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Work and non-work noise exposure

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ABSTRACT

Most, if not all, industrialised countries now have in place occupational health and safety regulations with regard to hazardous noise exposure in the workplace. The challenge now is how to account for exposure to non-work and leisure noise and how to determine if this is a potential problem replacing or in addition to workplace noise. Recent studies undertaken by the National Acoustic Laboratories indicate that non-work and leisure noise exposure can have a significant effect compared to workplace noise thus compounding the problem of maintaining good hearing health. These studies have also provided a straight forward method for the comparison of the overall effects of all noise exposure using a noise exposure profile.

INTRODUCTION

It is well established that exposure to ‘too much’ noise is a hazard to hearing health (WHO: 1980). This is also universally acknowledged through the existence of the International Standard *ISO 1999 Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment* a document that is widely used to estimate the probable hearing loss due to noise exposure from regular workplace activities.

If the difference between noise and sound is primarily one of concept and not of definable physical properties then ISO 1999 is also reasonably applicable to all forms of noise and sound that affects humans and not meerly occupational noise. This is of course applicable in the case of musicians whose ‘occupational noise exposure’ is the appreciative audience’s sound (Chasin: 1996).

ISO 1999 can be used to estimate the effects of noise and sound on hearing regardless of the source or the listener’s judgement as to whether it is noise or sound. Through the use of ISO 1999 there is an exposure–response relationship established for the population. While this relationship may not be exact it is well established in principle and widely used as well as being the basis of most, if not all, workplace noise exposure standards commonly used throughout the world today (I-INCE: 1997). [It should be noted that ISO 1999 being statistically based is not applicable to the individual, only to the group.]

Exposure standards are used to establish whether or not a place of work is hazardous to hearing health. Usually there are two exposure standards created: one for continuous noise; and one for impulse noise. In this document only continuous noise will be considered as it tends to be the most common source of noise exposure problems in connection with work related hearing loss claims. (ASCC: 2006).

There are some discussions concerning the more precise details of the exposure-response model, for example, should intermittent noise be treated in a similar manner to continuous noise (Bradford & Hardy: 1979; Dixon Ward, Royster & Royster: 2000) and should the exchange rate for increasing equivalent continuous sound pressure level be 3, 4 or 5 dB. By far the majority of jurisdictions have accepted a 3 dB exchange rate based on an ‘equal energy’ principle (*ie* doubling the exposure doubles the damage) though there are some uses of the 5 dB exchange rate still in use (I-INCE: 1997). In its simplest form exposure is considered to be cumulative over the life-time (ISO 1999).

For the purposes of the current exercise the acceptable exposure criteria that will be applied will be an eight hour, equivalent continuous A-weighted sound pressure level ($L_{Aeq,8h}$) of 85 dB. It should be noted however, that this value is not critical to the argument if, for example, an $L_{Aeq,8h}$ of 80 dB (1 Pa^2h) should be preferred the accompanying reasoning is analogous.

CONSTRUCTING A NOISE EXPOSURE PROFILE

We can compare the total life-time exposure to noise through the use of a noise exposure profile. This work is an extension of what has been presented elsewhere as initial proposals (Williams: 2010; Williams: 2008) examining the total effects of non-work noise over the life-cycle.

Consider the case of noise exposure from the workplace. A measurement of the instantaneous noise level or sound pressure level (SPL) gives a single point measure and perhaps an indication of possible hazardous exposure. The SPL is more likely to be averaged over a selected time period by modern sound level meters to create the steady equivalent continuous sound pressure level (L_{eq}) thus providing a better indication of the possible noise hazard arising from the exposure. This

L_{eq} is usually modified, according to International protocols, with an A–weighted frequency response (L_{Aeq}) designed to better characterise the effect of the noise on the typical human ear. This L_{Aeq} which has been measured over a particular time period ($L_{Aeq,T}$) is then normalised to an eight hour equivalent value through a well defined process (AS/NZS 1269.1)in order to produce an A-weighted noise exposure level ($L_{Aeq,8h}$ or $L_{A,EX}$). This exposure level is then compared to the relavent noise exposure standard in order to determine if the noise exposure standard is exceeded and if preventative action is required. This $L_{Aeq,8h}$ or $L_{A,EX}$ provides the first point in the construction of a noise exposure profile for noise exposure versus time.

Take an individual worker whose employer maintains the noise levels in the workplace such that the $L_{Aeq,8h}$ is maintained just fractionally below the mandated level of 85 dB (NOHSC: 2000) and call this level the acceptable daily exposure (ade[1]). Using the 3 dB exchange rate every 3 dB increase in the $L_{Aeq,8h}$ increases the exposure by one ade. After one year this worker would have been exposed to an equivalent acceptable yearly exposure (aye) at work. If it is taken that there are approximately 220 working days per year then 220 ade are equivalent to one aye (ie 1 aye ≡ 220 ade). After 42 years of work, from 18 to 60 years old, this individual would have been exposed to a total of 42 aye or 9,240 ade. *Figure 1* illustrates this process with a constant exposure rate assuming, for simplicity, the individual remains in the same or similar employment over the 42 years. *Figure 1* then would be their work noise exposure profile showing both accumulation rate and total exposure.

