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An examination of the noise emissions data of construction plant and machinery with regard to the prediction of environmental noise

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1. INTRODUCTION

There are a number of techniques which can be used to predict the level of noise arising from the operation of construction sites. Sophisticated deterministic models can be used to give very accurate predictions of noise levels [1]. Reasonably accurate predictions can be obtained using less complex calculation methods such as that given in the British Standard BS5228 [2]. Lewis and Gibbs have recently proposed a new approach for the preliminary estimation of site noise where through the application of stochastic modelling the noise sources and propagation processes can be represented statistically [3].

Whether using a computer ray-tracing program, a simplified deterministic method or a stochastic model, each prediction method requires source data. In all cases, the prediction begins with a determination of the source characteristics and in particular the noise level. A number of data sources are available including the present BS5228 Standard, the maximum permitted sound power level under the EC Regulations, or preferably from measurements made on sites. This paper examines source data commonly used for the prediction of construction site noise immissions, i.e. the total amount of noise from all contributing sources at a given position.

Even since the earliest version of BS5228 there have been legislative and commercial pressures to make plant less noisy. It is EC legislation however that has had most influence on the sound power levels of construction machinery. Manufacturers and importers of construction plant in the European Community have been required to have standard noise measurements performed and to have their machinery labelled with a guaranteed maximum sound power level satisfying specific requirements for each plant type.

The requirements of the EC Regulations have meant that more noise measurement data is becoming available from the standard testing. Standard tests carried out to satisfy the EC Regulations are performed on machinery supplied by manufacturers. This machinery may be expected to be new or well maintained, and all silencing and noise reduction equipment can be expected to be in good working order. A variety of organisations have extensive sources of noise data on typical machines in use. Over the years, consultancies build up their own databases of noise measurements obtained during projects on specific machinery, operations and sites. Test houses assemble data from Regulation tests. Similarly manufacturers assemble standard test data and results obtained during engineering noise control developments. In this paper a series of analyses are presented of the noise emission data from over 400 measurements of various powers and types of construction and open site plant including excavators, excavator-loaders, loaders, power generators, compressors and concrete breakers. The sound power level data was obtained from on-site measurements performed by consultants, and from ISO tests performed for manufacturers. Comparisons are made with data from the British Standard BS5228.

2. ISO MEASUREMENT STANDARDS

The basic noise emission measurement standards applying to the measurement of source sound power levels are ISO 3744 [4] and ISO 3746 [5]. Supplements to these standards are given for specific equipment. Application of elements of ISO 4871 [6] and associated measurement uncertainties are used to guarantee that sound power levels from the plant satisfy the noise limits. ISO 6393 [7] describes the method of measurement of noise emitted to the environment under stationary test conditions. ISO 6395 [8] describes the method of measurement of exterior noise in dynamic test conditions for earth-moving equipment such as excavators, loaders and excavator-loaders. The existence of these well defined standards and the requirement that they be used by consultants and test houses might be expected to have resulted in recently acquired data being more accurate and consistent than that obtained in earlier years.

3. COMPARISON OF BS5228 DATA & ISO MEASUREMENT DATA

In discussing the development of BS5228, Jones [9] describes how the noise level data of the Standard has evolved. Some limited information was contained in the 1975 edition. This was subsequently augmented in the 1984 revision by the extensive on-site, real-life measurements of CIRIA [10]. In the 1997 Standard some post-1990 data have been included for machinery measured on opencast coal sites. However, BS5228 recommends that the method likely to provide the most accurate prediction is to obtain noise measurements on a similar item of plant operating in the same mode and at the same power over a representative period.

