Proceedings of the Institute of Acoustics

SOUND TRANSMISSION LOSS OF OPEN SCREENS

R. Lyons and B.M. Gibbs

The Acoustics Research, Unit School of Architecture and Building Engineering, University of Liverpool P.O.Box 147, Liverpool, L69 3BX, Great Britain.

INTRODUCTION

This paper is concerned with the sound reduction index (SRI) of open forms of screen commonly used where there is a requirement for acoustic control together with natural ventilation. Applications include plantroom machinery noise control, plantroom intake and exhaust openings and highway noise barriers requiring a line of sight. In this work the open screen is assumed part of an enclosure or element of a building facade. Acoustic louvres which comprise a horizontal angled blade section with absorbent material on the underside are commercially available. Increased acoustic performance is obtained for louvres which form a chevron blade shape. The mechanisms of control include mass, absorption and diffraction which can be controlled by varying the geometry of the screen The insertion losses obtained are typically 5dB - 10dB for open areas of the order of 50%.

Such screens have been investigated in the form of free standing barriers, Tanioku et al [1] studied barriers with a slit area of 3% of the total area. Measurements and prediction indicated that the solid and slit type barriers gave almost equal attenuation in the far field. Wassilieff.[2] considered the attenuation by a regular slit screen (picket barrier) and invoked mass-layer theory and optical diffraction models for prediction. By careful selection of correct gap width significant improvement in attenuation at low frequencies when compared with solid barriers were obtained. This results from destructive interference by the sound passing through the gaps with the sound transmission around the barrier. It is pointed out that the improved insertion loss by this action occurs at certain frequencies, but constructive interference at other frequencies will result in a reduced insertion loss.

In this paper open screens, consisting of two leaves with vertical staggered openings, are considered. This type of screen offers the advantages of economy and ease of construction and could be used for walk-through access. A measurement parametric survey was undertaken in order to extract the maximum, albeit still small, insertion loss while ensuring adequate free area for ventilation, and it was here that difficulties were encountered in the use of standard methods of measurement for low insertion loss devices.

MEASUREMENT

The following methods were considered:-

(i) ISO 140:1978 [3]

(ii) ASTM E90 -75 [4]

(iii) BS 4718:1971 [5]

(iv) DIN 52210/75 [6]

ASTM E90 -75 and DIN 52210/75 are the American and German equivalents of ISO 140, and in the U.K. the majority of manufacturers use ISO 140 for testing louvres. BS 4718 was discounted as it applies to the special case of in-duct elements.

The facilities at Liverpool University provide a reverberation transmission suite the dimensions of which satisfy ISO 140, with the exception of the aperture test area which is 3.5m^2 as opposed to the recommended 10m^2, (refer table 1).The aperture minimum edge length is 1.66m and measurements below 400Hz should be treated with a degree of caution.In accordance with part 2 of ISO 140 six consecutive insertion loss measurements were taken to determine the repeatability. Results are given in table 2.

The cut-off frequency [7] was determined from : $f_c = \left[M c^3 Rt / 8.8\pi V \right]^{1/2}$ [1]
where Rt is the reverberation time, V is the room volume and M is the modal overlap for which a value of unity [7,8] was assigned. The lowest frequency at which the reverberant field was considered statistically reliable was 250Hz and 200Hz for the source and receiver rooms, respectively. As a prelude to the measurement of the low insertion loss screens it was decided to measure that of the open aperture, including measurements in both directions to check reciprocity. Figure 1 shows these results. Above 1KHz the deviation in insertion loss from zero was no greater than 1dB. Below 1KHz there is a gradual increase as frequency decreases. This could be attributable to the mass-layer effect at the aperture. However when using the small receiver room the values are closer to zero indicating a dependence on room effects not aperture effects as more modes are excited in a larger source room.

