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THE HML METHOD: AN ACCEPTABLE PROCEDURE FOR RATING THE ATTENUATION OF A HEARING PROTECTOR

S J Karmy

Bilsom International, Fountain House, Odiham, Basingstoke.

0.0 Summary

The main objective of this paper is to present a simplified method for rating the attenuation of a hearing protector so that its suitability for use in a given noise environment can be assessed. The technique is known as HML and was developed by a colleague of the author, R Lundin of Bilsom AB, who also provided the data given in this paper.

A comparison is made in this paper between the accuracy of the HML method, and a proposed ISO method known as ENR. The latter is based upon the NRR rating currently used in the USA.

It is demonstrated that the ENR rating method is not as accurate as the HML technique, and that acceptance of ENR will lead to ear defenders being specified for use in industry which provide an unnecessarily high degree of low frequency attenuation. This would have a threefold effect. Firstly the intelligibility of received speech would be unnecessarily reduced, secondly the comfort of the ear protector would be reduced, leading in all probability to the third problem, this being a reduction in wearing time by the employee.

All three problems can be avoided by use of the HML method.

1.0 Introduction

As a consequence of the increasing number of enquiries made to the Bilsom Advisory Service during the last five years it is evident that industry requires a simplified method for specifying an acoustically correct hearing protector for use in a given noise environment. The present UK specification procedure is described in the 1972 Code of Practice (Department of Labour 1972) and requires noise measurement in octave bands, followed by mathematical calculations which the average Safety Officer in industry does not find simple. With the advent of new UK noise legislation to be promulgated by January 1st 1990, it would be unfortunate if pressure on Safety Officers to specify the correct type of protection were to increase without some attempt being made to ensure that an approved but simplified specification method was available.

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Several authors have already proposed simplified rating methods (Beddoe 1980, Cluff 1978, Tobias 1977, Waugh 1976, Johnson 1974, Botsford 1973), but after critical appraisal that which gained widest acceptance is now found embraced within the American NRR rating scheme (Environmental Protection Agency 1979). Unfortunately the NRR attenuation rating method does suffer from problems, as will be shown later in this paper, such that the user of an earmuff specified by the NRR rating method could be disadvantaged in a noisy environment. The imminent problem faced by the UK is that the NRR rating method has been re-presented in a form known as ENR in ISO discussion document number DIS 8353, currently being circulated for voting to member countries. If accepted by ISO the ENR method would be recommended for use in the UK. Section 2.0 of this paper describes an alternative - the HML method, whilst Section 3.0 compares the results obtained using the HML and ENR techniques with those produced by use of the UK long octave band method. This latter method is taken to be the most accurate but most laborious procedure for calculating protector effectiveness.

The ENR and UK octave band methods are not explained further in this paper as they are fully described in the references given earlier.

2.0 The HML Method

The HML method seeks to generate three laboratory calculated parameters, H M and L, which can be utilised by the ear protector user to predict the performance of the earmuff in noises with a wide range of frequency content. To derive H M and L, use is made of the 100 "NOISH" industrial noises (Kroes 1975) which provided the foundation for the choice of "typical" noise spectrum used in the NRR method. The 100 spectra are stated to be typical of industry, the various configurations being present in proportion to the number of employees exposed to those spectra.

Using the UK long octave band method, the noise reduction R offered by a given hearing protector in each of the 100 noise spectra can be calculated. Figure 1 shows the results of such a calculation for the Bilsom Compact earmuff, plotted against a parameter (Lc-La) which defines the frequency characteristic of each of the 100 noises. Lc is a 'C' weighted measurement of the noise in question, whilst La is an 'A' weighted measurement. As an example, a high positive (Lc-La) value would indicate a noise spectrum with a large low frequency content, as a consequence of the shape of the 'A' and 'C' weighting curves.

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Experimentation with similar plots derived using different types of hearing protector showed that the long octave band method results could be adequately described by two straight lines meeting at an (Lc-La) value of 2, the line ends being defined at (Lc-La) values of -2 and 10 respectively. These three co-ordinates give the H M and L values, as shown on Figure 1.

