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SOUND POWER CHARACTERISTICS OF INDUSTRIAL MACHINERY

H. J. Eun, W. M. Lee and Y. S. Kim

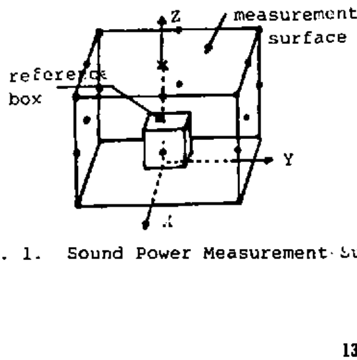
Acoustics Standards Laboratory, Korea Standards Research Institute,
Daedeog Science Town, Choong-nam, KOREA

INTRODUCTION

The sound characteristics of a machine is often stated in terms of its sound power, either overall level or octave-band level, or both. Since sound power represents the total acoustic output of a machine, this enables the machine users to predict the noise level in a given environment before the machine installation. For regulatory officers, this provides useful criterion for the product noise level. This paper describes the result of a study aimed at understanding the sound power characteristics of various kinds of industrial machinery. A total of 340 machines in use were tested, covering 21 different categories of machines.

MEASUREMENT AND RESULT

The ISO standard 3744 [1] stipulates that the sound power be measured using an array of microphones over a hemispheric or a rectangular surface. Although use of a hemisphere is generally preferred, it is often impractical to apply it for large machines. For this reason, we used the rectangular surfaces for all the machines. The basic measurement scheme is shown in Fig. 1.



* The 17 dots in this figure indicate the microphone positions.

Fig. 1. Sound Power Measurement Surface

The microphone outputs were recorded on multi-channel tape recorders, and were played back in laboratory. For a given octave-band, the sound

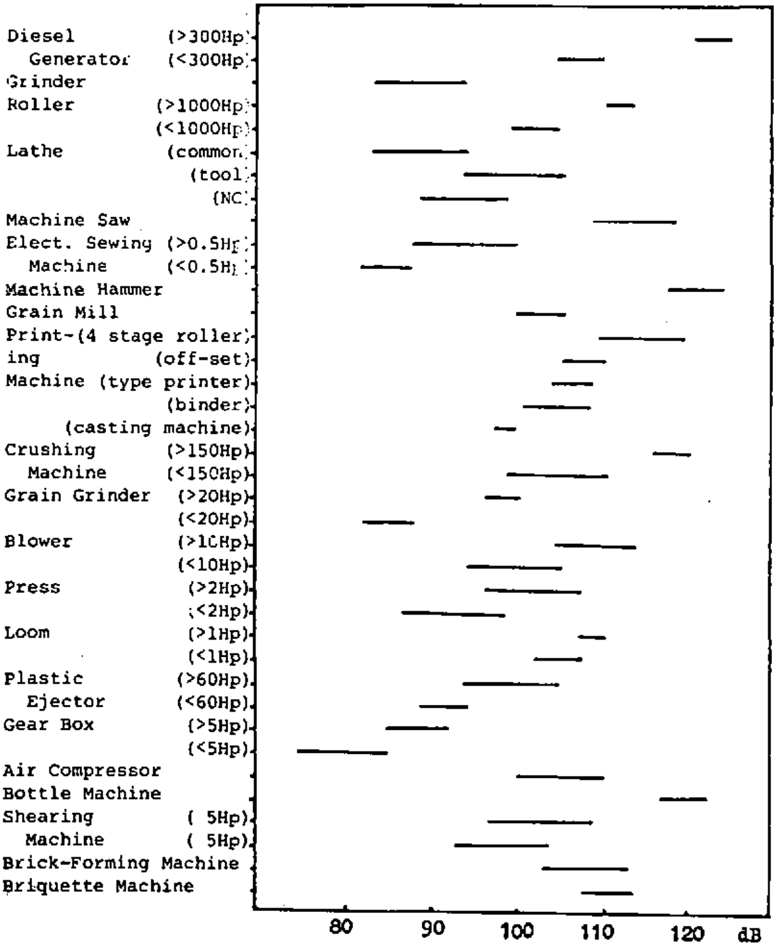


Fig. 2. Summary of Machine Sound Powers (A-Weighted)

power is estimated using the following equation.