A correction is required for low-loss test specimens, (less than 15dB), where the sound energy feeds back into the source room from the receiver room. The standard transmission loss equation [3] is replaced by :

$$TL = 10 \, Log_{10} \left\{ Antilog_{10} (L_1 - L_2 / 10) - 1 \right\} + 10 \, Log_{10} (S/A_2) \qquad [2]$$

Where L_1 and L_2 are the source and receiver room sound pressure levels respectively, S is the specimen test area and A_2 is the receiver room total absorption. Corrected aperture measurements are shown in figure 2 for the large receiver room. The over correction, resulting in negative values, may be the result of incorrect estimates of $1/A^2$ Coupling of the two rooms by the test specimen will be significant when the transmission loss is small and the receiving room reverberation time measurement will be influenced by the energy transmitted into the source room and then back again during decay measurements.(4,8,9) No double decay curves were observed in the present work, however longer reverberation times with open apertures than those with the screens in position indicated a dependence of reverberation times upon room coupling. Adjustment of the absorption in the source room can be made to suppress coupling and improve results, but this may have adverse effects on the room diffusivity. Bies et al (8) suggest a procedure for open aperture measurement involving the determination of level differences in both directions and of the absorption in both rooms, which eliminates the need to alter the absorption in the source room. Further work with the method of Bies et al and using adjustments of the absorption is to be undertaken, but it is clear that the ISO 140 method is not practical for testing open screens such as acoustic louvres and as such manufacturers data obtained by such methods must be treated with some caution.

SCREEN PERFORMANCE

Despite the uncertainties in absolute measurements in the low frequency range, the facilities and the ISO 140 method gave good repeatability (table 2) .In a limited parametric survey of double screens, panel width, air gap and distance between the leaves (air cavity) were varied. Small changes in the screen configuration yielded consistent (albeit small) changes in insertion loss with no cross-over. The results obtained are therefore good indicators of incremental effects but not of absolute or in-situ insertion loss.

As a prelude to the analysis of the performance of double screens, single open screens were investigated, and measured values were compared to the theories of Wassilief.(2) He employed the mass layer effect (11), which is dependent upon the screen open area ratio and depth, and the air in the opening acts as an inert mass at frequencies whose wavelengths are well above the width of the panel, his prediction gave close agreement with the measured insertion loss at low frequencies. At the point where the picket width was of the order of between λ and $^2/_3\lambda$ the mass-layer model failed and use of the optical diffraction model gave closer agreement. An example is shown in figure 3 for a 100mm thick picket screen of 200mm wide pickets and 55mm air gaps with a calculated effective mass (11) of $0.80 Kg.m^{-2}$. The results have been corrected by subtracting the open aperture loss.The two regions are seen, that of mass effect up to

400Hz and above this frequency the plateau effect. Low frequency measurements of the double leaf screen yielded gradients varying from 2dB per octave up to 12dB per octave, as against gradients of 5dB-6dB per octave predicted from the mass-layer effect. In addition, for a particular air gap the gradients are seen to be independent of air cavity width.

Above 400Hz-500Hz the transmission loss curves diverge to give a set of curves with decreasing transmission loss as air cavity increases. Here the insertion loss is highly dependent upon absorption and line of sight. For small air cavities the screen provides a narrow absorbent path, and gives high insertion losses. As the air cavity increases a wider less efficient path operates and eventually the high frequencies will "beam" through the screen giving a fall off in attenuation. Work on prediction and measurement of single and double leaf screens continues.

OTHER METHODS OF MEASUREMENT

There remains a need for methods of measurement of open screens,which will provide manufacturers with easily interpretive and applicable data. The Acoustics Committee of the Heating Ventilation and Air Conditioning Manufacturers Association (HEVAC) are currently drafting a test procedure for acoustic louvres.The procedure will involve reverberant to free field measurement, hence eliminating the effects of room coupling. The measurement of static insertion loss, flow generated noise and static pressure drop across the louvre will be included.The free field measurements will be measured so as to take account of any directional effects, and the level difference will be found from measurements with and without the louvre in position.

