Proceedings of the Institute of Acoustics

SOME APPLICATIONS FOR THE SINGLE NUMBER RATING OF HEARING PROTECTORS

R J Weston

RAF Institute of Community and Occupational Medicine, Halton

INTRODUCTION

The recognised method for determing whether a hearing protector which you have issued to your workers is giving sufficient attenuation, is to analyse the noise into octave bands, subtract the attenuation of the hearing protector and overlay the resulting spectra with the damage risk criteria. This methodology is perfectly adequate in the factory environment where the noise is both steady and continuous, but becomes over complicated where both the noise spectra and intensity are variables. This is especially so if the intensity of the noise is high enough to require exposure time limits to be applied. Thus it can be seen that there is a need to define a simpler method of determining the level of protection in these instances. It would be particularly useful in order to derive an exposure time limit where hearing protectors cannot provide complete protection against some of the noise levels experienced in the RAF environment.

The acoustician is continually being asked to express a hearing protector's attenuation characteristics as a single number. It followes on that where there are many variables, a persons noise exposure should be calculated in terms of the Equivalent Continuous Sound Level (L_{Aeq}). In fact the draft prevention of Damage to Hearing from Noise at Work regulations require the employer to make an assessment of the noise in similiar terms, where his employees are likely to be exposed above the first action level. This means that where the "daily personal exposure" (ie L_{Aeq}) exceeds 85dB(A) there is a need to express hearing protector attenuation in simple terms and to be able to apply that factor to the overall exposure and thus determine the exposure at the ear.

As an illustration RAF ground crew during the working day may be exposed to engine start up procedures which as in the case of the Tornado aircraft may involve running up to a high engine power often inside a protective enclosure.

This exposure is then coupled to that of engine testing at which running times and engine settings will depend on the fault and how long it takes to diagnose. With so many variables it is impossible to calculate the average dose let alone the worst case. By monitoring the environment with a dose meter attached to personnel it should be possible to collect sufficent data in order to estimate the average and worst case "daily personal exposure" at the ear.

ENR and HML

This paper describes work to show that the principles applied to the Single Number Rating of Hearing Protectors can be extended to measurements of terms of L_{eq}.Consequently they have application in areas where a persons daily personal exposure level is not easily calculable. Two draft proposals have been discussed by the I.S.O.

The simplest of these is the Estimated Noise Reduction (ENR) method(1). The ENR of a hearing protector is calculated from the following relationship:

$$ENR = L_C - L'_A - K$$

Where: L_C = 100 dB is the total C-weighted Sound Pressure Level of pink noise

L'_A = the total A weighted Sound Pressure at the ear due to the attenuation by the hearing protector in question of the pink noise divided into its octave values

K = constant

The second draft proposal is slightly more involved. It is a three number method proposed by Bilsom known as the HML method(2). The attenuation index (R) using the HML method is calculated from the following formulae.

SOME APPLICATIONS FOR THE SINGLE NUMBER RATING OF HEARING PROTECTORS

$$R = M - \frac{H - M}{40}(L_c - L_c - 2) \text{ when } (L_c - L_A) < 2$$

$$R = M - \frac{M - L}{8}(L_c - L_A - 2) \text{ when } (L_c - L_A) > 2$$

"H", "M" and "L" are three points on the attenuation graph, which are calculated from 5 standard noise spectra in the following relationship.

$$R = 100 - 10 \log \sum_{f=125}^{8000} 10^{0.1 (L_f + A_f - R_f)}$$

The principle behind both these simplified rating methods is that whatever the shape of the noise spectra, the relationship of the 'C' weighted noise level outside the hearing protector to the "A" weighted noise at the ear beneath the hearing protector is approximately constant. There is a significant difference between the two methodologies. The two attenuation indices do not describe the same charactistics.

$$ENR = L_C - L'_A - K$$

$$R = L_A - L'_A$$

and it can be shown that

$$R = ENR - (L_C - L_A)$$

It is not the objective of this work at this stage to test the relative accuraces of the two methods but rather to test their applicability when measuring the employes daily dose in Leq terms. In this context the attenuation indices would have already been calculated.

SOME APPLICATIONS FOR THE SINGLE NUMBER RATING OF HEARING PROTECTORS

LABORATORY AND FIELD EXPERIMENTS

Laboratory tests have been carried out in a reverberant room using a real subject. A B&K dosemeter was modified with extra 20 dB of gain to reduce the cut off threshold to 60dB(A). This was coupled to a "Knowles" miniature microphone and attached beneath the hearing protector to measure L´A. A similar dosemeter modified to the "C" weighting curve, was attached to the outside of the hearing protector. A third dosemeter measured the external L_A dose. A number of different sound spectra were then generated in the room for short periods and the dose levels recorded.

Subjects were similarly instrumented in a field test where the subject had to enter the chamber of an uninstalled Jet engine test facility. Dose measurements were taken for a range of sound spectra levels and durations. Initial results show that both methods gives consistent results in L_{eq} terms. There were wider attenuation variations in the field test but then this will be expected and are due to the way individuals wear their hearing protectors and to the exact siting of the dosemeter microphone.

CONCLUSION

In the military environment the soldier, sailor and airman is exposed to a many types of noise, most of them excessive in level, such that they are operating on the limit of their effectiveness. In the case of the infantryman the range of noise could span that of riding in an armoured troop carrier coupled with the firing of a Karl Gustav Rocket Launcher. Within the RAF environment it may include that created by a Tornado Aircraft in a hardened aircraft shelter where levels of 115 dB(A) are quickly reached and that caused by exposure to engine run-ups and take-off operations on the main runway when maximum levels in excess of 120dB(A) can be experienced. Whilst it is possible to measure static noise levels and spectra at different engine settings and at different distances from the source, it has proved impossible to calculate daily personal exposure even for one man, let alone a whole group, because of the non-predictability of operational circumstances. Static noise trials with a Tornado in a HAS have shown that at certain engine power settings the issued hearing defenders do not give sufficent protection. In practice the exposure times to individual occurances are relatively short although repeated during the day. Attempts to monitor the dose at-the-ear, (ie L'_A) using miniature microphones on the ground crew, have proved disasterous because the subjects were either breaking the microphone-dosemeter coupling cables during their work, taking headsets off or in other ways invalidating the dosemeter readings.

Accordingly it can be seen that with a known simplified measure of the insertion loss of the hearing protector, all that has to be monitored is the external (to the hearing protector) noise environment and from which the daily personal exposure level can be estimated.

Of the two simplified methods the ENR is obviously the most straight forward since all that is required is to attach a "C" weighted dosemeter to the person being assesed. This can be continued over a number of days in order to determine his or her average daily dose.

The HML method is more complicated. First both L_{Ceq} and L_{Aeq} have to be monitored, and the difference between them calculated to determine R since:

$$R \propto 2 > (L_C - L_A) > 2$$

However having determined R_C from a graph, the daily personal dose at the ear can be calculated from

$$L'_A = L_A - R$$

SOME APPLICATIONS FOR THE SINGLE NUMBER RATING OF HEARING PROTECTORS

REFERENCES

1. ISO DP/8353 — Acoustic estimated noise reduction of hearing protectors ISO/TC43 SC1: Noise

2. Lundin, Rune — Three methods for calculating the attenuation index of a hearing protector - A presentation and a comparison. Bilsom Advisory Service Bilsom AB, Sweden.