PRACTICAL EXAMPLES OF THE USE OF SOUND INTENSITY TECHNIQUES IN INDUSTRIAL NOISE CONTROL

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Introduction

The theory of the sound intensity meter and its use in the measurement of sound power levels of noise sources in reverberant situations are well known. This paper describes two case studies which illustrate the use of the sound intensity technique in assessing the performance of acoustic enclosures.

Case 1

The first case concerns a canning plant in the food processing industry. The plant was located in a fairly reverberant room (concrete floor, tiled walls and plaster ceiling) and consisted of three noise sources: a machine which filled the cans, a second machine which sealed the cans, and a pumping unit. A preliminary assessment indicated that the can-sealing machine was the major noise source.

In an attempt to reduce the overall noise level the can-sealing machine was fitted with an acoustic enclosure of rigid plastic sheet. Practical considerations such as cleaning, maintenance, access etc meant that there were significant open areas in the finished enclosure. As a result of fitting the enclosure the overall sound pressure level, measured in the reverberant field, was reduced from 99 dB(A) before fitting the enclosure, to 92 dB(A) after the enclosure was fitted.

The question which then arose is whether the noise reduction of 7 dB(A) is limited by the noise from the other two machines, by the open areas in the enclosure, or by the sound reduction index of the enclosure material. The answer to this question determines the next stage in the noise reduction process ie. either noise reduction treatment to the other two machines, or improvement of the enclosure either by sealing the open areas or by using a material for the enclosure with a higher sound reduction index value.

A measurement survey using a sound intensity meter was carried out, in order to find the answer to this question. The sound intensity meter was used to measure the sound power level radiated from each of the three noise sources ie. the can filling machine, the pumping unit and the enclosed can-sealing machine. For each of the three sources an imaginary rectangular control surface which completely encloses the source was defined. In each case in order to simplify the measurement procedure the control surface was subdivided into conveniently identifiable elements. The sound intensity probe was swept over each element of area in order to measure the intensity radiating from that element. The intensity is then combined with the area of the element to give the sound power contribution of that element. The sound power level of the noise source is obtained by combining the contributions from all the elements of the control surface.

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The results of this survey produced the following values for the A-weighted sound power levels of the three sources:

Enclosed can-sealing machine	89 dB(A)
can-filling machine	95 dB(A)
pumping unit	97 dB(A)

These results indicated that the can-sealing machine was no longer the major noise source, once it had been enclosed.

In order to assess the effectiveness of the enclosure it is necessary to compare measurements before and after the fitting of the enclosure. Only sound pressure level measurements were taken before enclosing the can-sealing machine. It is therefore necessary to relate sound power levels (PWLs) to the reverberant sound pressure levels (SPLs) in the room. This can be done via the following equation, based on simple room acoustics theory:

$$SPL = SWL + 10 \log (4/R)$$

where R is the room constant, related to the surface area of the room and the amount of acoustic absorption it contains. The room absorption, the room constant and thus the sound power level to sound pressure level correction factor were calculated from measurements of the reverberation time in the room. A correction factor of 8 dB (plus or minus 1 dB) was obtained for the octave bands from 63 Hz to 8 kHz. Confirmation of this result was obtained by using the correction factor to convert the measured sound power levels to sound pressure level contributions from each of the three sources. The three calculated SPLs were then combined and compared with measured SPLs. The calculated and measured SPLs agreed to within 2 dB in all bands, except at 63 Hz, where the difference was 4 dB. Since this band was not contributing significantly to the overall dB(A) level this discrepancy was ignored. The difference between calculated and measured A-weighted sound levels was 1 dB(A).

The SWL to SPL correction factor of 8 dB(A) can now be used to evaluate the enclosure performance. Subtracting 8 dB(A) from the three sound power levels quoted earlier gives the following sound levels from each of the component sources:

Enclosed can-sealing machine	81 dB(A)
can-filling machine	87 dB(A)
pumping unit	89 dB(A)

Combining these three levels using the rules of decibel addition gives a total level of 92 dB(A), in agreement with the directly measured value. Before the can-sealing machine was enclosed this total level was 99 dB(A). Assuming that the sound level contributions from two of the sources are unchanged it is possible to calculate the sound level produced by the can-sealing machine before enclosure, ie. the level which, when combined with 87 dB(A) and 89 dB(A), produces a total level of 99 dB(A). Using the rules of decibel arithmetic this level will be 98 dB(A). Comparing this with the level of 81 dB(A) before enclosure it can be seen that the reduction produced by the enclosure is 17 dB(A).

It was then possible to assess the effect of enclosing the open areas of the enclosure, and of using heavier materials for the enclosure panels.

Case 2

The second case concerns the noise from a bottling plant. The bottles travel along a long conveyor line in a large, highly reverberant factory area in which there are also other noise sources.

A partial acoustic enclosure was built over the entire length of the conveyor line. The enclosure was made out of plastic sheet and consisted of roof panels permanently in position with vertical side panels which were hinged at their top edges to allow quick access to the lines of bottles when necessary. The side panels extended down to a few centimetres below the conveyor, but the area below was open for access to the floor area beneath the conveyor line.

A sound intensity survey was carried out over the entire surface area of the conveyor line in order to assess the effectiveness of the enclosure. The sound power levels from the enclosed and open areas of the line were measured, first of all with all the side panels closed, and then with them hinged open. The results of this exercise, for the A-weighted sound power levels (SWLs) are:

With side panels closed:

SWL from enclosure surfaces (side and top panels)	95.5 dB(A)
SWL from open areas below conveyor	102.3 dB(A)
TOTAL	103.1 dB(A)

With side panels hinged open:

SWL from side and top surfaces	104.9 dB(A)
SWL from open areas below conveyor	102.3 dB(A)
TOTAL	106.8 dB(A)

The figure of 104.9 dB(A) does not represent the sound power level radiated before the enclosure was fitted, because of the presence of the roof panels, which were not openable. In order to allow for this the average difference in sound power level radiated from the side panels when open and when closed, was measured. This was approximately 11 dB(A). Assuming that a similar difference would apply to the fixed roof panels it is possible to estimate the sound power radiation from the conveyor line before enclosure:

SWL from side and top surfaces	106.8 dB(A)
SWL from open areas below conveyor	102.3 dB(A)
TOTAL	108.1 dB(A)

By comparing this total figure of 108.1 dB(A) before enclosure with the figure of 103.1 dB(A) with the enclosure in position, it can be seen that the reduction achieved by the enclosure was 5 dB(A). Again it was then possible to assess the effect of extending the enclosure to the areas which are open at present, and of using heavier materials for the panels of the enclosure.