inter-noise 83

MEASUREMENT OF THE SOUND INSULATION OF SMALL ENCLOSURES

Hans G. Jonasson

Statens provningsanstalt, Acoustics Laboratory, S-501 15 Boras, Sweden

INTRODUCTION

Noise abatement is very often accomplished by means of different kinds of enclosures. There is no ISO-standard dealing with the sound insulation of enclosures. ASTM has one method, the E 596-78, which is based on reciprocity measurements in a reverberation room. As a part of a joint Scandinavian project aiming at a NORDTEST-method to measure and rate the sound insulation of different kinds of enclosures the ASTM-method and some other methods have been tested on small (<2 m^3) enclosures.

TEST PROCEDURES

The measurements have been carried out on 9 different enclosures. 8 consisted of 50 mm mineral wool covered on both sides by 1 mm sheet metal. The inside was either perforated (23 %) or not. The exterior volume was either 0.87 m^3 or 0.13 m^3. The enclosure had either an opening or not. The size of the opening is defined by the sealing ratio ψ which equals the total area of the enclosure divided by the open area. In the following a notation like 0.87/abs/113 will mean an enclosure with the volume 0.87 m^3, with sound absorbing interior surfaces and the sealing ratio ψ = 113.

In addition a commercially available enclosure for printers denoted 0.12/abs/60 with a plexiglass hood was tested. The absorptive layer was 20 mm thick and the walls were of 12 mm chip board.

$D_r(L_p)$ and $D(L_W)$ were measured. $D_r(L_p)$ indicates the reciprocal sound pressure level difference according to ASTM and $D(L_W)$ the difference in sound power level measured according to ISO 3741 with an impact machine, that is a modified ISO 140 building acoustical tapping machine tapping on a 4 mm thick steel plate, as sound source. In addition the printer enclosure was measured with a printer as sound source.

SOME RESULTS

In Fig.1 $D_r(L_p)$-measurements according to ASTM and $D(L_w)$-measurements according to ISO 3741 with the impact machine are compared for a 0.87 m³ absorbing enclosure. The agreement is very good for the completely sealed enclosure and not too bad for the $\psi = 113$ enclosure. It is also interesting to notice how good the approximation $10 \lg \psi = 20.5$ dB works for the $\psi = 113$ case.

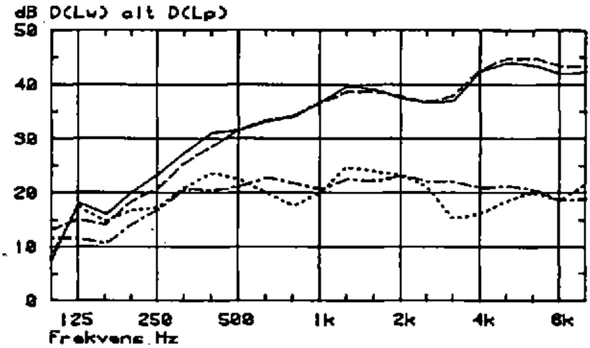

Fig.1.
$V = 0.87$ m³
Absorbing
— $D(L_w)$, $\psi = \infty$
--- $D_r(L_p)$, $\psi = \infty$
-·- $D_r(L_p)$, $\psi = 113$
··· $D(L_w)$, $\psi = 113$

A corresponding comparison is made for a 0.13 m³ reflecting enclosure in Fig.2. The agreement is much less satisfactory in this case.

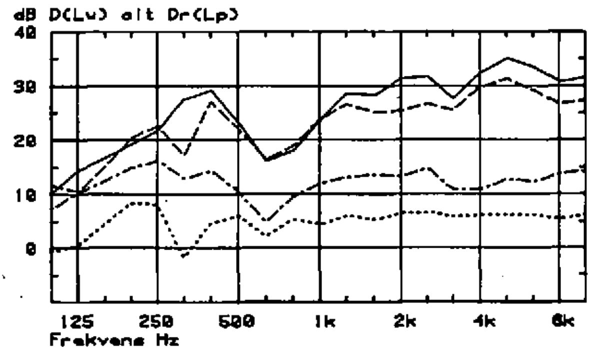

Fig.2.
$V = 0.13$ m³
Reflecting
— $D(L_w)$, $\psi = \infty$
--- $D_r(L_p)$, $\psi = \infty$
-·- $D(L_w)$, $\psi = 32$
··· $D_r(L_p)$, $\psi = 32$

Other measurements support the tendency that the more the test object deviates from a large, absorptive, sealed enclosure the worse agreement between $D_r(L_p)$ and $D(L_w)$ measurements.

