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An acoustic chamber for sound intensity measurements

N TANDON† and U KRISTIANSEN*

ITMMEC, Indian Institute of Technology, New Delhi 110016

† Present address: ELAB Sintef-Gruppen, Institutt fur Fysikalsk Elektronikk, Lydteknisk Senter-NTH, 7034, Trondheim-NTH, Norway

* Division of Telecommunication Acoustics, Norwegian Technical University, Trondheim, Norway

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Abstract. The construction and performance of an acoustic chamber suitable for sound intensity measurements is described. The walls and the ceiling of the room are treated with glass wool sheets, air gap and pleated carpet in that order for sound absorption. The final testing of the room shows that good sound absorption is obtained down to low frequencies. The sound absorption coefficient for the room varies between 0·83 and 0·91 for different frequencies.

Keywords. Acoustic chamber; sound intensity.

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1. Introduction

Sound intensity measurements are currently being increasingly used for machinery noise work. These measurements are useful for sound source location in addition to being used for other purposes such as sound power determination. Using the intensity technique, I, the real time averaged intensity is measured directly and is defined as $\overline{pu}$ with p and u being sound pressure and particle velocity respectively.

It is shown that (Fahy 1977)

$$\text{intensity, } I \approx \frac{1}{2\rho\Delta x}\int_{\infty}^{-\infty} \frac{I_m\{c_{12}(\omega)\}}{\omega}\,\mathrm{d}\omega, \tag{1}$$

where Δx is the distance between two microphones, ρ, the density of the medium and c_{12} cross-spectral density function of the microphone signals. The sound intensity measuring technique is therefore based on the use of a two-channel signal analyzer and a small microcomputer to do the necessary adjustments to the cross-spectral density function, c_{12} and calculate the 1/3 octave levels etc.

The effect of phase mismatch between the two channels depends on the frequency, the difference between intensity and pressure level $(L_I - L_p)$, and the microphone spacing. For the measuring direction and the maximum intensity direction coincident,

† To whom correspondence should be addressed.

$L_I - L_p$ can be used as a measure of the reactivity of the sound field. It is shown (Broch 1984) that a phase mismatch of 0·3° of sound intensity analyzing system, using microphone spacing of 12 mm at 800 Hz introduces an error of +0·1 dB or −0·2 dB (depending on the sign of phase mismatch) in the measured intensity in a free field ($L_I = L_p$) whereas it is +1 dB or −2 dB in a reactive field $L_I = L_p - 10$ dB. This shows that a highly damped room is preferable for sound intensity measurements. Such a room for sound power and other measurements is much less expensive as compared to an anechoic room.

2. Construction of the room

The walls and the ceiling of a room of approximately 5 × 5 × 3·5 m dimensions and hard floor isolated from the walls, were treated with sound absorbing materials for this purpose. This room had its walls and ceiling covered with thin sheets of plywood and cork fitted over a wooden frame. Some measurements (Strøm 1979) indicate that heavy carpets or curtains can give the same damping effect as mineral wool when provided with a moderate airbacking. A sample of the locally procured cotton carpet (1·28 kg/m²) was tested in the standing wave apparatus with and without airbacking. It is seen (figure 1) that the carpet has a good high frequency absorption capability [curve (i)] and that it will absorb sound at low frequencies with an airbacking [curve (ii)]. The dip in curve (ii) at high frequencies could be due to wavelength effect ($\lambda/2$ = airbacking) caused by the one dimensionality of the standing wave method. This effect is not expected in the room as: (i) sound waves are incident on the material from many different directions (ii) the airbacking will be damped with glass wool to be fixed on the walls and the ceiling (iii) the carpet is to be folded to form pleats to avoid a well-defined plane (figure 3). It was decided to have a larger airbacking (approx. 150 mm) in the room design to extend the low frequency absorption characteristics to lower frequencies.

Accordingly the walls and the ceiling of the room were first treated with 50 mm thick glass wool sheets (Spintex 400) and a wooden frame was used to maintain a uniform air gap between the folded carpet and the glass wool (figures 2 to 4). This arrangement also protects from the harmful particles of glass wool, as they fall behind the carpets. The

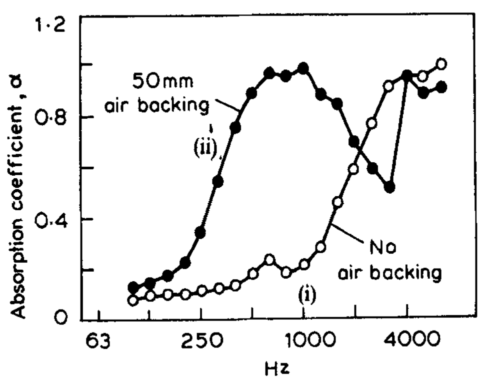

Figure 1. Sound absorption coefficient measured with standing wave tube.

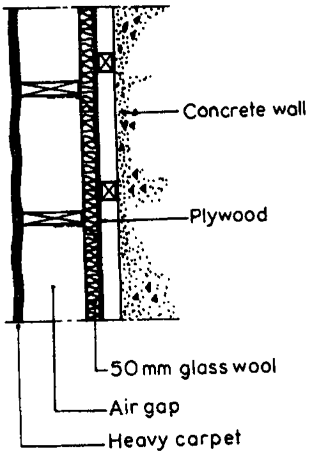

Figure 2. Acoustic treatment of room.

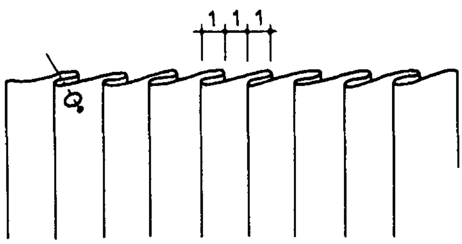

Figure 3. Carpet folded to form pleats.

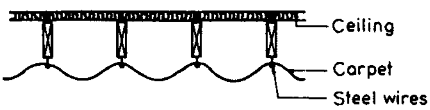

Figure 4. Carpet on ceiling.

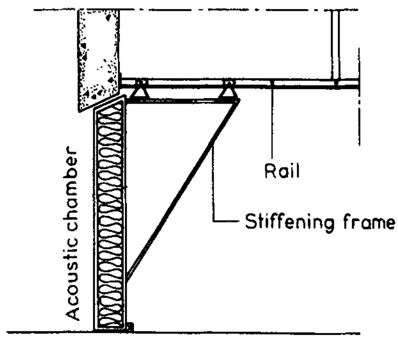

Figure 5. Door of acoustic chamber.

Table 1. Results of measurements on the performance of the room.

	Reverberation time (sec)		
Frequency	Average	Standard deviation σ_n	Sound absorption coefficient, α
125	0·16	0·0076	0·85
250	0·162	0·0087	0·84
500	0·163	0·01	0·83
1000	0·154	0·0041	0·88
2000	0·149	0·0035	0·91
4000	0·155	0·0032	0·88
8000	0·156	0·0021	0·87

door to the room slides outside on the rails and is made of two wooden boards with loose glass wool filled between the boards (figure 5).

3. Performance of the room

The performance of the completed room was assessed by measuring the reverberation time in octave bands by the filtered wide band noise method (Ginn 1978) for several positions of the microphone and sound source in the room and calculating the sound absorption coefficients using Sabine's formula. The results of these measurements are given in table 1.

4. Conclusion

The room provides good sound absorption down to low frequencies. It should be well suited for sound power and other measurements by the acoustic intensity technique.

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