, who otherwise may be tempted just to keep reading without testing the understand of that point.

It is disappointing that some of the content has not been updated to reflect current standards, materials and terminology. For example it is incorrectly stated that the limit in Australia for occupational noise, LAeq,8h is 90 dB(A) and this is reinforced in the example. In the section on instrumentation, one paragraph on statistical analysers which "…can often be left in the field.." and does not mention the more common term of environmental noise loggers. While the references to Bies and Hansen for more complex mathematics are valuable, perhaps a little more of the more basic material could have been included. For example Appendix A deals with the physical properties of materials but the reader must refer to Bies and Hansen for examples of typical acoustic properties. Further, the original reference for diagrams and charts is not always clearly given, in particular for those which have been extracted from standards.

Overall, this will be a valuable reference book for those currently working in noise control and for those engineers entering the field or wishing to refresh their knowledge. It will also be a valuable reference book for teachers and students undertaking courses on acoustics.

Marion Burgess

Urban Sound Environment

Jian Kang

Taylor and Francis, 2007, 419pp, soft cover ISBN 0 203 00478 7 2, hard ISBN 10 415 35857 4, approx A$154

Study of the urban sound environment has developed over recent decades and this book aims to cover the essential knowledge and basic principles in the field. With more emphasis on noise measurement and the European requirements for noise mapping it is clearly important to understand the implications of the quantitative data obtained.

The book comprises seven chapters, starting with fundamentals and then dealing with evaluation, modelling and mitigation. The author is clearly not aiming to provide the answer to all the questions about the urban sound environment. It is also not aimed at the government planning department seeking a quick overview of the issue. The book does comprise an excellent reference for the topic and a resource with comparative data from various studies. To this end it saves the reader the effort of tracking down the various papers and reports, in which much of this material would have been first published, and sets the findings in context with other work on the topics.

The term soundscape is increasingly used in discussions on the acoustics of many environments in which people spend time, such as urban, suburban, recreational etc. A valuable analysis of the various factors involved in this concept is provided. The author identifies that it is not just a 'passive perception factor' but must be considered as part of the design process of the entire space. He deals with both micro- and macro-scale scale modelling of spaces ranging from library reading rooms through to football stadia, street canyons and city plazas.

The author emphasises the need to have an interdisciplinary approach and provides a series of case studies – from Europe and Asia. These highlight the similarities but also the cultural differences in the design and perception of the people in cities around the world. It is also valuable to note the different approaches to the studies – the full references are provided for the user who wishes to obtain more details of any particular study. One small criticism is that in contrast to the quantitative summaries of the various psychoacoustic studies, the section on the mitigation of urban noise provides an overview and the options but lacks guidance on the quantitative reduction that could be achieved.

While this book is not for the novice acoustician it is certainly a valuable reference book for those working in the various disciplines associated with the urban environment. These include acousticians, urban planners, landscape architects, transport engineers etc as well as those interested in sociology and psychology.

Marion Burgess

Marion Burgess is a research officer at the Acoustics and Vibration Unit of the University of NSW at the Australian Defence Force Academy. She has considerable experience in reasearch teaching and consulting in acoustics.

Handbook for Sound Engineers, Third Edition

Glen M. Ballou, Editor

Elsevier/Focal Press, 2005, 1553pp (Paperback edition) ISBN-13: 978-0-240-80758-4, ISBN-10: 0-240-880758-8, Approx A$140

Since publication of the first edition, the *Handbook for Sound Engineers* (HSE) has been regarded as the most comprehensive single-source text for all things related to audio. Previously also known as "The New Audio Cyclopedia", this current edition does away with the alternate title, and provides updates on recent technologies and current trends in audio and audio reproduction systems.

As with the previous edition, this third edition maintains the familiar 7 Parts: Acoustics; Electronic Components; Electro-acoustic Devices; Electronic Audio Circuits and Equipment; Recording and Playback; Design Applications; Measurements. Each Part has been revised and updated to reflect changes in technology with several new chapters added to cover new and emerging technologies.

Updated Parts and added chapters include emerging technologies in digital signal processing, virtual systems and digital networking. Chapters have been added to include interpretation and assistive listening systems, intercoms, acoustic and sound system modeling and auralisation, surround sound and in-ear monitoring. Each new chapter has been well researched and provides detailed information relating to the topic.

Since the publication of HSE Second Edition in 1991, research and development in digital technologies has provided significant advancement in the applications for digital media. Digital technology has now found applications in test and measurement equipment, audio recording manufacturing and reproduction, live sound and sound generating equipment. Digital technology is now common place and large sections of text have been dedicated to understanding and exploring the digital technologies.