CONCLUSIONS

The laboratory facilities at Liverpool University were set up to ISO 140 standards excepting aperture area, and measurements of single and double leaf screens undertaken. Problems with the measurements of these low-loss screens and the open aperture revealed errors in using the standard method of transmission loss measurement [3],and the known correction equation [2] [9].Correction of the source room absorption or alteration of the measurement method could be used to reduce errors in low-loss screen measurements and further work on this is required.

It is clear that ISO 140 is not practical for measuring absolute or in-situ insertion losses of open forms of screen and as such manufacturers data on acoustic louvres obtained by such methods should be treated with some caution. However the measurements of the double screen clearly indicate the effects of varied screen configurations.The use of mass-layer effect for prediction at low frequencies is not applicable to the double screen as the different configurations show gradients varying from 2dB to 12dB per octave. The transmission loss at mid and high frequencies are dependent upon the line of sight offered by the screen opening. Further work involving prediction, standard methods and other methods of measurement, such as HEVAC, impulse and intensity, continues.

ACKNOWLEDGEMENTS

To SERC and Sound Attenuators Limited for supporting this research.

REFERENCES

(1) Y. Tanioku, K. Konishi and Z. Maekawa : Noise reduction of a slit-type barrier by using line integral method and full scale model measurement. Internoise 1987 pp 395-398
(2) C. Wassilief.: Improving the noise reduction of picket barriers. JASA 84(2) August 1988 pp 645-650
(3) ISO 140:1978. Methods of measurement of sound insulation in buildings and of building elements. Parts 1to3.
(4) ASTM E90-75 : Standard method for laboratory measurement of airborne sound transmission loss of building partitions. August 1975.
(5) BS4718:1971 : Methods of test for silencers for air distribution systems.
(6) DIN 52210/75 : Luft und Trittshalldamung (Tests in building acoustics : Airborne and impact sound measurement methods).
(7) M.J. Crocker and A.J. Price : Noise and noise control. Volume 1. CRC Press 1975 p189.
(8) D.A. Bies and J.M. Davies : An investigation of the measurement of transmission loss. JSV (1977) 53(2) pp 203-221.
(9) A. London : Tentative recommended practise for laboratory measurement of airborne sound transmission loss of building floors and walls. JASA 23(6) Nov 1951 pp686-689.
(10) T. Mariner : Critique of the reverberant room method of measuring airborne sound transmission loss. JASA 33(8) August1961 pp1131-1139
(11) L. Cremer and H.A. Muller : Principles and applications of room acoustics. Volume 2 Hirzel Verlag 1978 (p182).

	Receiver room	Source room	ISO 140
Volume (m^3)	122.00	74.00	50.00
Area (m^2)	149.00	109.50	--
Test area (m^2)	3.50	3.50	10.00
Min edge length (m)	1.66	1.66	2.30

Table 1 : Dimensions of facilities at Liverpool University and ISO 140. requirements.

Frequency (hertz)	TL1-TL2 (dB)	TL3-TL4 (dB)	TL5-TL6 (dB)	ISO Allow. difference (dB)
100	0.20	0.50	0.30	5.00
125	-0.10	-0.60	-1.10	5.00
160	-0.40	0.90	-0.10	5.00
200	0.50	-0.10	0.30	5.00
250	0.00	0.10	0.20	3.00
315	0.20	1.30	-1.00	2.00
400	-0.60	0.40	0.10	2.00
500	-0.20	-0.50	0.00	2.00
630	-0.10	-0.50	0.00	1.00
800	-0.20	0.10	0.00	1.00
1000	-0.10	-0.30	0.30	1.00
1250	0.20	0.80	0.30	1.00
1600	0.00	0.10	0.10	2.00
2000	-0.10	0.60	0.00	2.00
2500	-0.40	0.50	-0.10	2.00
3150	0.00	0.70	0.10	2.00
4000	-0.20	0.10	-0.10	2.00
5000	0.00	0.20	0.10	2.00

Table 2 : Measurements of repeatability to ISO 140 part 2.