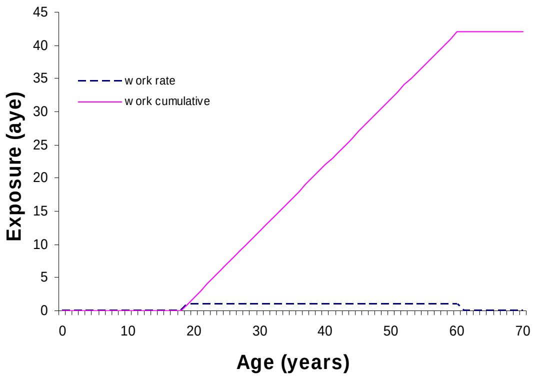

Figure 1: Yearly rate and cumulative exposure for an individualexposed to one acceptable yearly exposure (aye) per year for 42 years of working

For most people life does not tend to simply consist of work alone. Leisure and non-work activities play a large part in our lives and sometimes our noise exposure. Thus we can now expand the above example to leisure activities at the end of a working week in order to better understand total noise exposure over the life-time.

One of many possible activities may be, for example, going out for an evening with friends. While there entertainment may be provided by a live band. Measurements gathered[2] show that at many venues, when a live band is playing with amplified music the L_{Aeq} are typically around 105 dB for a fifteen minute set. If our individual stays for a total of five hours during which three sets are played the exposure ($E_{A,T}$) from the band alone is equivalent to 9.5 ade (9.49 Pa^2h) almost double what they would receive during a normal working week with no leisure noise exposure (*viz* 5 ade/week).

{Note:The A-weighted sound energy over period T, $E_{A,T} = 4.T.10^{0.1(L_{Aeq}-100)}$*, T = exposure time in hours. An* $L_{Aeq,8h}$ *of 85 dB ≡* $1.01Pa^2h$*}*

If a typical young adult commences attending live music venues in their late teens and ceases in their early 20s, in this case 24 years, then their leisure noise profile from the live music attendance would take the form as shown in *Figure 2*. The attendance rate is taken as being as shown in *Table 1* ranging from four in the first year, age 17, to eight in the final year age 24.

Age (yrs)	*Live music events per year*	*Yearly music exposure(ade) (9.5 per event)*
17	4	38
18	12	114
19	14	133
20	15	142.5
21	15	142.5
22	12	114
23	10	95
24	8	76

Table 1: Age and attendance rate of noise exposureat music events

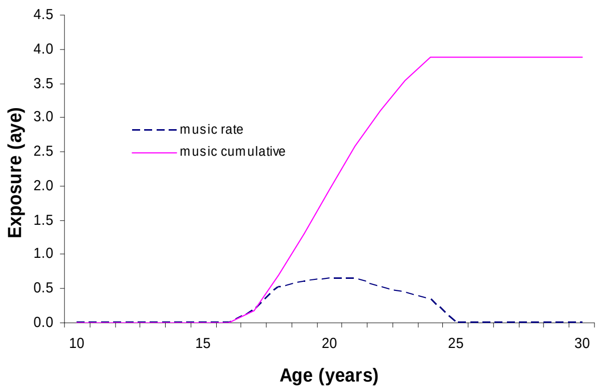

Figure 2*:* Rate and cumulative exposure from music noise

Figure 3 shows the cumulative noise exposure from work place noise, music events and the combined work and music exposure.

[1] Coincidentally this is equivalent to one Pascal squared hour (1 Pa^2h), the sound energy

[2] Such measurements were made by the author by visiting suitable venues.

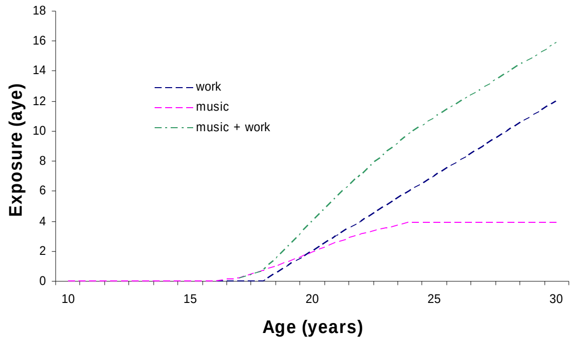

Figure 3: The cumulative noise exposure of work; music; and work + music

The next inclusion into our profile is dance music, common to many young people. This may come from very large, live concert events, dance parties, night clubs or raves. These events can last several hours with typical L_{Aeq}s of around 100 dB. If a duration of four hours is selected then one event is equivalent to 16 ade (16 Pa^{2}h). Our subject may attend two such events in the first year when they are 18 and four in each of the next six years as also presented in *Table 2*. The rate and cumulative profile is shown in *Figure 4*.