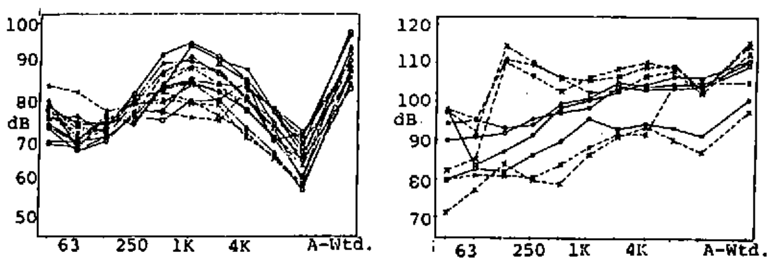
$$L_W = 10 \log\left[\frac{1}{N}\sum_{i=1}^{N} 10^{L_i/10}\right] + \log\left(\frac{S}{S_o}\right) - K$$

where L_W = sound power level re 1 pW
L_i = measured sound pressure level for i-th microphone
N = number of microphone positions
S = area of the measurement surface (m^2)
S_o = reference area (1 m^2)
K = environmental correction factor

For each machine tested, we followed the environmental checking process as specified in the ISO standard in order to insure that the environmental correction factor be less than 2 dB. Thus, we expect that the sound power data presented in this paper are accurate within ± 3 dB for most of the frequency range of interest.

Fig. 2 shows the range A-weighted sound power levels for each category of machines. The machines in this figure may be divided into two groups, those whose sounds are more mechanical origin and those whose sounds are more aerodynamic origin. The former includes typically lathes and presses whose sound outputs heavily depend on the operating conditions. The latter includes blowers, air compressors and diesel generators whose sound outputs are largely independent on the external loadings. Thus, the relatively large ranges of sound powers for the former group of machines are attributable to the varying test workpieces as well as machine horse powers, while those for the latter group of machines are mainly due to the wide range of horse powers of machines tested.

Fig. 3 illustrates two examples of sound power spectra. It is noted in Fig. a that the lathe noise has a broad peak around 1 KHz regardless of the machine horse powers and the workpieces used. It is believed that this peak is related with the machine rpm whose range was mostly 500 - 1000, although exact correlation has not been attempted. Fig. b shows different aspect of sound power spectrum. Apart from some



(a) Lathes (b) Machine Saws

Fig. 3. Examples of Sound Power Spectra

irregularities in the low frequency region, the general trend is an increasing sound power with increasing frequency. Such high frequency sound powers are attributable to the high passing frequency of the saw-teeth through the wood. Table 1 summarizes the frequency characteristics of sound powers based on such spectra.

Table 1. Frequency characteristics of sound powers

Frequency characteristics	Categories of machines
mainly below 1 KHz	diesel generators, grain (or stone) crushing machines roller, printing machines, plastic ejectors. grain milling machines, gear boxes, air compressors, grain grinding machines, blowers, grinders, presses, briquette-forming machines
mainly above 1 KHz	wood saws, looms
generally uniform	shearing machines, brick-forming machines, machine hammers, bottle machines, electric sewing machines
peak around a specific frequency	lathes

As this table shows, the majority of industrial machines emit noise in the frequency range below 1 KHz, implying the difficulty of controlling the machine noise.

CONCLUSION

Due to the insufficiency of the number of machines tested for each category, it was difficult to realize much meaningful relations between the sound outputs and the machine horse powers. Nevertheless, the sound powers are seen to increase generally with increasing horse powers for such machines as diesel generators and blowers whose sound outputs are relatively insensitive to the external loading. For other machines, we have concluded that the dominent factor in determining the sound output is the operational modes rather than the horse power. Some of the result presented here may well be compared with existing data, especially those for blowers, generators and air compressors [2] . For other machines, existing data are only piecemeal and thus meaningful comparisons are very difficult. We believe that the result here represents well the range of sound powers of machines in normal industrial use and hope that this could be a useful guide for anyone working in this field.

REFERENCES

[1] ISO STANDARD 3744, "Determination of sound power levels of noise sources-Engineering methods for free-field conditions over a reflecting plane" (1977)

[2] L. L. Faulkner, "Handbook of Industrial Noise Control", Industrial Press Inc. (1976)