inter-noise 83

THE OPTIMAL MEASUREMENT DISTANCES FOR INTENSITY DETERMINATION OF SOUND POWER

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INTRODUCTION

The intensity technique is a very powerful tool for determining the sound power of equipments under high background noise level conditions. Under such conditions error levels can be very high since they are proportional to the ratio between the background noise and the measured noise. Consequently it is important to find which measurement procedure can minimise this error. A very important paremeter is the measurement distance from the sound source. The hypothesis of the existence of an optimal distance was presented in [1]. This hypothesis has been verified in the case of a simple source by a computer simulation [2]. The goal of this paper is to present the first results of the experimental work undertaken to validate this hypothesis.

EXPERIMENTAL SET-UP AND MEASUREMENT PROCEDURE

The equipment to be measured is the main pump of one of the boiler feed pumps in a 900 MW unit of a nuclear power plant. In a first series of measurements, in an attempt to separate the pump noise field from the background noise field the pump was surrounded by noise barriers that formed a partial enclosure open only at the top as shown on figure 1. A second series of measurements was to be performed after removal of the pump enclosure. Because the removal of the enclosure was not possible before the shut-down of the unit, an identical pump on the next unit was used for the second series of measurements.

The measurements were made in 24 points affected to equal areas of 5 measurement surfaces located respectively at 5, 10, 20, 40 and 80 cm from the pump body. For each surface the normalized variance and standard deviation on the sound power W were computed from the variance on the intensity I :

$$\mathrm{var}\,(W)/W^2 = (1/N)\ \mathrm{var}\,(I)/\bar{I}^2 \qquad (1)$$

The ratio between background noise and pump noise WB/W was evaluated using the approximate formula :

$$WB/W = \int |I|\ dS \ / \int I\ dS \qquad (2)$$

which is a good approximation of the exact formula ($WB/W = \int |I_B|\,dS / \int I\ dS$) for high values of WB/W and tends towards one when WB/W tends towards zero.

RESULTS AND ANALYSIS

The results are given on plots of normalized standard deviation versus measurement distance for third octave bands. In addition the ratio WB/W is represented on the plots. Three third octave frequencies are given on figure 2, 3 an 4 : 400 Hz and 800 Hz which are the first and second harmonics of the pump blade passage frequency and 4000 Hz.

Enclosure case (Fig. 2a, 3a, 4a)

Closer to the source the standard deviation on sound power (SDW) is going up as expected. This is to be seen at low frequency, i.e. on the 400 Hertz plot, where the value of SDW at 5 cm is 5 times its value at 10 cm. At higher frequencies, i.e. the 4000 Hertz case, this effect cannot be seen as the shortest distance, 5 cm, is not close enough to the source for that high a frequency.

Going away from the source the value of SDW stays generally at a low level as expected for the unperturbed field from a source. Because the enclosure let some background noise in, the ratio WB/W does go up with distance and some increase in SDW can be noticed at 80 cm in the 400 Hertz case for example.

No enclosure case (Fig. 2b, 3b, 4b)

For most third octave bands, 400 Hz and 4000 Hz for example, the background noise level is higher than in the enclosure case, the ration WB/W is higher and shows a tendancy to increase with increasing distance from the source ; as a result the value of SDW is higher and increases also with increasing distance from the source. The minimum of SDW is rejected to the closest distance because of the high background noise.

For other third octave bands, 800 Hz for example, the background noise is not significantly different from the enclosure case, consequently the values of SDW don't show a significantly different trend.

CONCLUSIONS

From this experiment a temptative rule of thumb could be : for the highest precision, in case of severe background noise problem (such as in the no enclosure case) it is best to use a distance very close to the source, i.e. 5 cm, whereas for lower background noise levels (such as in the enclosure case) it is best to use a distance of the order of 10 to 40 cm. Further experiments are necessary to understand how those rules vary with the type of source radiation.

REFERENCES

[1] F. Laville, "La normalisation de la détermination intensimétrique de la puissance acoustique", Acoustic Intensity Conference, Senlis, 1981.

[2] F. Laville, "L'échantillonnage des champs d'intensité acoustique", I.C.A., Paris, 1983.

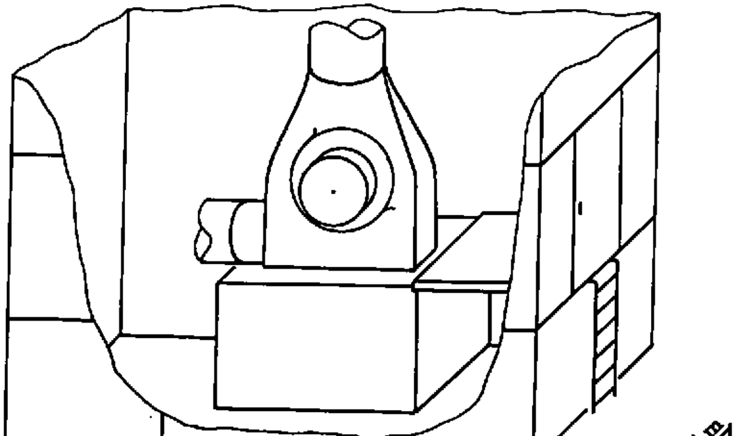

Figure 1 - Boiler feed pump in partial enclosure

(a) enclosure (b) no enclosure

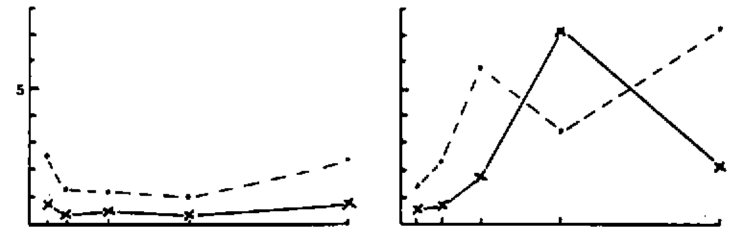

Figure 2 - Third octave 400 Hz

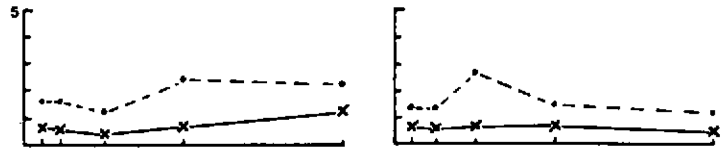

Figure 3 - Third octave 800 Hz

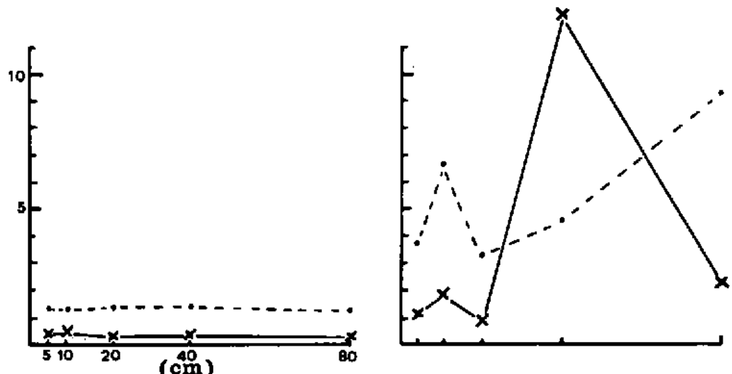

Figure 4 - Third octave 4000 Hz

SDW —x— WB/W - - - • - - -