In practice, the H M and L values would be calculated by the manufacturer using the eight reference spectra shown in Table 1, which are groupings of the 100 NIOSH spectra referenced earlier. The attenuation index R for each of the 8 reference noises is calculated according to the long method. Using the first four R and corresponding (Lc-La) values, a rectilinear regression produces a value for H. Similarly values for L and M are produced by rectilinear regression of the R and (Lc-La) values generated from the last 4 reference noises.

The manufacturer could either supply the H M and L values in the form of a graph as represented by the solid line in Figure 1, or on an easy to use "ready-calculator".

In the case of the graphical presentation, the R or noise reduction value supplied by the given protector in a given (Lc-La) noise environment would be obtained as shown by the dotted line example on Figure 1, illustrated for a noise with an (Lc-La) value of (-0.5). Alternatively R can be calculated using simple formulae, given knowledge of H M L and the (Lc-La) value.

3.0 A comparison of the accuracy of the HML and ENR methods

3.1 Method

To assess the implications of each method on the user populations, the attenuation measurements obtained at each frequency from each of the 30 test subjects during BS5108 attenuation testing were utilised. The apparent effectiveness of the Bilsom Compact earmuff in each of the 100 NIOSH noises was calculated using the ENR and HML methods. The accuracy of each technique was evaluated by comparison with the results obtained using the long, octave band method of attenuation calculation.

The high number of comparisons thus formed were plotted as cumulative distributions. To aid discussion, the results were subdivided into three classes: these being the results obtained from noises with (Lc-La) values below 0dB, between 0 and 4dB, and above 4dB respectively, otherwise known as high, medium and low frequency noises.

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3.2 Results and Discussion

The comparisons described above are presented in figures 2, 3 and 4. These show that for high frequency noises the ENR method considerably underestimates the attenuation capability of the hearing protector, unlike the HML method which is far more accurate. The HML method is also more accurate than the ENR method for medium and low frequency noises, although the effect is not as pronounced as it is for the high frequency noises.

It is worth noting that in all three cases the HML method gives the closest approximation to the 84% of the population receiving the calculated protection, a result for which the long method strives.

The reason for the large inaccuracy of the ENR method in high frequency noises can be seen in Figure 5, which shows the assumed protection of the Compact earmuff as defined in UK terms, against the assumed protection as effectively described by the ENR protocol.

If it is required to reduce the perceived noise to a given maximum level beneath the ear protector, the conservative ENR estimate of protector performance at high frequencies could cause a heavier duty earmuff to be issued than is actually necessary. The shape of the attenuation curves in Figure 5 are such that the low frequency protection thus provided by this heavier duty protector will then also be far higher than is actually needed, reducing the ability of the wearer to hear spoken communication far more than is necessary.

Furthermore the further a hearing protector lies towards the "heavy duty" end of the range, the less comfortable it will be. The less comfortable an ear protector, the more likely it is to be unused for portions of a noise exposed day, leading to the possibility of the employee receiving a dangerous noise dose.

The three effects described above will be most pronounced in environments with higher frequency noise spectra, as it is under these circumstances that the ENR method will be the most inaccurate.

4.0 Conclusions

HML is a simplified method of specifying the acoustic suitability of a hearing protector for use in a given noise environment. Requiring only a noise measurement to be made in dB(A) and dB(C) the method is no more demanding than the ENR protocol currently proposed by ISO, and is far simpler than the long octave band method described in the current Code of Practice.

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The HML method has been shown in this paper to be accurate, far more so than the ENR technique which has serious disadvantages, especially if used in high frequency noise spectra. These disadvantages include the specification of overprotective ear defenders with a commensurate reduction in comfort, probably wearing time, and received speech intelligibility.

The HML method describes the frequency dependent attenuation of a hearing protector better than does the ENR method, and also provides three parameters, H M and L, by which the protector can be ranked with its peers, depending upon the spectrum of the noise environment in which it is to be used.

It is thought that the HML method of ear protector assessment is superior to the proposed ISO ENR method, and should be adopted for use in the UK.

