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SAMPLING TECHNIQUES FOR NOISE MONITORING AROUND INDUSTRIAL PREMISES

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Introduction.

Part III of the Control of Pollution Act[1], 1974, provides local authorities with powers to control noise from fixed premises, particularly industrial premises, within specially designated areas called Noise Abatement Zones (N.A.Z.). The current regulations[2] governing measurement procedures within a N.A.Z. require that the typical noise emission at the boundary of the premise be measured in terms of the A-weighted equivalent continuous sound level, L_{eq}, over a given period. Consequently, noise monitoring around a large, complex industrial site, with several measurement positions, could be very time-consuming if continuous measurements were employed for a full working period of 8 hours or more. The application of sampling techniques for the analysis of community noise level data[3,4] and construction site noise[5] has been investigated previously, but there is little information regarding the use of sampling methods for the estimation of industrial noise emission. This paper compares two short-term sampling techniques for use by local authorities with limited staffing and equipment resources. Results are presented from research into the accuracy of L_{eq} estimates obtained using these techniques on noise level data recorded around a large industrial site exhibiting a variety of temporal noise patterns.

Terminology.

As the nomenclature for the sampling schemes investigated in this paper are not in common use, a brief description of each is given:

(i) Block sampling. A single period of continuous measurement recored at any time during the period of interest.

(ii) Random sampling. A combination of short duration measurements, 5 or 10 minutes long, repeated at random intervals throughout the period of interest.

Measurement and analysis procedures.

Continuous noise recordings were made using a digital, data-logging system at selected positions around a large industrial site for a 12-hour working cycle. L_{eq} values were determined for each 5-minute and 30-minute interval throughout the period together with the 12-hour L_{eq} value. Typical diurnal variations of the 30-minute values are illustrated in Figure 1 for two independant boundary positions, showing the diversity of noise patterns that can be encountered around a single industrial site.

The following procedure was adopted to simulate the application of the random sampling technique to the data. A measurement time was selected for investigation and a corresponding number of 5-minute L_{eq} values were taken at random from 144 values comprising a 12-hour period (e.g. 6 randomly selected 5-minute values would be required for a 30 minute measurement time.). These values were then averaged logarithmically to yield a single L_{eq} level for the measurement time in question and when compared to the 12-hour L_{eq} level, the error in using the smaller measurement period can be determined. By repeating this procedure for different random combinations of 5-minute values, the probability of obtaining an estimate within a specified error range of the 12-hour value can be determined. The same analysis procedure was used for the block sampling technique, except that consecutive 5-minute L_{eq} values were used in the combinations.

SAMPLING TECHNIQUES FOR NOISE MONITORING AROUND INDUSTRIAL PREMISES

Results.

Figures 2a and 2b give the distributions of 5-minute L_{eq} values for the noise patterns in Figure 1, whilst Figure 3 compares the application of random and block sampling to the distributions. The probability of obtaining an estimate within ±2dB(A) of the 12-hour L_{eq} value is shown as a function of measurement time (the ±2dB(A) accuracy used being similar to that accepted for the calculation of road traffic noise in the UK[6].). The mean measurement times required to achieve this level of accuracy with a confidence level >90% are given in Table 1 for five positions around the site boundary. The standard deviation values indicate the effect of noise variability on the measurement time needed for an L_{eq} estimate of the required accuracy.

Discussion.

From Figure 3 and Table 1, it is clear that for the same degree of accuracy, the random sampling technique offers considerable savings in measurement time compared to block sampling (7 hours 35 minutes for the five positions considered), when obtaining an estimate of the 12-hour L_{eq} level. Obviously the temporal-variation in noise level will determine for how long the sampling scheme should be applied. As L_{eq} is an energy-based index, the level and duration of peak events in a noise pattern will greatly influence the necessary measurement times. For example, the large degree of variability at position 5 produces a positively skewed 5-minute L_{eq} distribution with a correspondingly high standard deviation, (Figure 2b). Consequently, the 12-hour L_{eq} value lies outside the modal values of the distribution and, as shown in Figure 3, a much longer measurement time is necessary at position 5 compared with position 3 for an estimate of the required accuracy.

One disadvantage of the random sampling method is that considerable re-location of equipment will be involved if the maximum amount of data is to be collected from a single site visit. However, with a sampling interval of only five minutes, this is the maximum time that would be lost if a particular sample was corrupted be peaks of extraneous noise. Considerably more time would be wasted if these unwanted peaks occurred near the end of a block sampling period. The most suitable equipment for use with the random sampling method is probably one of the recently introduced precision integrating sound level meters. These instruments are relatively inexpensive, lightweight, portable, easy to set up and calibrate and give a direct L_{eq} reading for any desired period (say 5 minutes).

Conclusions.

