Noise exposure profiles

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ABSTRACT

This paper seeks to present a methodology for developing a noise exposure profile. A noise profile represents the cumulative noise exposure on an individual, group or population from multiple noise sources arising from work, non-work and leisure activities. This profile is capable of presenting the effects of noise and any contribution from particular sources in a much clearer manner than through a set of abstract figures.

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.

More recently by using the convention that noise is defined as "unwanted sound" that which we call sound must be at least wanted by someone. If the difference between noise and sound is primarily one of concept and not of definable physical properties then it seems that ISO 1999 is also reasonably applicable to all forms of noise and sound that affects humans and not simply occupational noise. This is of course already carried out in the case of musicians whose 'occupational noise exposure' is the appreciative audience's sound (Chasin: 1996).

Basically ISO 1999 should be able to 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. Thus 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).

These 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 should be preferred the accompanying reasoning is analogous.

BUILDING A PROFILE

Initially consider an example of noise exposure derived 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 noise. This L_{eq} is usually modified, according to conventional 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 mathematical process 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 recommended 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.

Now consider an individual worker who's 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 and call this level the acceptable daily exposure (ade[1]). Using the 3 dB exchange rate, for 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

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

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.

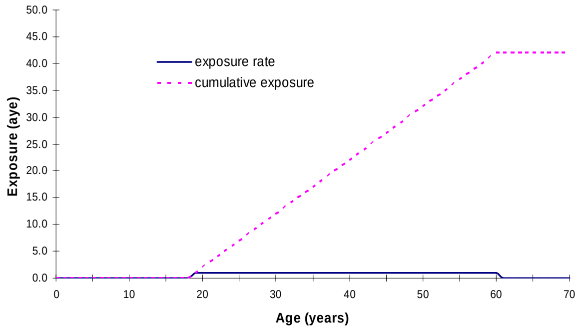

Figure 1: *Yearly exposure rate and cumulative exposure for an individualexposed to one acceptable yearly exposure (aye) per year for 42 years of working*

Expanding the above simple example, at the end of a typical working week the noise exposure would be five ade. To this we must add noise from any leisure and/or non-work activities if we are to better understand the accumulation of 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] that show that at many venues, when a live rock band is playing with amplified music the L_{Aeq} can typically be 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 from the band alone is equivalent to 9.5 ade (9.49 Pa^2h) double what they would receive during a normal working week with no leisure noise exposure. If four of these events were attended in one year the aye would be 0.17.

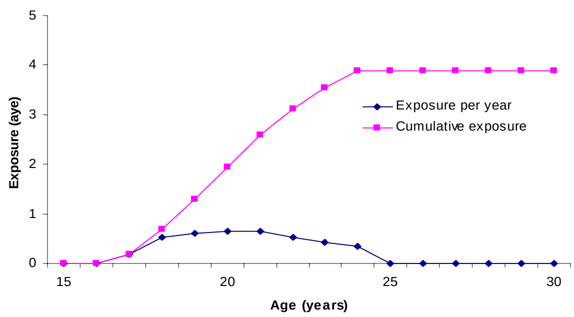

Figure 2: Exposure rate and cumulative exposure from music noise.

Age (yrs)	Music events/yr	Music (aye)	Dance/ concerts (aye/ year)	Concert (aye/yr)
17	4	0.17	-	-
18	12	0.51	2	1.45
19	14	0.60	4	2.91
20	15	0.65	4	2.91
21	15	0.65	4	2.91
22	12	0.52	4	2.91
23	10	0.43	4	2.91
24	8	0.35	-	-

Table 1: Age and attendance rate at music events, dance parties and concerts

Table 1 presents the leisure activity of a typical young adult who commences attending live music in their late teens, ceasing at age 24. Their leisure noise profile from the live music attendance could 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.

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

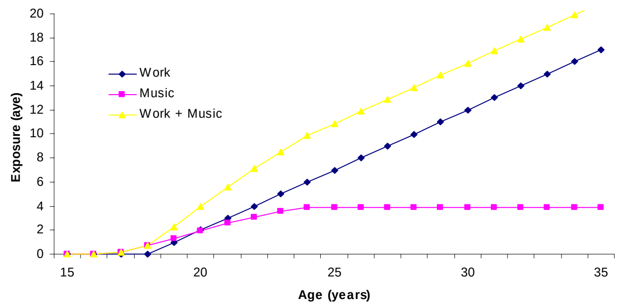

Figure 3: The cumulative noise exposure of work, music and work + music.

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} of around 110 dB. If a duration of four hours is selected then one event is equivalent to 160 ade (160 Pa^2h). Our subject may attend two such events in the first year when they are 18 and four in each of the next six years. This would result in 1.45 aye in the first year and 2.91 in each of the following years as presented in *Table 1*. The profile is as in *Figure 4*.

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

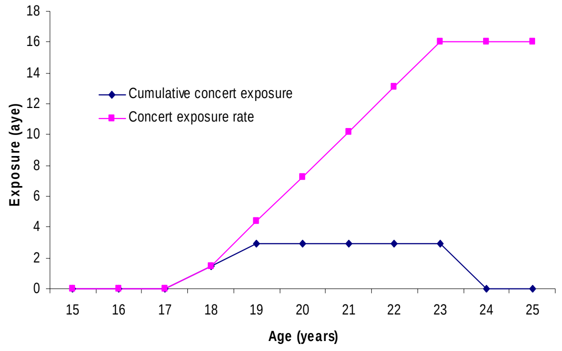

Figure 4: Rate and cumulative exposure due to 'concert' noise.

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 approximately ten years ahead of the work only exposure colleagues. This graph has been plotted for the whole working life assuming retirement at age 60.

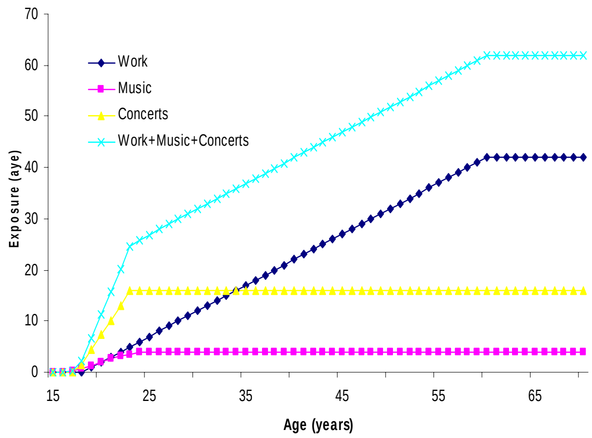

Figure 5: Individual and cumulative exposures for work, music and concert noiseexposure extended over to retirement from working life at age 60 years.

DISCUSSION

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

From *Figure 5* the difference in the cumulative effects of work only noise and of work and leisure noise is obvious. So to is the fact that even when the music exposure is reduced and finally ceases there is an 'off set' to the cumulative exposure curve of the leisure noise exposed individual. Overall this has the effect of making the exposed individual's hearing appear 'older' than it really is. For example in *Figure 5*, if we consider an individual with work only noise exposure at age 30 they have a cumulative exposure of 12 aye while the individual who both work and music exposure has reached this exposure by about age 21, nine years earlier.

This effect is of much more significance when considering that a work only individual retires with a total exposure of 42 aye when 60 years old, a figure reached by the work + music + concert attendee at about age 40, 20 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 20 years.

The process of using such a profile allows noise exposure data from significant sources to be conveniently included and simply assessed in a clear manner to see the overall cumulative effect on the individual or group involved. Additionally for educational purposes this method of presentation clearly 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 which commonly involve discussions based on pure tone audiogrammes.

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 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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