In Fig.3 both the ASTM-method and the $D(L_w)$-method are compared with a printer as sound source for the printer enclosure. There is no clear indication whether the reciprocity method or the impact machine method is the best one.

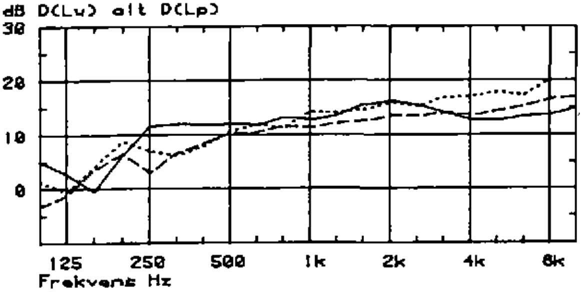

Fig.3.
$V = 0.12\ m^3$
Partly absorbing
$\psi = 60$
—— Printer
--- Reciprocal
··· Impact machine

RATING

For practical purposes it is desirable to have a single number rating system. For enclosures designed for a single type of machine the obvious choice is to use $D(L_{WA})$ for the actual machine type.

For general purpose enclosures it is more complicated. ASTM has introduced the noise isolation class NIC which is based on 1/3 octave measurements and the established building acoustical reference curve for sound reduction index measurements. One drawback whith NIC is that it does not take different source spectra into consideration.

Another possibility is to calcultate $D(L_{WA})$ for different spectra using $D(L_w)$ measurements. One method which has been applied on hearing muffs is to calculate $D(L_{WA})$ for a flat spectrum and then make a correction for the difference between C- and A-weighted levels. By using this method we can construct an enclosure insulation class EIC defined by

$$EIC = 10\ \lg n - 10\ \lg \sum_{i=1}^{n} 10^{-(D_i+A_i)/10} - \Delta CA \qquad (1)$$

where n = the number of frequency bands used
D_i = the insertion insulation $D(L_w)$ or $D_r(L_p)$ for frequency band i
A_i = the A-weighting constants (usually >0 in (1))
Δ_{CA} = $L_{WC} - L_{WA}$ for the actual sound source.

In Table 1 some comparisons are made between different single number ratings. We can see that the NIC-rating is very good for a flat (0 dB/octave) spectrum. In those cases it gives a reasonable agreement with the EIC-rating. However, the NIC-rating is not very satisfactory for low frequency sources. EIC is then considerably better although by no means perfect.

Table 1. Comparison between different single number ratings

Enclosure	Calculated $D(L_{WA})$ and EIC for different spectra								NIC
	+3 dB/oct		0 dB/oct		-3 dB/oct		-6 dB/oct		
	D	EIC	D	EIC	D	EIC	D	EIC	
0.87/abs/∞	38.8	35	32.5	33	24.3	28	18.2	23	33
0.87/abs/113	18.7	21	19.1	19	18.8	14	16.5	9	22
0.13/abs/∞	36.8	33	30.3	31	22.8	26	17.7	21	29
0.13/abs/32	18.2	20	17.5	18	15.9	13	14.1	8	14
0.87/refl/∞	31.8	31	28.9	29	25.3	24	20.9	19	27
0.87/refl/113	10.8	13	10.3	11	10.3	6	11.1	1	8
0.13/refl/∞	28.7	27	24.6	25	20.5	20	18.0	15	23
0.13/refl/32	12.4	14	11.5	12	10.7	7	10.7	2	5

CONCLUSIONS

For large absorbing and well sealed enclosures the insertion insulation can be determined either by $D(L_W)$ measurements using any suitable source or by $D_r(L_p)$ reciprocity measurements. In these cases the agreement will be rather good in 1/3 octave bands and very good using a single number rating.

When the enclosure deviates from the ideal case above the agreement between different methods will become less and less satisfactory the more openings and the more reflecting interior the enclosure has. In these cases it will be necessary to measure the insertion insulation with the actual sound source.

It is not satisfactory to have a single number rating not taking different source spectra into consideration. One possibility is to use the EIC rating which includes a correction term based on the difference between C- and A-weighting, which thus must be known for the actual sound source.

REFERENCE

Hans Jonasson & Lennart Eslon 1983
Measurement of the sound insulation of small enclosures
Report SP-RAPP 1982-30 from the Swedish National Testing Institute