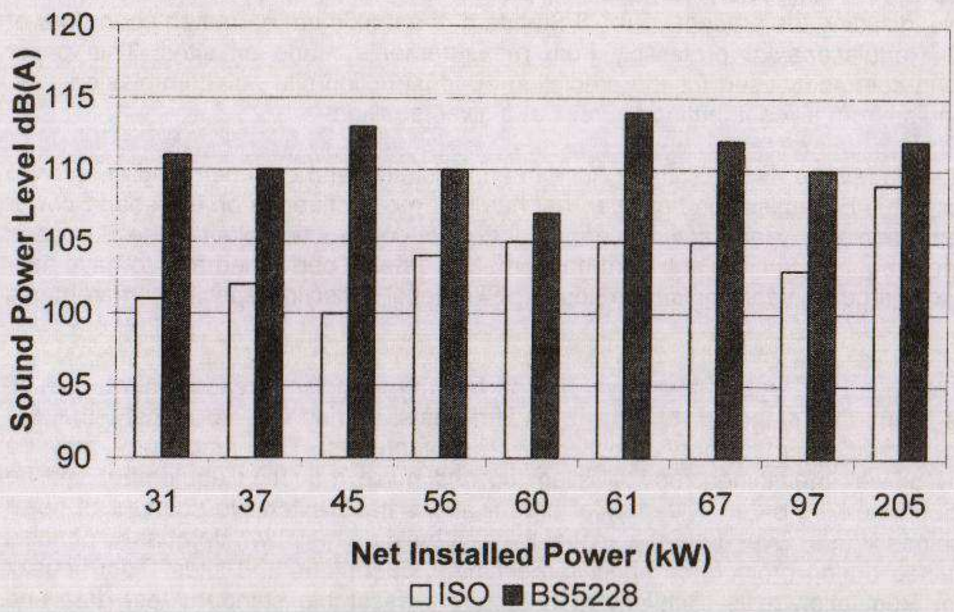

Figure 1: Comparison of the sound power levels of various loaders as presented in BS5228 and measured using the ISO methodology

3.1 Pre 1990 Data

The sound power levels of loaders of various net installed powers as presented in BS5228 are shown in figure 1. Also shown are the sound power levels of loaders of the same power, but measured since 1993 using the ISO methodology. It is seen that for each of the nine sample loaders, the sound power level referenced from BS5228 exceeds that measured recently using ISO. The greatest difference seen is 13dB(A) while the mean difference is 7dB(A).

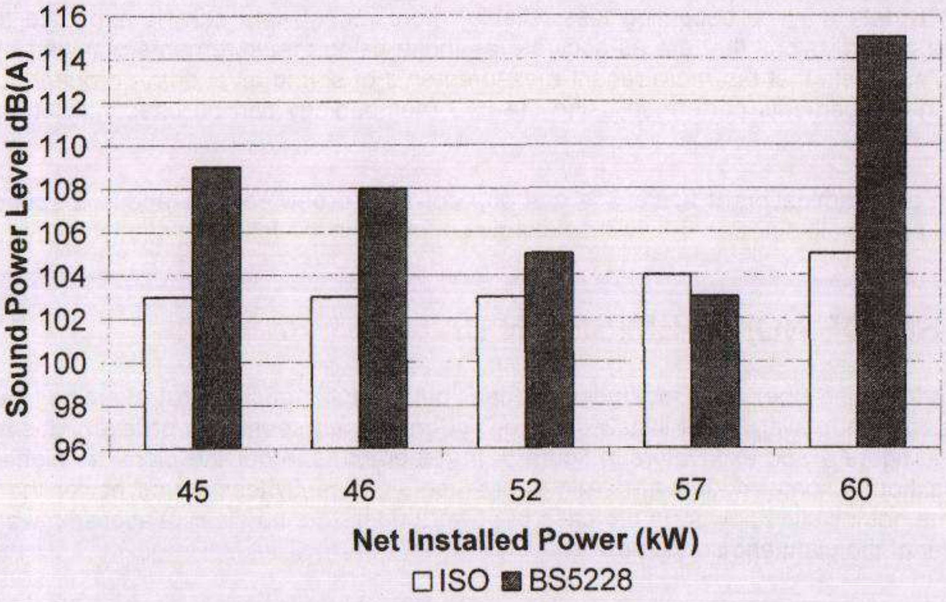

Figure 2: Comparison of the sound power levels of various excavator-loaders as presented in BS5228 and measured using the ISO methodology

A similar comparison is seen for excavator-loaders of various net installed powers in figure 2. Again it is seen that for all but one example the sound power level referenced from BS5228 exceeds that measured recently using ISO. There is no clear correlation between net installed power and difference in sound power levels.