Significant portions of the *Handbook for Sound Engineers* are dedicated to the more typical technologies including microphones, loudspeakers, audio system design and audio engineering. These too, have also been updated to include recent advancements and refinements.

Each chapter can be read as a stand-alone text. Most chapters provide diagrams, relevant pictures and supporting examples to assist with the understanding of the topic. Subsequent chapters from different authors read and are presented in a similar format. Diagrams are typically clear and well presented. Photos and pictures (including computer based screen captures) are presented in high definition greyscale which sometimes detracts a little from the information presented. However, it is understood that a colour reproduction of *Handbook for Sound Engineers* would significantly increase the cost of publication.

Handbook for Sound Engineers is primarily an American text with expertise from England and Europe. As a result, formulae and worked examples in some chapters are using the American terminology while others are working to metric standards. As with the previous edition, care should be taken in reading and working through examples: units or standards may change between chapters. It is hoped that future editions would be published with reference to SI units throughout. It should be noted that the final chapter "Fundamentals and Units of Measurement", among other things provides a comprehensive table of US to SI Units Conversion Factors.

Handbook for Sound Engineers has been written by well known and industry recognised authors, providing chapters in their relevant field of experience within a particular part. This is a stand-alone reference text that can be used by professionals and those looking to learn more about audio related topics. This is an excellent resource, providing solid background information on each of the key parts of audio and audio reproduction. The text provides comprehensive information on all represented topics and most chapters provide references to related texts for further reading.

Although the paperback version provided for review may be less durable than the hardcover second edition currently sitting on the bookshelf, the much-reduced cost of the current edition will make this text readily available to a wider audience. *Handbook for Sound Engineers* is the textbook (if there is only one book on the shelf), which provides all things audio in one place.

Tim Kuschel

Tim Kuschel is an acoustic consultant and architectural projects coordinator.

Coming from a background in architecture and music his business, GUZ BOX design and audio, he specialises in architectural acoustics and sound reinforcement design.

Acoustics and Psychoacoustics Third edition.

David M. Howard and Jamie Angus.

Focal Press, 2006. 411 pp (Paperback edition) ISBN-13 : 978-0-24-051995-1, ISBN-10 : 0-240-51995-7, approx A$92.

This already popular book has been updated and improved. The major addition to the third edition is the inclusion of an audio CD. It includes anechoically recorded samples of various musical instruments and voices. There are also a number of audio demonstrations that augment, rather than repeat, those available on the well known CD compiled by Houtsma, Rossing and Wagenaars.

The book covers a wide range of topics, with a chapter each on sound, hearing, harmony and temperament, the operation of musical instruments including the voice, psychoacoustics, acoustics of rooms and signal processing. Despite the breadth, the depth is considerable: these chapters are more than introductions. The illustrations are many and clear.

One interesting feature is the regular use of quotations from distinguished researchers and authors. This works well when the authors in question have done a good job, which is usually the case, but a notable exception is the explanation of the reflections in a conical bore. A small but regular blemish is use of an inappropriate number of significant figures. These do not detract however from a work that is both very broad and very well done.

Who should read this book? Many universities offer courses in the science(s) of music. Such courses offer interesting subject matter, varied and approachable laboratory sessions and introductions to a range of scientific disciplines. Because of its breadth, the Howard and Angus book is well suited as both a text and a reference for such courses.

However, its attraction is much broader than this. It would make a useful, introductory reference to a range of areas in acoustics and psychoacoustics. It is a useful reference for specialists, too, as few of us can claim expertise in all of the areas covered.

Joe Wolfe

Joe Wolfe is a professor of physics at the University of New South Wales. He researches music acoustics and writes introductory articles on this topic on the web.

Made in Germany
PTB Type Approval
No: 21.21 / 06.01

SINUS
Messtechnik GmbH

- Soundbook™ + SAMURAI™ = the **All-in-one instrument** from SINUS Messtechnik GmbH
- Multichannel sound level meter according IEC 61672-1, IEC 60804 and IEC 60651 type 1
- SAMURAI™ basic software includes DAT-recorder, frequency analyzer, reverberation time
- 2 / 4 / 8 channels with 40 kHz bandwith, 2 tacho-, 5 AUX- und 2/4 analog output channels
- Various software options available for a wide range of applications in acoustics und vibration
- Remote control, network integration and synchronization of several devices possible …

SINUS Australian
& New Zealand
representative:

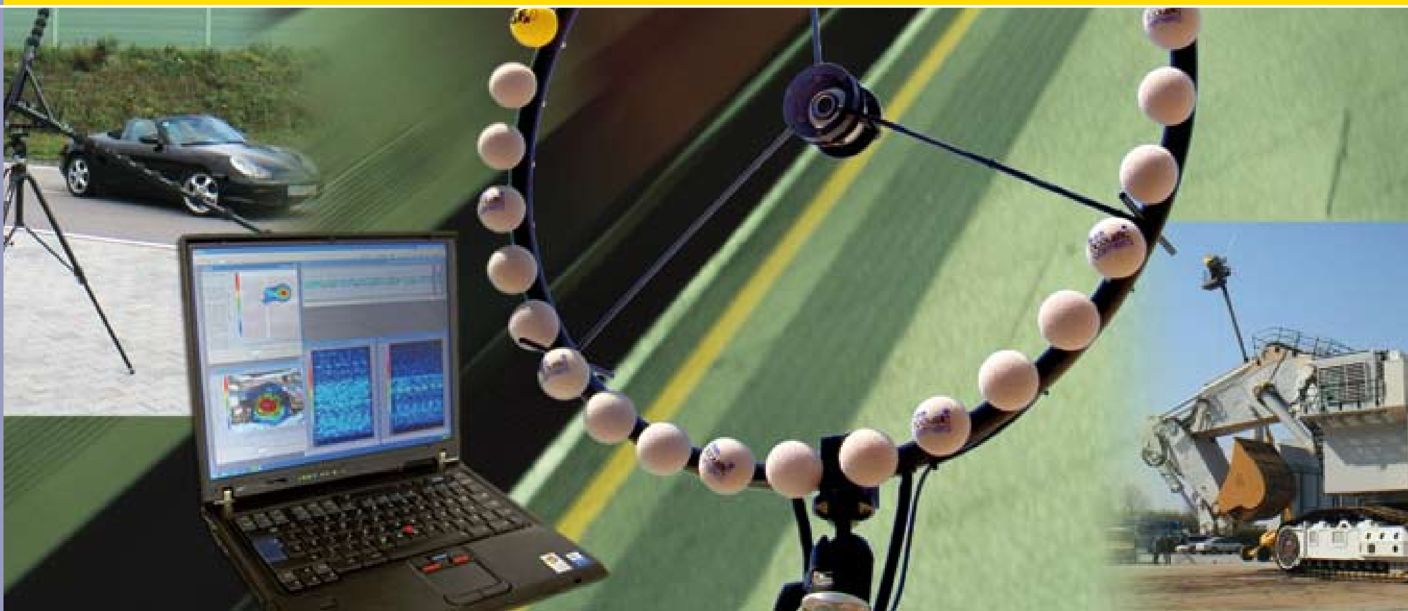
Savery & Associates Pty Ltd
PO Box 265 The Gap
QLD 4061, Australia

- Phone: (617) 3300 6288
- Fax: (617) 3300 6244

- www.savery.com.au
- jsavery@savery.com.au

Acoustic Camera

A revolutionary solution to locate sources of noise



+61 (0)2 9874 8638

FEATURES

- Vivid, accurate, fast location of noise
- High quality acoustic images in seconds
- Instant, accurate documentation
- Easy to use, anywhere

APPLICATIONS

- Noise reduction
- Environmental monitoring
- Fault visualisation
- Sound optimisation

HW TECHNOLOGIES
PO Box 545 · West Ryde NSW 1685 · Australia
Phone: +61 (0)2 9874 8638 · Fax: +61 (0)2 9874 8131
Web: www.hwtechnologies.com.au · Email: info@hwtechnologies.com.au

HW Technologies
Testing · Production Equipment · Acoustic Analysis

Diary

2007

8 - 10 March, Brisbane
Aust Conf on Listening & Spoken Language
www.hi2007.com.au/

09 - 12 April, Vienna. Austria.
2007 ICU Int Cong Ultrasonics
www.icultrasonics.org

10 - 12 April, Loughboro
4th Int Conf on Bio-Acoustics.
www.ioa.org.uk

16 - 18 April, Shonan, Japan.
29th Int Symp Acoustical Imaging
http://publicweb.shonan-it.ac.jp/ai29/AI29.html

16 - 20 April, Honolulu
IEEE Intl Conf on Acoustics, Speech & Signal Processing (IEEE ICASSP 2007).
www.icassp2007.org

