COMPARISON OF THE CALCULATED ASSUMED ATTENUATION OF HEARING PROTECTORS USING TWO METHODS - OCTAVE-BAND METHOD AND THE PROPOSED ISO SINGLE NUMBER RATING STANDARD

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INTRODUCTION

The Department of Employment Code of Practice for reducing the exposure of employed persons to noise published in 1972 (1) recommends that the suitability of hearing protection be assessed by using octave-band attenuation data for the hearing protector, the standard deviation of these data and the measured octave-band spectrum of the noise. The method thus requires that 8 measurements of the noise have to be made (or a real-time octave-band analyser or tape recording and subsequent analysis) followed by a number of calculations to determine the reduced spectrum and its A-weighted value. These calculations may need to be repeated for all hearing protectors whose suitability is to be assessed. Whilst this is the most reliable and thorough method in general use it is inconvenient because it requires additional equipment, octave-band filters or real-time analyser, and a number of calculations to be made. Thus in recent years efforts have been made to produce a method from which a forecast of the protection can be made based on the A or C weighted level of the noise; such a method has been adopted legally in the USA where hearing protectors must be accompanied by 'Noise Reduction Rating' (NRR) data. ISO have circulated a Draft Proposal for a Standard for 'Estimating the noise reduction for hearing protectors' (2). This Paper reports a comparison of the calculated assumed reduction due to a number of protectors for a range of typical industrial noise spectra using both methods.

CALCULATIONS

The noise spectra used for this comparison are shown in Figure 1 and were taken from Delaney et al (3). The octave-band spectra are given in Table 1 and a description of the sources is in Table 2. They cover a range likely to be encountered in industrial noise measurements and were normalised to 100 dB at 1 kHz for the calculations. The C - A weighted values of these spectra cover the range +1.4 to -14.9 dB (spectra 8 and 1 respectively).

Octave-band attenuation data, determined according to BS 5108, was used to calculate the assumed octave-band sound pressure level "under" the protector and this was recombined to give the reduced A-weighted SPL and hence the A-weighted reduction due to the protector. The calculations were performed using data for 69 protectors.

The same octave-band attenuation data was used to calculate the Effective Noise Reduction (ENR) using the procedures set out in ISO DP 8535 (2). ISO DP 8353 enables the ENR to be calculated for a range of degrees of protection "80% to 95% the occasions when the protector is worn by various people in various noise spectra". For the present comparisons the A-weighted reduction based on ENR95 was calculated from the C-weighted level of each spectrum.

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RESULTS

The mean A-weighted assumed reduction from octave-band attenuation data and from ENR_{95} are plotted in Figure 2. Also presented are the highest reductions (from Spectrum 8) and lowest (from Spectrum 1).

DISCUSSION

A comparison of the mean results for all eleven spectra shows that ENR_{95} predicts a lower assumed reduction than the Octave-band method by 2 dB or less. There are a number of protectors for which the assumed reduction is lower by up to 10 dB and only one where ENR_{95} gives a higher estimate of the assumed reduction and then by less than 1 dB. These results are in broad agreement with those of Berger (4) for NRR. The general lower estimate of the assumed reduction is as would be expected since ENR_{95} is intended to cover 95% of wearers and the Octave-band method 84%. The difference between the two assessments would result in about a 2 dB change in assumed attenuation.

For the spectrum which produced the highest calculated reduction by the protectors (Spectrum 8 where C - A = +1.4 dB) the ENR_{95} is lower by a greater extent but there is similarity in the shape of the two curves (top two curves in Figure 2). Whereas for the spectrum which resulted in the lowest calculated reductions (Spectrum 1 where C - A = -14.9 dB) the two curves are dissimilar but again ENR_{95} is lower where significant differences occur. The difference between ENR_{95} and ENR_{80} is typically about 4 dB for the range of spectra considered here (and ENR_{95} is about 3 dB lower than ENR_{85}).

Both Waugh (5) and Berger (4) comment that the accuracy of a single number rating is dependent on the accuracy of the octave-band attenuation data for the protectors. The present comparison supports this view. They both comment that the differences between single number rating and octave-band assessment are small compared with the differences between Laboratory data and "Real World" attenuation data for protectors. This study of the ISO ENR_{95} Rating would also support this view.