5.0 References

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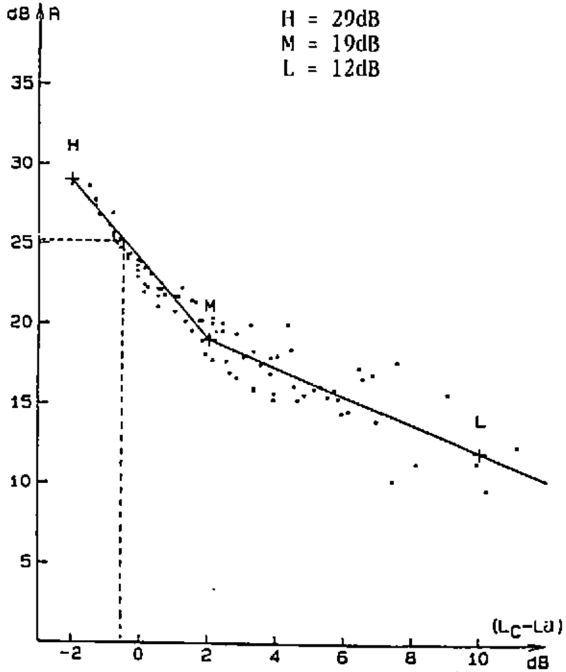

Figure 1 Bilsom Compact Earmuff
Dots: Long method for 100 noises
Solid line: The HML method.

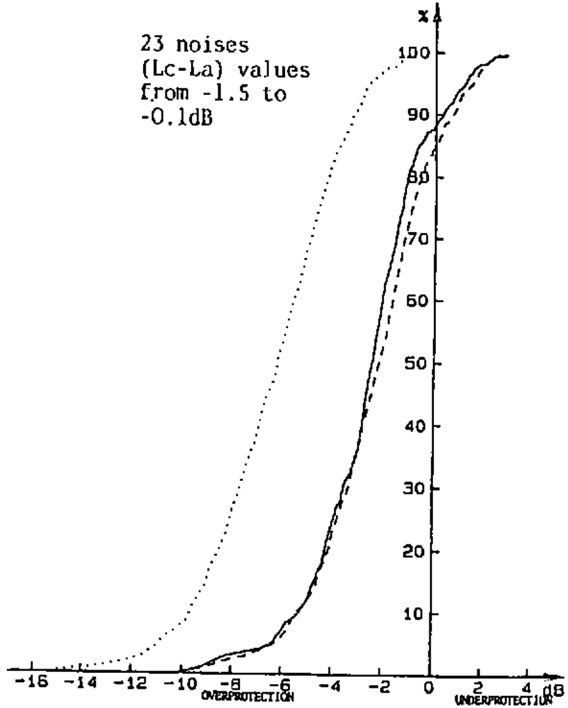

Figure 2 Distribution of R values for 15 individuals measured twice according to the long method (solid line) the HML method (dashed line) and the ENR Method (dotted line).