16 - 20 May, Honolulu,
IEEE Int Conf on Acoustics, Speech & Signal Processing (IEEE ICASSP 2007)
www.icassp2007.org

01 - 03 June, Lanzhou, China.
VS Tech 2007, 2nd Int Symp Advanced Technology Vibration & Sound
www.jsme.or.jp/dmc/Meeting/VSTech2007.pdf

03 - 07 June, Bologna
11th Int Conf on Hand-Arm Vibration
www.associazioneitalianadiacustica.it/HAV2007/index.htm

11-14 June Krakow
8th Conf Active Noise & Vib Control Methods
http://www.drgania.agh.edu.pl

18 - 21 June, Aberdeen
Oceans07 Conf.
www.oceans07ieeeaberdeen.org

25 - 29 June, Heraklion
2nd Int Conf Underwater Acoustic Measurements: Technologies and Results.
www.uam2007.gr

02 - 06 July, Heraklion
8th Int Conf Theoretical & Computational Acoustics.
www.iacm.forth.gr/~ictca07

3-5 July, Lille, France
1st European Forum on Effective Solutions Managing Occupational Noise Risks
http://www.noiseatwork.eu/

4-7 July, 2007, Athens
2nd IC- EpsMsO Int Conf Experiment/Process/System Modelling/Simulation/Optimization www.epsmso.gr/

9-12 July, Cairns
ICSV14 incorporating AAS Annual Conference
www.icsv14.com

16 - 21 July, Paris, France
2th Int Conf Phonon Scattering in Condensed Matter.
www.isen.fr/phonons2007

06 - 10 August, Saarbrücken, Germany
16th Intl Cong of Phonetic Sciences (ICPhS)
www.icphs2007.de

28-31 August, Istanbul.
INTEERNOISE 2007
www.internoise2007.org.tr

27-31 August, Antwerp
INTERSPEECH 2007.
www.interspeech2007.org/

2-7 September, Madrid
ICA2007
www.ica2007madrid.org

9-12 September, Barcelona.
Symposium on Musical Acoustics (ISMA2007)
www.ica2007madrid.org

9 - 12 September, Sevilla
Symposium on Room Acoustics
www.ica2007madrid.org

17-19 September, Lyon
Fan noise 2007
www.fannoise2007.org

20 - 22 September, Lyon
2nd Int Conf Wind Turbine Noise
www.windturbinenoise2007.org/

18 - 19 September, Edinburgh, UK.
Int Conf on Detection and Classification of Underwater Targets.
www.ioa.org.uk

22 - 24 October, Reno
Noise-Con 2007
www.inceusa.org/nc07/

28 - 31 October, New York
IEEE Int Ultrasonics Symposium
www.ieee-ultrasonics2007.org/

2008

30 June - 4 July, Paris,
Acoustis'08 Paris
www.acoustics08-Paris.org

07 - 10 July, Stockholm
18th Intl Symp Nonlinear Acoustics (ISNA18).
benflo@mech.kth.se

28 July - 1 August, Mashantucke
Noise Effects 2008
Int Cong Noise as a Public Health Problem
www.icben.org

22 - 26 September, Brisbane
INTERSPEECH 2008 - 10th Intl Conf on Spoken Language Processing (ICSLP).
www.interspeech2008.org

26–29 October, Shanghai
Internoise 2008
www.internoise2008.org/

2009

06 - 10 September, Brighton, UK
InterSpeech 2009 Conference.
www.interspeech2009.org

2010

23-27 August, Sydney
ICA2010
http://www.ica2010sydney.org/

Meeting dates can change so please ensure you check the www pages.
Meeting Calendars are available on http://www.icacommission.org

New Members

Member

Tom Candalepas (Vic), Glen Copelin (QLD), Michael Hayne (QLD), James Heddle (QLD), Michael Lanchester (QLD), Valeri Lenchine (SA), Ross Leo (NSW), Sue Riddler (NSW), Karel Ruber (NSW)

Graduate

Leo Tsui (NSW), Aloysius Chang (QLD)

Student

Jer-Ming Chen (NSW), Craig McPherson (QLD), Selma Mujic (NSW)

Graduate

Leo Tsui (NSW), Aloysius Chang (QLD)

Student

Jer-Ming Chen (NSW), Craig McPherson (QLD), Selma Mujic (NSW)

Acoustics Australia

Annual Index Vol 34 2006

PAPERS

ACOUSTICS FORUM

AUSTRALIAN ACOUSTICAL SOCIETY ENQUIRIES

NATIONAL MATTERS

* Notification of change of address
* Payment of annual subscription
* Proceedings of annual conferences