TRANSMISSION LOSS OF OPEN SCREENS

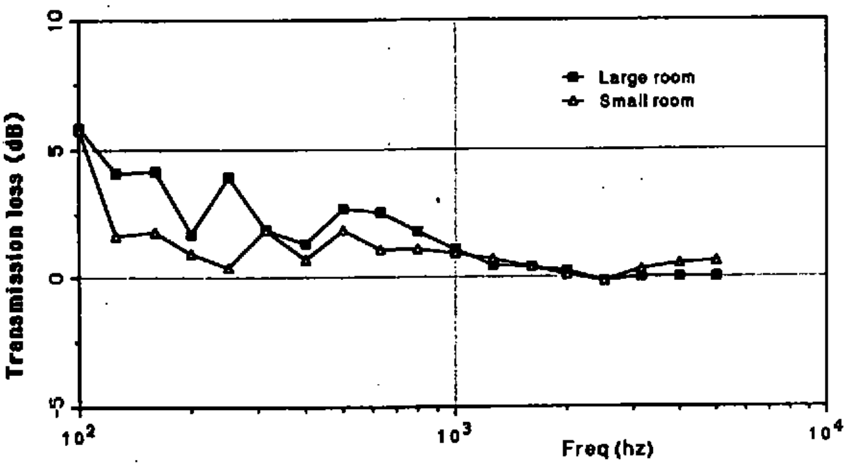

Fig 1 : Open aperture transmission loss for large & small receiver room

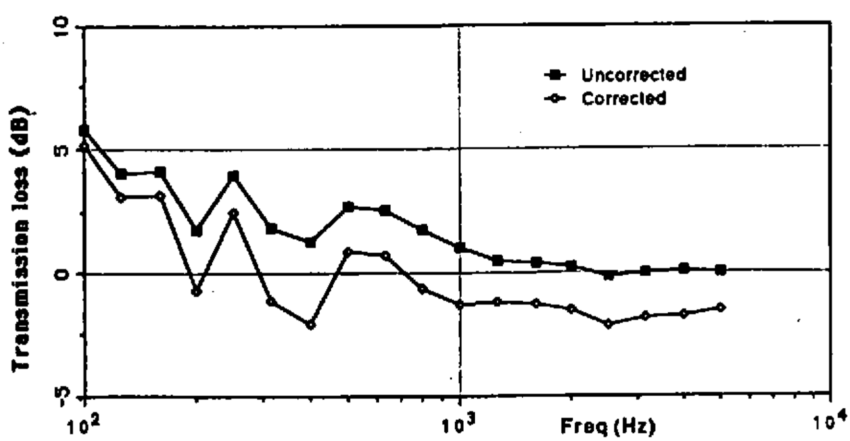

Fig 2 : Corrected open aperture transmission loss for large receiver room

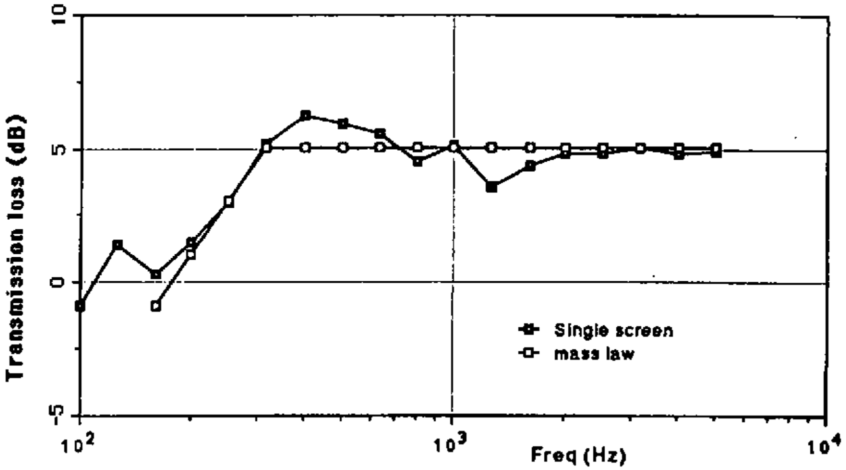

Fig 3 : Single screen (200mm panels,55mm air gap)