A Discussion of the Australian National Standard for Occupational Noise

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ABSTRACT: In 1974, the National Health and Medical Research Council warned that "the estimated risks associated with exposure to noise at levels of 85 and 90 dB(A) over a working life-time lead to an incidence of hearing loss in the working community which is unacceptable on medical grounds in the long term". Despite this warning, Australian legislatures set an 8-hour equivalent continuous A-weighted sound pressure level ($L_{Aeq,8h}$) of 90 dB(A) as the occupational noise exposure limit until recent years. Partly as a result of this, occupational noise-induced hearing loss has continued to be a highly prevalent industrial disease in Australia and the associated costs of compensation have escalated since 1988. In response to this situation, the National Occupational Health and Safety Commission in 1992 declared an $L_{Aeq,8h}$ of 85 dB(A) as the Australian National Standard for Occupational Noise and this is gradually being adopted by Australian legislatures. However, given the current magnitude of the problem, a stricter limit seems appropriate. A standard of 80 dB(A) would come much closer to an acceptable solution to the problem of occupational noise-induced hearing loss.

1. INTRODUCTION

It has been widely assumed that the goal of occupational noise management is prevention of noise-induced hearing disability in workers. The underlying assumption of this approach is that it is permissible to damage the hearing of workers as long as that damage does not result in associated disability, where hearing disability is defined, narrowly, as loss of the ability to understand speech for the purposes of everyday life. Impairment of the threshold sensitivity of an initially normal ear of about 20 dB is necessary before hearing disability in this sense begins to occur. If the goal of occupational noise management is only prevention of hearing disability, in the narrowly defined sense of disability, then noise-induced threshold impairment of 20 dB is permissible. However, it is likely that continuing research into hearing will reveal hearing disabilities, in the broad sense of loss of normal abilities to hear for the purposes of everyday life, are associated with impairment of hearing threshold sensitivity of 20 dB or less. For example, every 6 dB loss of hearing threshold sensitivity across frequency can be expected to halve the distance from which sounds can be heard, i.e., to result in contraction of the auditory horizon. A 20 dB loss of sensitivity across frequency can be expected to result in a 10-fold reduction in the distance of the auditory horizon.

The narrow approach to occupational noise management therefore does not go far enough in the direction of protection of the well-being of workers. The basic premise of this article is that the primary goal of occupational noise management should be prevention of noise-induced damage to the inner ears of workers. There is physiological evidence that inner ear damage caused by noise exposure accumulates prior to the onset of hearing threshold impairment [1], which itself accumulates prior to the onset of hearing disability. Objective assessment of the state of the outer hair cells of the inner ear can be made by measurement of otoacoustic emissions [2], which are sounds emitted from the inner ear after stimulation by external sound. Because noise-induced damage to the inner ear may precede the occurrence of threshold impairment, otoacoustic emission testing may provide a more sensitive indication of damage than audiometric thresholds and might eventually replace audiometry as a method of detecting noise-induced damage to the ear in occupational noise management programs [3]. However, further research and standardisation of otoacoustic emission measurement techniques are required before otoacoustic emission testing can be considered for this application [4]. In the meantime, audiometric testing of hearing threshold sensitivity will continue to be the preferred method of monitoring the status of the inner ear in the management of occupational noise exposure. At present, therefore, the practical goal of occupational noise management programs should be to prevent noise-induced hearing threshold impairment.

2. NHMRC MODEL REGULATIONS (1974)

In 1974, the National Health and Medical Research Council (NHMRC) published its Model Regulations for Hearing Conservation [5]. The NHMRC recommended that the daily 8-hour equivalent continuous A-weighted sound pressure level ($L_{Aeq,8h}$): (1) should not exceed 90 dB(A) for existing premises; (2) should not exceed 85 dB(A) for any premises at and after a period of 5 years from the time that the regulations were brought into effect; and (3) should not exceed 85 dB(A)

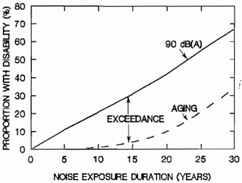

Figure 1. Estimated proportion of a population of otologically screened males with hearing disability, when the population is not exposed to harmful noise (effects of aging alone) and when the population is exposed to occupational noise with an $L_{Aeq,8h}$ of 90 dB(A), as a function of duration of noise exposure, in years. The difference between the two curves at any noise exposure duration is described as hearing disability exceedance. For the purposes of this graph, occupational noise exposure is assumed to begin at the age of 20 years.