General Secretary
AAS– Professional Centre of Australia
Private Bag 1, Darlinghurst 2010
Tel/Fax (03) 5470 6381
email: GeneralSecretary@acoustics.asn.au
www.acoustics.asn.au

SOCIETY SUBSCRIPTION RATES

For 2005/2006 Financial Year:

Fellow and Member	$110.00
Graduate, Associate and Subscriber	$85.00
Retired	$35.00
Student	$25.00

Including GST

DIVISIONAL MATTERS

Enquiries regarding membership and sustaining membership should be directed to the appropriate State Division Secretary

AAS - NSW Division
Mr Neill Gross
c/- Wilkinson Murray
Level 1, 123 Willoughby Road
CROWS NEST NSW 2065
Sec: Ms T Gowen
Tel: (02) 8218 0500
Fax: (02) 8218 0501
tgowen@tpg.com.au

AAS - Queensland Division
PO Box 760
Spring Hill Qld 4004
Sec: Richard Devereux
Tel: (07) 3217 0055
Fax: (07) 3217 0066
rdevereux@acran.com.au

AAS - SA Division
Department of Mech Eng
University of Adelaide
SOUTH AUSTRALIA 5005
Sec: Anthony Zander
Tel: (08) 8303 5461
Fax: (08) 8303 4367
azander@mecheng.
adelaide.edu.au

AAS - Victoria Division
PO Box 417
Collins St. West
PO MELBOURNE 8007
Sec: Jim Antonopoulos
Tel (03) 9526 8450
Fax (03) 9526 8472
jim.antonopoulos@
heggies.com.au

AAS–WA Division
Unit 3
2 Hardy Street,
SOUTH PERTH 6151
Sec: Norbert Gabriels
Tel (08) 9474 5966
Fax (08) 9474 5977
gabriels@iinet.net.au

ACOUSTICS AUSTRALIA INFORMATION

GENERAL BUSINESS

Advertising Subscriptions

Mrs Leigh Wallbank
PO Box 579, CRONULLA 2230
Tel (02) 9528 4362
Fax (02) 9589 0547
wallbank@zipworld.com.au

PRINTING, ARTWORK

Cliff Lewis Cronulla Printing
91-93 Parraweena Road
CARINGBAH NSW 222
Tel (02) 9525 6588 Fax (02) 9524 8712
email: matthew@clp.com.au

ADVERTISING RATES

B&W	Non-members	Sus Mem
1/1 Page	$660.00	$588.50
1/2 Page	$429.00	$385.00
1/3 Page	$330.00	$297.00
1/4 Page	$275.00	$247.50

Spot colour: $121.00 per colour
Prepared insert: $357.50 Conditions apply
Column rate: $22.00 per cm (1/3 p 5.5cm width)
All rates include GST

Discounted rates for 3 consecutive ads in advance

Special rates available for 4-colour printing

All enquiries to: Mrs Leigh Wallbank
Tel (02) 9528 4362 Fax (02) 9589 0547
wallbank@zipworld.com.au

ARTICLES & REPORTS NEWS, BOOK REVIEWS NEW PRODUCTS

The Editor
Acoustics Australia
Acoustics & Vibration Unit, ADFA
CANBERRA ACT 2600
Tel (02) 6268 8241
Fax (02) 6268 8276
AcousticsAustralia@acoustics.asn.au

SUBSCRIPTION RATES

	Aust	Overseas
1 year	A$63.80	A$73.00
2 year	A$110.00	A$130.00
3 year	A$156.20	A$187.00

Australian rates include GST.
Overseas subscriptions go by airmail
Discounted for new subscriptions
20% Discount for extra copies
Agents rates are discounted.

ACOUSTICS AUSTRALIA ADVERTISER INDEX - VOL 33 No 1

NORSONIC
Sound Level Meters

Nor130 series of Sound Level Meters

- Single Measurement Range
- Parallel LAeq and LCpeak
- Real-time octave
- Large internal memory
- Clock synchronized measurements
- Statistical analysis
- Transfer software included

Nor131

The Nor130 Series of Sound Level Meters are designed and manufactured to the latest sound level meter standards and comprises two products. The Nor131 is a Class 1 (precision) instrument whilst the Nor132 is designed in accordance with the less accurate Class 2 requirements. Both meters offer the same features with exception of the detachable preamplifier which is only available on the Nor131 version.

Applications

- Noise hazards in the workplace
- Prescription of hearing protection
- Environmental noise investigations
- Product noise testing