Plant type	No in sample	Mean difference dB(A)
Power Generators	9	10
Loaders	9	7
Concrete Breakers	3	7
Excavators	13	5
Excavator-loader	5	4
Compressors	3	1

Table 1: Mean difference between BS5228 and ISO measured data for selected plant items

The results are of these and other comparisons are summarised in Table 1 together with those for power generators, excavators, compressors and concrete breakers. In addition to the mean difference in sound power levels, the table also shows the number of items of each type used for comparison. As can be seen, caution must be exercised in the interpretation of these comparisons since the number of machines in each sample is small. Nevertheless the results indicate that the sound power levels quoted in BS5228 for these types of plant tend to be significantly higher than those measured more recently using the ISO methodology.

3.2 Post 1990 Data

An interesting contrast can be provided by a similar analysis using the recent data published in BS5228. Figure 3 compares the sound power levels for diesel excavators given in BS5228, measured on opencast coal sites since 1990, with ISO measured data since 1993. For power ratings less than 250kW almost all the measured sound power levels are found to lie in a band where values obtained by the different methods are within +/- 3 dB of each other. This means that while earlier BS5228 data may be becoming less reliable, more recent data can be expected to produce predictions of immissions that are as accurate as those using measurements obtained by the ISO tests. This suggests that the more recent measurements of sound level data on opencast coal sites and the measurements performed using the ISO methodology can be used with equal confidence.

Also apparent from an examination of figure 3 is a strong correlation between the acoustic sound power level and the net installed power. This will be examined further in the following section.

4. ANALYSIS OF NOISE-EMISSION DATA

Measurements made using the ISO methodology can be usefully applied to examine the relationships between plant power or net installed power and measured sound power level. This is shown for loaders in figure 4 and excavators in figure 5. In general, the larger the plant the higher the sound power, although some models are seen to produce significantly less sound power than others with the same net installed power. In the case of power generators no clear relationship was seen between power of the plant and sound power.

The plot of figure 4 of the ISO methodology measured data for the loaders shows a strong relationship between the net installed power and the sound power level. An overall trend is seen between net installed power and sound power for the loaders although the number of high power items is low.

The plot of figure 5 of the ISO methodology measured data for the excavators shows a very strong relationship between the net installed power and the sound power level. A linear relationship is seen between net installed power when plotted using a logarithmic scale and sound power for the excavators.

Figure 6 shows an overall comparison of sound power levels for various net installed powers for excavators, excavator-loaders and loaders. It can be seen that all three types of machinery exhibit similar relationships between the net installed power and the sound power level. This comparison indicates that for a given net installed power loaders will tend to be as noisy as excavator-loaders and slightly noisier than excavators.

This analysis suggests that it may be possible to establish a simple relationship between net installed power and the sound power level of some types of construction machinery. Whilst at first sight this might seem a surprising conclusion, it may be a natural result of the greater attention paid to plant noise emissions by manufacturers in recent years. In all areas of low noise product design it