Two sampling schemes for the assessment of noise emission at the boundary of an industrial site have been described. Random sampling offers considerable savings in measurement time when estimating L_{eq} values for long periods, to a reasonable degree of accuracy. For the selection of appropriate measurement times, some prior knowledge is required of the noise level variations at selected measurement positions. From a preliminary survey conducted around the premises prior to the commencement of the measurement programme, the character of the sources contributing to the overall noise emission could be determined and an assessment made of the noise variability to be expected at any chosen position. Without this information, our results indicate that a measurement time of 2 hours with random sampling would be adequate for a position exposed to considerable noise variations. Finally, it must be appreciated that any noise level resulting from a sampling scheme is a statistical quantity, which is itself subject to error. Any levels determined subsequently using the same technique may differ without there being any significant change in the overall noise output. Only after a number of repeated measurements are analysed for a given position, can the magnitude of the errors involved be estimated and the basis for long-term control established.

References.

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Site boundary position.	Standard deviation of distribution of 5-minute L_{eq} values. dB(A).	Mean measurement time(mins)	
		Random Sampling	Block Sampling
1	1.25	5	5
2	1.83	15	70
3	2.35	30	190
4	2.78	60	190
5	3.64	100	210

Table 1. Comparison of measurement times (on the basis of three repeated 12-hour measurements) for random and block sampling, to obtain L_{eq} estimates within ±2dB(A) of the 12-hour value for a confidence level >90%.

SAMPLING TECHNIQUES FOR NOISE MONITORING AROUND INDUSTRIAL PREMISES

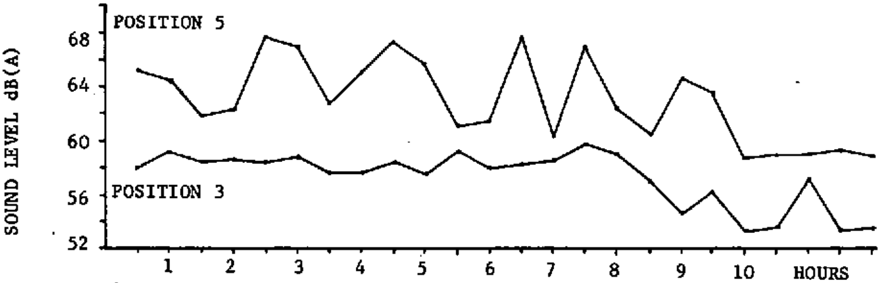

Figure 1. Diurnal variation of 30-minute L_{eq} values

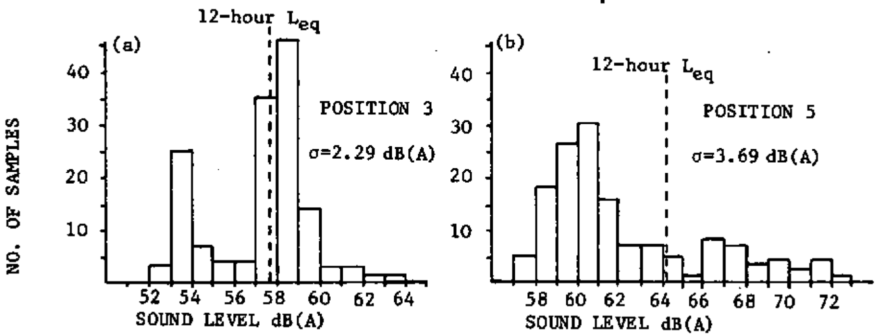

Figure 2. Distributions of 5-minute L_{eq} values

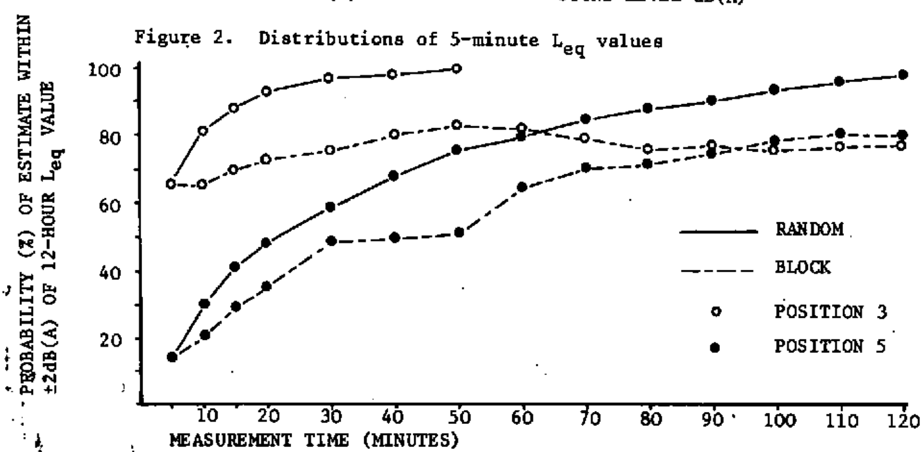

Figure 3. Comparison of accuracy for random and block sampling vs. measurement time