There are however some problems with the wording of ISO DP 8535 (2) both in the explanation of the calculations and in the stated application of the results. The latter implies that the ENR applies to the use of a protector in a number of noise spectra whereas from the range of ENR_{95} calculated for Spectra 1 and 8 this cannot be so. Additionally the method will give results to the number of decimal places available in the calculator in use and it is clear that the statistics of protector attenuation measurements indicate quoting results to even 1 dB is possibly over precise. The Standard could perhaps be modified to place protectors into bands thus reflecting the "estimated" nature of the data and to avoid protector users selecting devices on small differences in ENR. Indeed the method gives four values of ENR (for 80%, 85%, 90% and 95% rates of protection) which seems, to the author, to be unnecessary and likely to cause confusion in comparing or selecting protectors particularly as the difference between ENR_{95} and ENR_{80} is not very large. The title of the Standard suggests that it might be appropriate for the method to include a correction to produce an ENR that is a "Real World" estimate and this might be considered a useful enhancement of the method.

A more significant potential limitation to the application of the method is in its use of C-weighting as many modern sound level and integrating-averaging sound level meters no longer have a C-weighting setting. Some will have a Linear setting but there is a trend to producing instruments with A-weighting only. Thus many of the intended users of the simplified method may still have the expense of equipping with a suitable sound level meter.

CONCLUSION

From the comparisons made in this study it can be concluded that the ISO proposal for a simplified rating for hearing protection gives similar A-weighted reductions for a range of typical industrial noise spectra. In general ENR_{95} gives lower assumed reduction when compared with octave-band assessment. These conclusions apply for spectra with C - A weighting values from +1.4 to -14.9 dB.

However the points raised in the Discussion suggest that the present Draft of the ISO Proposal requires amendment before the method becomes properly practicable.

The views presented in this Paper are those of the author and not of the Health & Safety Executive.

REFERENCES

(1) Department of Employment, 'Code of Practice for reducing the exposure of employed persons to noise', HMSO 1972.

(2) International Standards Organisation, 'Acoustics - Estimated Noise Reduction of Hearing protectors', Second Draft Proposal ISO DP 8353 1983.

(3) M.E. Delaney, L.S. Whittle, K.M. Collins and K.S. Fancey, 'Calibration procedures for sound level meters to be used for measurements of industrial noise', NPL Acoustics Report Ac 75 July 1976.

(4) E.H. Berger, 'Using the NRR to estimate the real world performance of hearing protectors', Sound and Vibration, January 1983.

(5) R.Waugh, 'Simplified hearing protector ratings - an international comparison', Journal of Sound Vibration, (1984) 93(2).

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Table 1. Noise Spectra

Spectra	Frequency Hz									
	63	125	250	500	1k	2k	4k	8k	A	C
1	119	118	106	100	100	98	91	87	106.8	121.7
2	94	106	103	102	100	96	92	85	104.6	109.6
3	94	97	102	101	100	97	94	80	104.5	107.5
4	93	97	101	101	100	99	96	91	105.3	107.3
5	100	103	102	101	100	97	92	86	104.4	108.2
6	94	96	99	100	100	101	101	97	107.2	107.7
7	87	92	98	100	100	104	104	104	109.9	109.3
8	79	83	88	93	100	104	107	99	110.5	109.1
9	82	87	91	96	100	100	98	93	105.4	104.7
10	80	89	93	93	100	101	96	79	105.1	104.8
11	85	89	91	100	100	98	94	83	104.2	110.2

Table 2. Description of noise sources

Spectrum Number	Process description
1	Deltic diesel locomotive cab noise
2	Press shop, ball bearing manufacture, general engineering
3	General engineering
4	Printing presses, tube works, carpet weaving, general engineering, envelope manufacture
5	Printing presses, carpet weaving, ball bearing manufacture, nylon spinning
6	Metal sawing, envelope manufacture, carpet weaving, motor car manufacture
7	Beer canning
8	Tube shaping, bending and cutting
9	Tube shaping, beer canning, plastics moulding, sheet metal fabrication
10	Swaging
11	Processes in sugar refinery