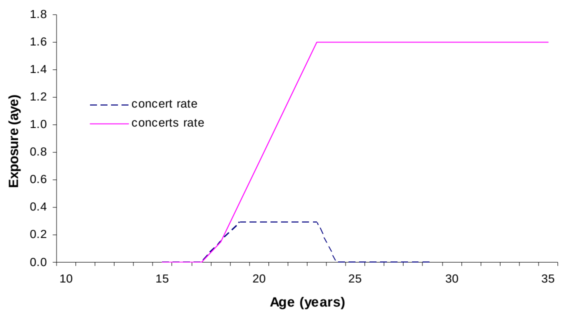

Figure 4: *Rate and cumulative exposure due to 'concert' noise.*

If the individual and cumulative exposure curves for work, music and concert noise are all plotted as in *Figure 5* then it is clear that the addition of the concert noise has now placed the individual around six years ahead of the work only exposure colleagues. This graph has been plotted for the whole working life assuming retirement at age 60 years.

Age *(yrs)*	***Concerts attended per year***	***Yearly concert exposure (ade) (16 per event)***
18	2	32
19	4	64
20	4	64
21	4	64
22	4	64
23	4	64

Table 2: *Age and attendance rate of noise exposure at concerts*

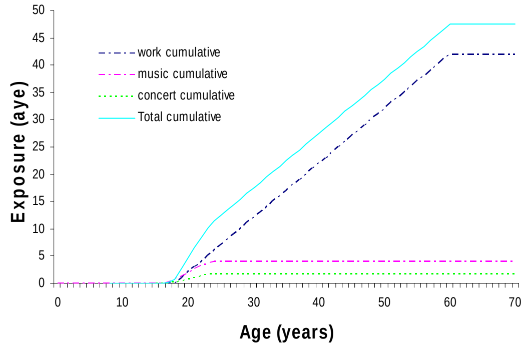

Figure 5: Individual and cumulative exposures for work, music and concert noise exposureextended to retirement from working life at age 60 years

DISCUSSION

The graphs presented show both the rate of noise exposure and the cumulative noise exposure from work, live music and dance music (parties, raves, night clubs or large live performances).

From *Figure 5* the cumulative effect of work noise and music is obvious. So too is the fact that even when the music exposure is reduced and then stopped there is an 'off set' or leftward shift to the cumulative exposure curve. Overall this has the effect of making the exposed individual's hearing appear 'older' than it really is. An individual with work only noise exposure at age 30 has a cumulative exposure of 12 aye while the individual who experiences both work + music + concert has reached that exposure by 24, six years earlier.

This effect is more significant when it is seen that the work only individual retires with a total exposure of 42 aye, however, this same value is reached by the work + music + concert attendee by age 54, six years earlier. If we accept the exposure/response relationship then the increased response must result in a greater risk to the possibility of noise injury and hearing damage, in this case by an increased lead time of six years. This is demonstrated in *Figure 6*. There is an increased noise exposure of around 13% due to the leisure noise components selected in this particular example.

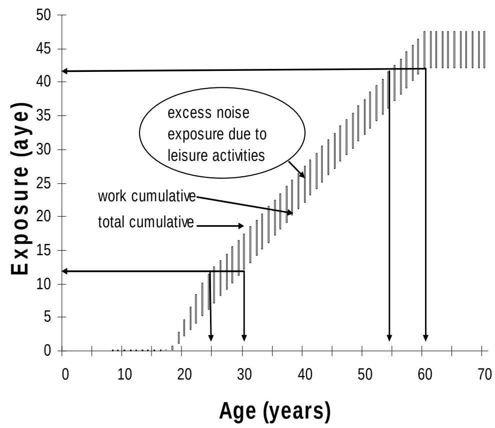

Figure 6: *Shaded area shows excess noise exposure due to leisure activities. Arrows show exposure reached at younger age due to leisure noise exposure.*

The process of using such a profile allows noise exposure data from significant sources to be conveniently included and simply assessed with respect to importance in a clear manner to see the overall cumulative effect on the individual or group involved. Additionally for educational purposes this method of presentation allows a visual demonstration of potential future hearing health problems. As an educational tool this may provide a more individualised approach compared to present methods.

Two further points to mention briefly here are that this form of modelling can include sound or noise from any source not only work or music. Ultimately it is theoretically possible to include all noise exposure and build a true life-time noise exposure profile. However, what must be kept in mind is the fact that the actual safe value for cumulative life-time noise exposure is not known and it may prove very difficult, if not impossible, to estimate a 'safe' life-time exposure.

CONCLUSION

The ability to construct a noise exposure profile has the potential to permit significant sources of noise hazard to be quickly assessed in a visually simple manner. If the major, significant sources of noise exposure are known then activities can be better developed and targeted for future prevention.

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