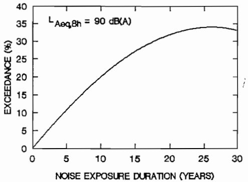

Figure 2. Hearing disability exceedance (as defined in the caption to Figure 1) for a population of otologically screened males exposed to an $L_{Aeq,8h}$ of 90 dB(A), as a function of duration of noise exposure, in years.

for any new premises after the time the regulations were brought into effect. The NHMRC warned that "the estimated risks associated with exposure to noise at levels of 85 and 90 dB(A) over a working life-time lead to an incidence of hearing loss in the working community which is unacceptable on medical grounds in the long term". The publication of these model regulations stimulated the development of actual hearing conservation regulations in the various Australian legislatures but, despite the warning concerning estimated risks, only recommendation (1) was brought into effect. By 1986, no Australian legislature had adopted recommendations (2) and (3) [6].

3. DISABILITY EXCEEDANCE

Partly because the maximum permissible 8-hour equivalent continuous A-weighted sound pressure level was set at 90 dB(A) in all jurisdictions, noise-induced hearing loss has continued to be a highly prevalent industrial disease in Australia [7], as would be expected from the NHMRC warning. The two curves presented in Figure 1 were derived from values given in a published table of the estimated prevalence of hearing disability in otologically screened, noise-exposed male populations [8], where otologically screened means free from all signs and symptoms of ear disease other than the effect of occupational noise exposure. The values in the table were calculated by means of equations given in International Standard ISO1999 [9] and the National Acoustic Laboratories (NAL) procedure for determining percentage loss of hearing [10]. In Australia, hearing disability for compensation purposes is quantified in terms of percentage loss of hearing, as determined by the NAL procedure. Hearing disability exists if the percentage loss of hearing is greater than zero. Some disability can be expected to occur in some workers not exposed to harmful levels of noise, as a result of the process of aging. This is represented by the lower of the two curves in the graph. For the purposes of the table and the graph, occupational noise exposure is assumed to begin at the age of 20 years. Thus, at the age of 50 years, about one-third of workers not exposed to harmful noise can be expected to have some hearing disability.

The higher of the two curves shows the proportion of workers who can be expected to have some hearing disability when they are exposed to noise with an $L_{Aeq,8h}$ of 90 dB(A). The difference between the two curves can be described as exceedance, where exceedance refers, in this context, to the amount by which the proportion of noise-exposed workers with hearing disability exceeds the proportion of workers who have hearing disability purely as a result of aging. Subtracting the curve for aging from the curve for 90 dB(A), the exceedance curve shown in Figure 2 is obtained. Reading this graph, after 25 years of exposure to noise with an $L_{Aeq,8h}$ of 90 dB(A), 34% of the exposed workers will have a hearing disability who would otherwise not have had any hearing disability. In view of the exceedance associated with an $L_{Aeq,8h}$ of 90 dB(A), it is not surprising that noise-induced hearing loss has continued to be a highly prevalent industrial disease in Australia.

Figure 3 shows that the cost of compensation claims for occupational noise-induced hearing loss in NSW grew from about 12 million dollars in 1988 to about 101 million dollars in 1996. Faced with escalating costs of this kind, the response of some relevant statutory authorities and legislators has been to introduce thresholds of hearing loss, of the order of 5 - 7%, that must be exceeded in order for claimants to be eligible for compensation. Since a large proportion of compensation claims for noise-induced hearing loss are for losses of 5% or less, this means that the costs of these claims and the associated administrative costs are eliminated. However, although this eases the financial burden of compensation, it does nothing to solve the problem of occupational noise-induced loss of hearing among workers.

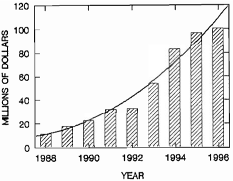

Figure 3. Cost, in millions of dollars per annum, of compensation claims for occupational noise-induced hearing loss in New South Wales from 1988 to 1996 (Source: Workcover Authority of NSW).

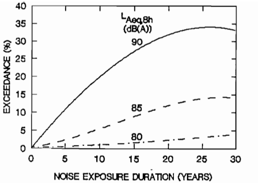

Figure 4. Hearing disability exceedance for a population of otologically screened males exposed to occupational noise with $L_{Aeq,8h}$ values of 80, 85 and 90 dB(A), as a function of duration of noise exposure, in years.

4. CURRENT NATIONAL STANDARD FOR OCCUPATIONAL NOISE

When the National Occupational Health and Safety Commission (NOHSC) was established in 1985, responsibility for setting occupational health standards passed from the NHMRC to the NOHSC. In response to its concern about the prevalence of occupational noise-induced hearing loss, the NOHSC formally declared the current Australian National Standard for Occupational Noise in 1992 and the National Code of Practice for Noise Management and Protection of Hearing at Work in 1993 [7]. The standard is an $L_{Aeq,8h}$ of 85 dB(A) and an unweighted (linear) peak sound pressure level, L_{peak}, of 140 dB. Like the original NHMRC model regulations, the National Standard and National Code of Practice are advisory documents but can be expected to affect regulations in the various Australian jurisdictions, as did the NHMRC model. By the end of 1996, the Commonwealth and most State and Territory governments had incorporated the National Standard in regulations and had either adopted the National Code of Practice verbatim or incorporated its principles in their own codes of practice [11].

