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OBLIQUE INCIDENCE TRANSMISSION LOSS BY AN IMPULSE METHOD

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1 INTRODUCTION

The accepted method of measurement of the airborne sound transmission of partitions requires steady state conditions and has a number of drawbacks when applied to situations out of laboratory test suites. The method described by a British Standard (1) measures an angle averaged sound reduction index as a function of frequency, in one third octave bands from 0.1 to 3.15 kHz. Corrections are made for the absorption characteristics of the reception room and it is assumed that the sound field in the transmission room is diffuse.

The performance of a panel in situ often differs markedly and adversely from that in laboratory conditions and this discrepancy is due to:-

a) poor workmanship in the construction of the panel
b) difference in mounting conditions and depth of reveals at the edge of the panel
c) the contribution of flanking sound which is sometimes greater than the direct component

The discrepancy may, of course, be any combination of a) b) or c) but the steady state test method, itself, gives no indication of the mode of failure. In order to obtain diagnostic information lost to the steady state method it is necessary to employ either correlation techniques or time of flight methods using short duration signals.

A description is given by Raes (2,3) of a method of measuring transmission loss in situ by use of a pulsed tone source of one third octave bandwidth. Visual inspection of the microphone output on a calibrated screen of an oscilloscope before and after passage through the wall under test gave the transmission loss.

Goff (4) gives a description of an analogue method of obtaining the cross-correlation function between a loudspeaker input and the output of a microscope same distance removed. On introducing an intervening panel and repeating the measurement the difference in signal amplitude is obtained. The difference in amplitude of the signal gave the transmission loss and agreement with prediction based on the mass law was good.

Louden (5) describes measurements on freely suspended panels using a repeated impulse generated from a loudspeaker. The trace of the impulse was photographed from the screen of the oscilloscope and the data taken from the resulting photographs was analysed by a Fourier transform on a digital computer. A free space measurement of the impulse response calibrated the system and this reference level was compared with the signal transmitted through the panel, thus obtaining the transmission loss. Normal incidence results were presented for four panels and agreement with mass law predictions was good. There were problems with background noise levels interfering with the recording of the transient signal.

Recent developments in the field of microprocessor technology have brought powerful techniques to bear on signal processing giving greater frequency resolution and enhanced signal to noise ratios. A description is now given of the use of these techniques in the measurement of transmission loss being test signals of sufficiently short duration, the analysis of the data being performed on an online mini computer.

2 EXPERIMENTAL METHOD AND RESULTS

The method of measuring transmission loss described here is similar to that given by Louden (5) and relies on the direct signal being separated in time from the scattered and reflected parts of the time history. The experimental arrangement is indicated in figure 1. The digital event recorder shown in the figure is a convenient signal capture device with an analogue to digital converter and digital storage.

The problem of low signal to background noise level is overcome by averaging the repeated transient signal derived from the computer memory (replayed via a digital to analogue converter). The repeated signal is reinforced while the random background noise averages to zero. Two refinements of this technique have been implemented which overcome problems resulting from synchronization with reverberent decays and with mains interference. The first problem has been overcome by the insertion of a random delay between the repeated transients. With this condition the reverberant decay takes on the character of random noise and averages to zero. The second problem was eliminated by the inversion of successive transient inputs to the loudspeaker (6) and subtracting the resulting signal from the running sum on alternate cycles. When this is done the phase of any mains breakthrough is reversed and so is removed from the averaged signal.

The waveform to be applied to the loudspeaker was initially formed in the digital memory of the computer and replayed through a digital to analogue converter. In the experiments described here this was a 0.05 milli-second square wave. The use of the computer to derive this waveform enables it to be inverted, by use of software, on alternate cycles of the signal averaging. At the same time as the transient signal was applied to the loudspeaker a trigger pulse was sent to the event recorder, and approximately 40 milliseconds of the output from the microphone recorded and stored into the digital memory of the event recorder. This data was then read into the computer and added to (or subtracted if the input transient was inverted) a memory block storing the sum of all previously recorded transients.

The apparatus was calibrated by recording the response of a loudspeaker in free space at a distance of one metre. The spectrum of the loudspeaker was obtained by modifying the time history such that all but the direct signal was set to zero and then operating with a Fast Fourier Transform. The free space spectrum was then stored in the computer memory as a reference.