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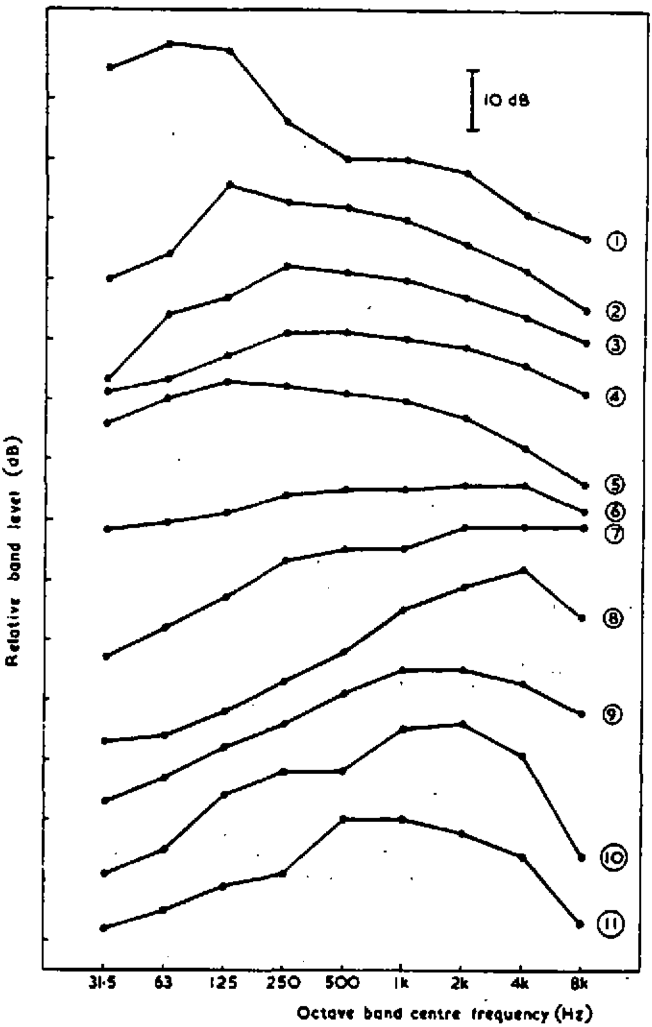
FIG. I OCTAVE BAND SPECTRA OF RANGE OF NOISES USED TO EVALUATE THE PERFORMANCE OF SOUND LEVEL METERS



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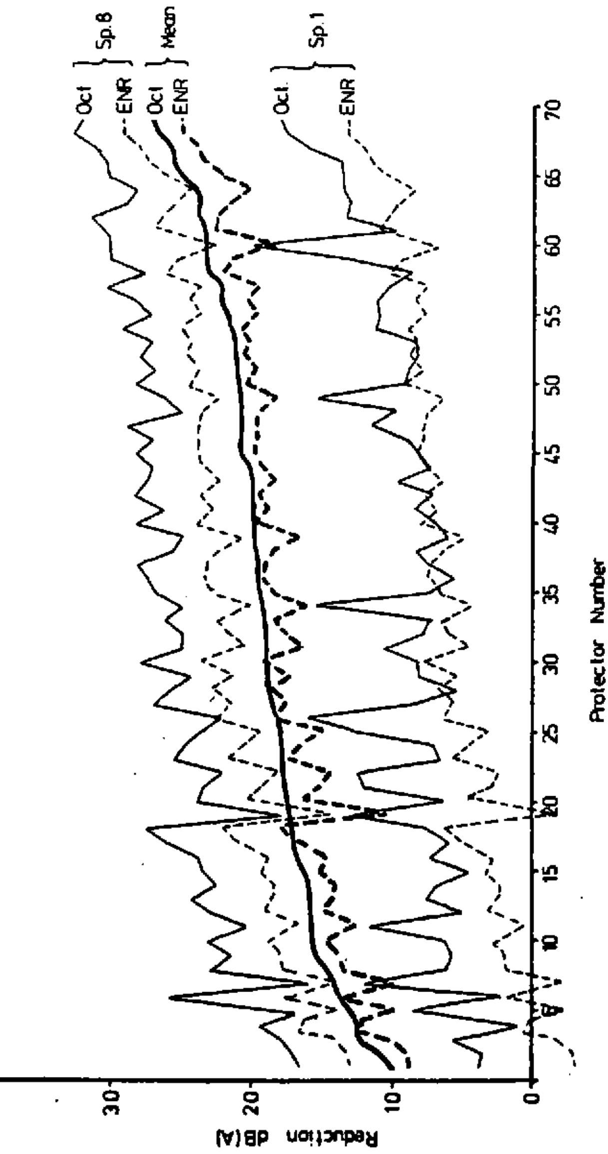

Figure 2 Calculated Reduction in SPL