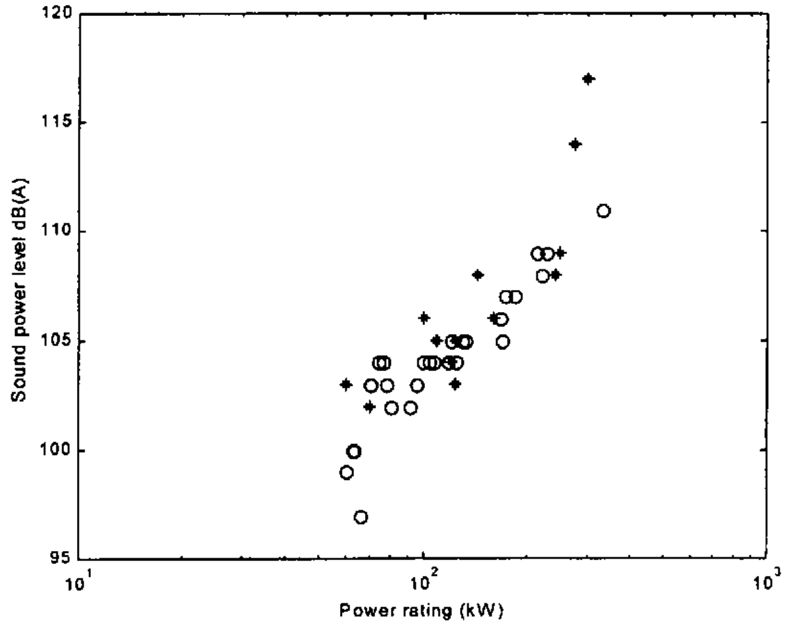

Figure 3: Comparing sound power levels for excavators: BS5228 (post 1990) (O) and ISO (*)

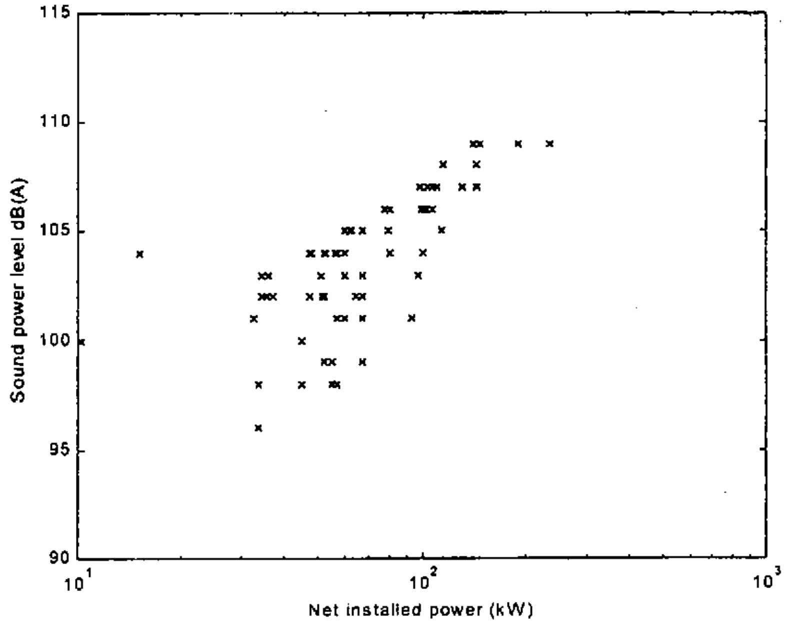

Figure 4: Sound power levels of loaders of various net installed powers as measured using ISO methodology