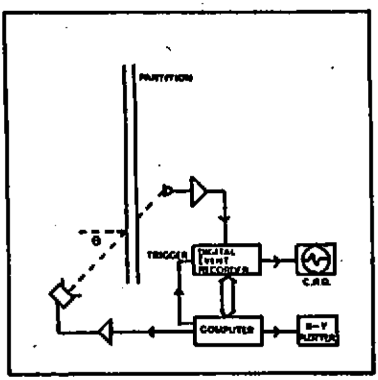

Figure 1
Experimental Arrangement

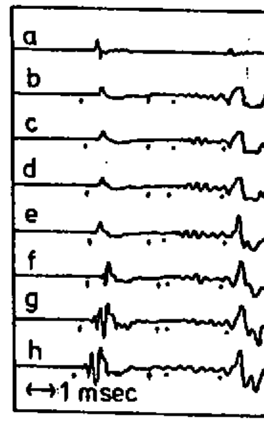

Figure 2
Recorded time histories
a) free space calibration
b-h) After transmission through perspec 0-60°
in 10° steps.

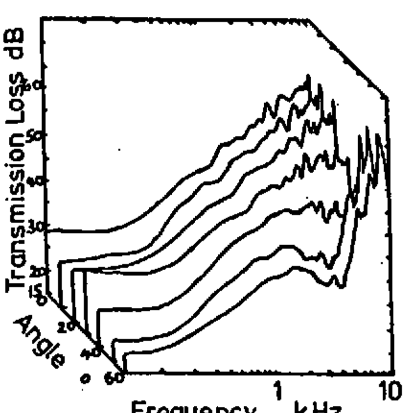

Figure 3
Experimental transmission loss of perspex sheet.

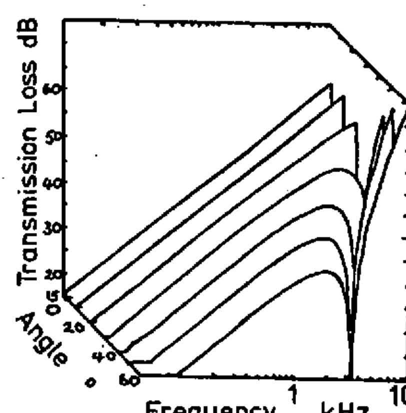

Figure 4
Theoretical transmission loss of perspex sheet.

The transmission loss for a test wall is obtained by repeating the procedure with the same source to receiver distance and with the wall inserted. The source was placed 0.75 metres from the wall to avoid standing waves between wall and loudspeaker.

In this study of the transmission loss of a free standing panel perspex was chosen as it is a well defined homogeneous material and is easily modelled theoretically. The plate dimensions and material constants were as follows:- thickness 13mm, density 1200 kg/m^3, Young's modulus 4.8×10^9 N/m^2. The panel was made from three sheets each of dimensions 1.2m by 2.4m giving overall dimensions of 3.6m by 2.4m.

The sound source was a moving coil loudspeaker (cone diameter 0.1m) mounted at the end of a rigid tube of perspex of diameter 0.2m and length 1.0m. With this arrangement the signal from the back of the loudspeaker would arrive at the microphone about six milliseconds after the radiated forward. In all measurements the microphone was placed on the axis of the loudspeaker, the angle of incidence being the angle between the axis and the normal to the panel surface.

The time history of the free space calibration signal is shown in figure 2a. The effect of the panel on the direct signal at different angles of incidence is shown in figure 2b - 2h. It is seen that the amplification of traces 2b-2h is 32 dB more than that of trace 2a in order to clearly show the time history of the now much reduced direct signal.

The transmission loss of the perspex as a function of frequency and angle of incidence, derived from the data of figure 2 is shown in figure 3. For comparison theoretical prediction is shown in figure 4. Agreement is in general good, although the coincidence dips in the experimental results are not as deep as predicted by theory. The difference between theory and measurement may be the result of the former being for incident plane waves and the latter being the result of using a moving coil loudspeaker more likely to produce a spherical wave field.

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