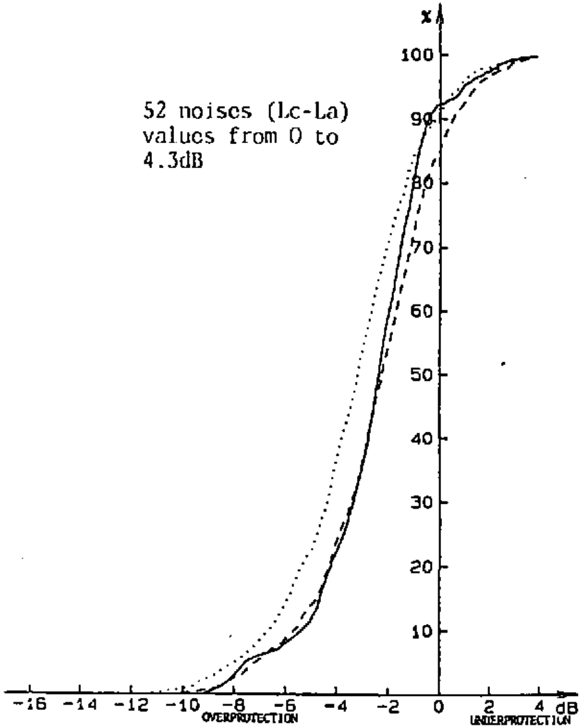

Figure 3

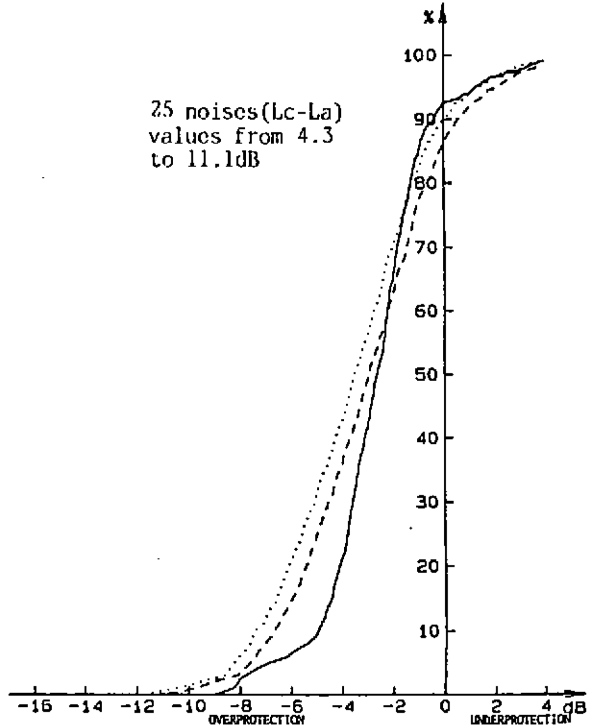

Figure 4

Distribution of R values for 15 individuals measured twice according to the long method (solid line) the HML method (dashed line) and the ENR method (dotted line).

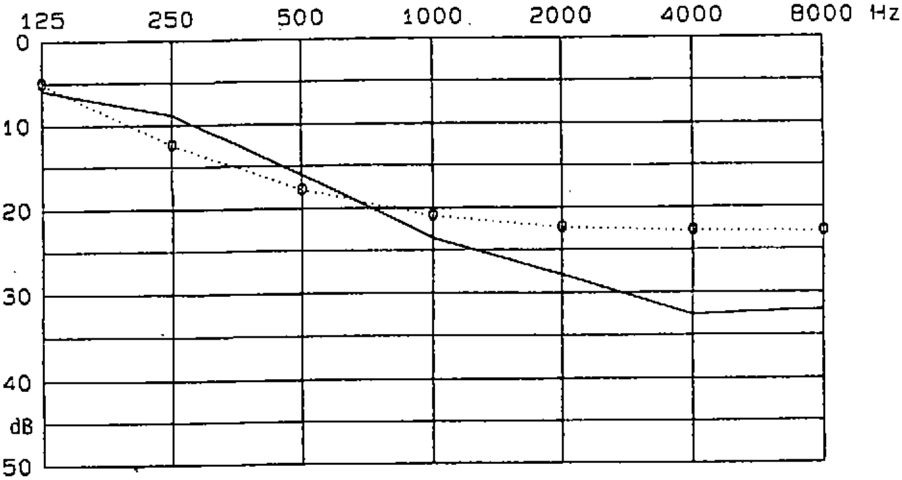

Figure 5 Assumed protection of the Bilsom Compact earmuff according to the long method (solid line) and the ENR method (dotted line).

Table 1 The eight reference noise spectra

Reference spectra Nr	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz	L_C-L_A dB
1	77, 6	78, 7	79, 4	84, 2	90, 4	95, 0	93, 7	93, 4	-1, 2
2	85, 7	85, 0	86, 9	87, 5	92, 8	95, 1	93, 0	91, 1	-0, 5
3	86, 0	87, 2	89, 4	91, 2	95, 0	93, 2	93, 1	90, 1	0, 1
4	91, 6	93, 3	93, 1	93, 0	95, 5	93, 1	91, 5	89, 9	1, 6
5	91, 6	93, 5	95, 1	95, 7	96, 4	91, 8	89, 4	84, 8	2, 3
6	96, 9	98, 1	97, 9	96, 5	95, 6	91, 8	89, 1	84, 1	4, 3
7	101, 9	100, 4	98, 8	96, 9	96, 3	90, 2	87, 0	83, 1	6, 1
8	103, 8	104, 1	102, 0	97, 0	94, 2	90, 2	86, 9	81, 0	8, 4