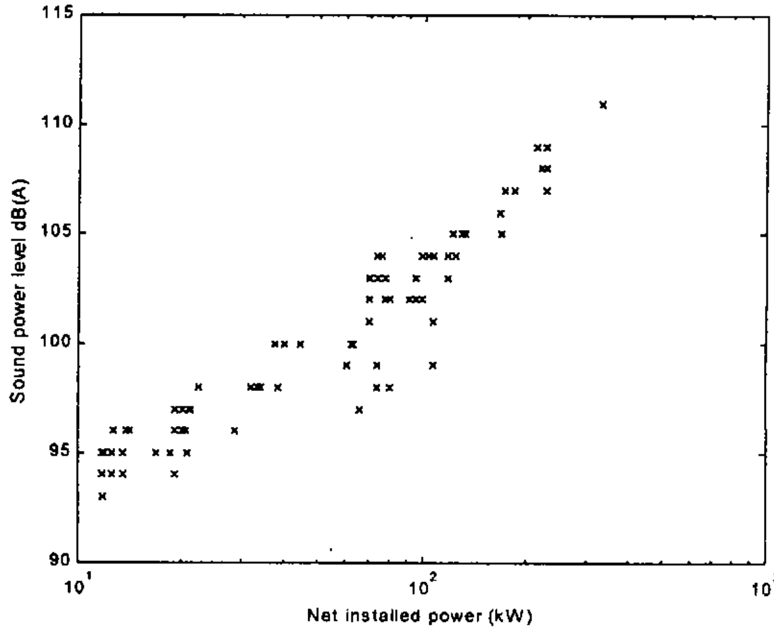

Figure 5: Sound power levels of excavators of various net installed powers as measured using ISO methodology

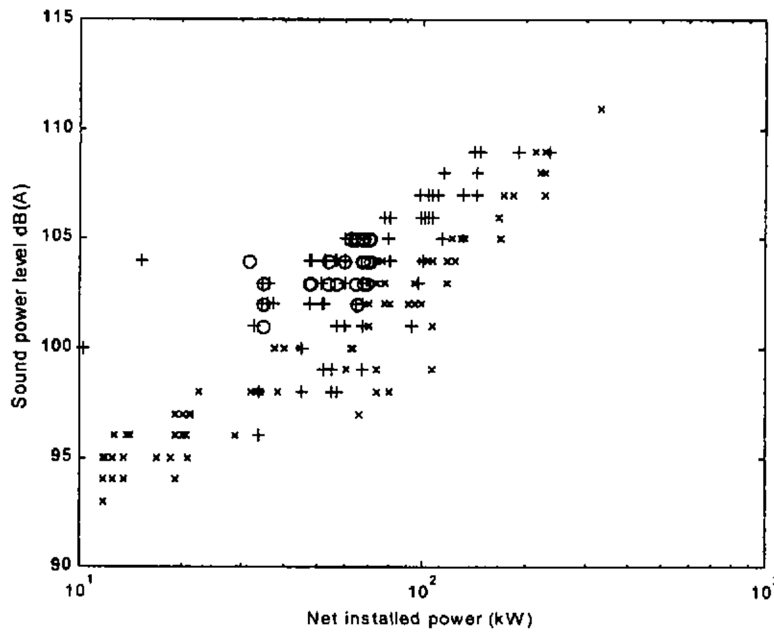

Figure 6: Comparing ISO measured sound power levels of excavators (X), excavator-loaders (O) and loaders (+).

is relatively easy to achieve a certain amount of noise reduction by attention to simple principles but it becomes progressively harder to improve on this. It is probable that these simple principles have now been adopted by all manufacturers leading to similar sound power levels for a particular item of plant irrespective of the manufacturer.

5. CONCLUSIONS

Limitations apply to the conclusions that can be drawn from a comparison between BS5228 and ISO methodology measured data. Too few comparisons are made for compressors and concrete breakers for any correlation to be made with confidence. However even allowing for measurement errors of +/-2dB the ISO methodology measured sound power levels are seen to be significantly less than the BS5228 sound power levels for the power generators, excavator-loaders, excavators and for the loaders. On first impression this comparison seems to indicate that contemporary construction plant is significantly quieter than that quoted in BS5228. However the comparison is not like-for-like since the contemporary ISO methodology is a stationary test under no-load conditions or a simulated dynamic test whereas much of the BS5228 data is activity specific obtained on site. Furthermore this comparison allows for no typical on-time or duty cycle information, perhaps further reducing the value of the comparison.

Analysis of large amounts of measurement data supplied from many different sources suggests that it may be possible to establish a simple relationship between net installed power and the sound power level of some types of construction machinery. This might be the result of the greater attention paid to plant noise emissions by manufacturers in recent years leading to a convergence of standards of design and manufacture. As more and more measurement data becomes available arising from the requirements set out in regulations, it should be analysed to see if the trends identified in this paper are confirmed. If this proves to be the case then the information should be made available as the basis of source sound power data for use in predictive models.

6. ACKNOWLEDGEMENTS

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