However, does this National Standard for Occupational Noise go far enough in limiting the permissible noise exposure of workers? In 1974, the NHMRC warned that the estimated risks associated with exposure over a working life-time to noise at levels of 85 dB(A), as well as 90 dB(A), lead to an incidence of hearing loss in the working community which is unacceptable in the long term. In 1987, Macrae [6] pointed out, in an article which presented a table concerning the estimated incidence of hearing threshold impairment in noise-exposed populations, that an $L_{Aeq,8h}$ of 80 dB(A) comes closer to meeting the occupational noise management goal of preventing noise-induced hearing threshold impairment in the workforce than an $L_{Aeq,8h}$ of 85 dB(A). The table showed that, if noise-induced hearing threshold impairment at the most affected frequency, 4 kHz, is not to exceed 10 dB over a working life-time for 95% of the noise-exposed population, then noise exposure levels must be kept to not greater than 85 dB(A) but if noise-induced threshold impairment at 4 kHz is not to exceed 2 dB over a working life-time for 95% of the noise-exposed population, then noise exposure levels must be kept to not greater than 80 dB(A). The table also showed that, in order to obtain no noise-induced threshold impairment at any frequency, an $L_{Aeq,8h}$ of 75 dB(A) or less is necessary.

5. CONCLUDING REMARKS

The relative effectiveness of different noise exposure limits can also be evaluated in terms of hearing disability exceedance, as defined earlier in this article. Figure 4 shows the exceedance for noise exposure levels of 80, 85 and 90 dB(A). It is apparent that a noise exposure limit of 85 dB(A) will do little better than halve the problem. Given the current magnitude of the problem, a stricter limit seems appropriate. A standard of 80 dB(A) would come much closer to an acceptable solution to the problem of occupational noise-induced hearing loss. When data concerning occupational noise-induced damage to the inner ear obtained by means of otoacoustic emission testing become available, an even stricter noise exposure standard may seem appropriate. In the meantime, industries would be well advised to aim for a noise exposure limit, $L_{Aeq,8h}$, of 80 dB(A) rather than the National Standard value of 85 dB(A) and serious consideration should be given to reducing the National Standard noise exposure limit to an $L_{Aeq,8h}$ of 80 dB(A).

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An Innovative Use of Hay Bales to Provide Ventilation Fan Noise Control

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This article discusses an unusual method that was successfully used to provide a low cost effective means to reduce noise. The source of noise was emitted from ventilation fans during the construction of the sewerage tunnel through the Blue Mountains west of Sydney. The article is presented to demonstrate the use of an unusual solution which solves a short term environmental problem at significant cost savings to the community.

BACKGROUND

During the early 1990's a sewerage tunnel was constructed from Warrimoo through to Katoomba. The tunnel enabled sewerage from townships scattered through the upper Blue Mountains to be treated in a modern sewerage treatment plant with significant environmental advantages. The City of the Blue Mountains is unusual in that it is a city within a National Park.

The construction of the tunnel required the short term use of sites within close proximity to residences (30 - 150m). Ambient noise levels at night in the Blue Mountains are free of the traffic disturbances experienced in most urban areas and typically have background noise levels, L_{A90} of 30-35 dB(A).

The tunnel construction required centrifugal type ventilation fans to operate continuously. No excessive noise was being generated at the construction site near Faulconbridge and project engineers for the construction authority requested urgent technical assistance. An immediate solution was needed.

ACOUSTIC INVESTIGATION

Statistical noise level analysis was undertaken during the early hours of the morning to establish the background noise level in a similar residential area located away from the construction site. An L_{A90} of 35.5 dB(A) was measured. The fan outlet noise level at 7 metres was measured at 92 dB(A) with predominant octave band noise levels at 500 Hz. A combination of distance and directivity losses reduced the fan noise level at the worst affected residence to 44 dB(A). The fan noise was clearly audible and sufficiently tonal to cause extreme annoyance.

A solution was required before the following night otherwise construction would be forced to cease.

THE SOLUTION

It was clear that an attenuator was needed, but where do you obtain one on such short notice, deliver it to a site 80 kms from Sydney and have it installed before night fall?

An absorptive silencer would provide sufficient sound insertion loss. This triggered the idea of using hay bales. By early afternoon, a 5m long absorptive silencer was constructed using the bales as blocks to form a tunnel. The solution could be extended if further noise reduction was needed.

The solution worked adequately achieving a 10 - 12 dB(A) noise reduction and satisfying the residents concerns.

The next construction site was located at Woodford with the ventilation fan located within 30 metres of a residence. A shipping container was used to house the fan and a labyrinth was constructed, again from hay bales placed within the container so that discharge air passed through a series of bends. The outlet of the container was pointed away from the residence to gain noise reduction through directivity effects. Significant cost savings were achieved.