## NOISE BREAKOUT FROM AIR HANDLING UNITS

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## INTRODUCTION

A major source of sound propagation within building environments is the Air Handling Unit, a basic piece of air conditioning machinery designed to heat, cool, filter, humidify, extract and move air around ductwork systems of a building. The main cause of the noise inside the unit is the fan and motor set designed to move the air through the system. In recent years specifications and standards relating to all spheres of Air Handling unit production have developed to demand high quality designs. One of these areas is the insulation of the units.

Two areas of insulation demand scrutiny. Firstly, the thermal properties of insulation. These properties aid conservation of energy of both the heaters and coolers inside the unit and it has developed to include not only the panels of a units casework but also its five cornered hollow pentapost frame where heat can leak out. Secondly, the acoustic properties of insulation. These properties aid attenuation of the noise created by the component parts of the air handling unit. Studies have been made on insertion losses of panel insulations but these did not include the insulation of the pentapost frame, which is usually carried out for thermal reasons.

Thermal requirements of air handling specifications can insist on pentapost insulation. An analysis was required to determine its acoustic properties and the effect it would have on the complex sound energy propagation of a noise source within an air handling unit casework. Two of the more common panel insulation materials were to be tested with the new idea of hollow cylindrical foam insulation (Armaflex) which is easy to install into the pentapost and expands to provide adequate thermal seals.

## TEST APPARATUS, CONDITIONS & OBJECTIVES

The acoustic enclosure used was a standard MTR air handling unit casework design having approximate overall dimensions of 1130mm high by 1130mm wide by 1130mm long. This gave us the nominal panel sizes of 1000mm square per side.

The construction of the unit was as follows:-

Framework, fully welded pentapost structure manufactured from 16 gauge mild steel and having a grey primer undercoat and hammer blue paint finish.

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Panels, double skinned nominal thickness 50mm, manufactured from an 18 gauge mild steel outer skin and a 20 gauge galvanised steel inner.
The panels fitted snugly into the pentapost frame, and gaps would be sealed over with a layer of neoprene duct tape. The base panel of the unit was designed to simulate a plantroom floor and as such was firmly bolted in position and insulated with a heavy grade Rockwool (200kg/m3)

The sound source inside the unit was a 1kw direct drive single phase fan blower which had a generous wide band noise coverage at reasonably high pressure levels. It was isolated from the unit casework by 2 inch thick expanded polystyrene.

To measure the sound pressure breakout from the unit a half inch calibrated condenser microphone was used connected to a digital frequency analyser.

All testing was done in a free field environment.

The object of the tests was to determine the insertion loss (IL) of the insulated enclosure with and without pentapost insulation. This was achieved by measuring the sound source without the enclosure and then with it in place, the difference between the two values being the IL. Thus:

$$IL = SPL_{wo} - SPL_{w}$$

NOTE: Problems do occur here because the addition of a sealed enclosure over a sound source increases the acoustic pressure inside. As our tests did not include a method for the measure of the internal SPL with the enclosure in place, we expected IL figures to be lower than the expected transmission loss figures would have been using:

$$TL = 10 \log_{10}(I_i / I_t)$$

where $I_i$ = sound incident on a panel
$I_t$ = sound transmitted by a panel

## TEST PROCEDURE TO ESTABLISH INSERTION LOSS

The air handling unit was placed in the centre of the anechoic chamber suitably isolated from the floor with 2 inch expanded polystyrene and its sound source placed inside approximately equidistant from the four vertical panels. The sound source was to be fixed in this position for the duration of the tests. To measure the breakout sound pressure level spectrum the microphone was placed one metre away from the centre of each panel. After an initial settling down period of two minutes the readings were taken and data recorded in octave bands over the frequency range 63Hz to 8kHz. The fan was kept running throughout the test procedure which took approximately 30 minutes to obtain a set of results. Background measurements were taken after each set of results were completed and it was decided that these readings would have to be at least 10dB less than the measured breakout sound pressure levels to dichotomise background interference from our readings.

Test data was collected for the casework with 50mm fibreglass insulation but without insulated pentapost, then Armaflex foam was added and the test repeated. The panels were then removed and testing done again to ascertain the sound pressure level spectrum of the fan blower from each of the panel measuring positions. The insulation in the panels was changed to Rockwool and the test was repeated.

## TEST RESULTS

Because of low sound propagation in the low frequency bands, the measured levels were not consistently high enough at 63Hz to warrant serious consideration and as previously planned were therefore eliminated from analysis.

Simple mathematical techniques were then used to derive IL from the measured data and also its average spectrum, taking into account all the panels. (Some rogue statistics did warrant omission from these calculations). These average figures can be represented graphically, see fig 1 and fig 2.

At once the similarity between insertion loss spectra can be observed with a peak at around 500Hz and a trough, possibly caused by an intrinsic resonance mode of the structure, at 2kHz. This applies to both the insulated and non-insulated tests and it suggests that although the Armaflex foam insulation in the pentapost does reduce the volume within the air handling unit, no significant change in the IL characteristic is noticed. Resonances caused by standing wave exitation are known to reduce with the addition of the sound-absorptive material which seems to be the case here. As we can see, the addition of the foam insulation increases the IL spectrum which we now assume must be attributable to the acoustic performance of the Aramaflex foam material, and not a change in sound propagation development within the box due to reduced free volume.

The inclusion of the foam material did not give quite the results that were expected and which have been empirically shown in a test by O'Keefe and Stewart [1]. In their model the greatest effect of the application of foam absorptive material was at the higher frequencies 2kHz and above, where the absorption and additional transmission loss of the foam is greatest. In our tests improvements were noted to be greater between 250Hz and 2KHz in the fibreglass tests and between 250Hz and 1KHz in the Rockwool tests, the insertion losses higher up proving to be

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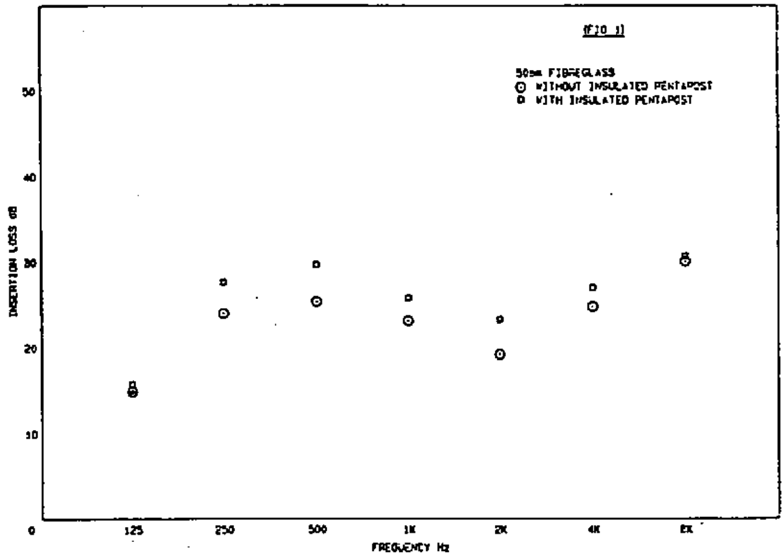
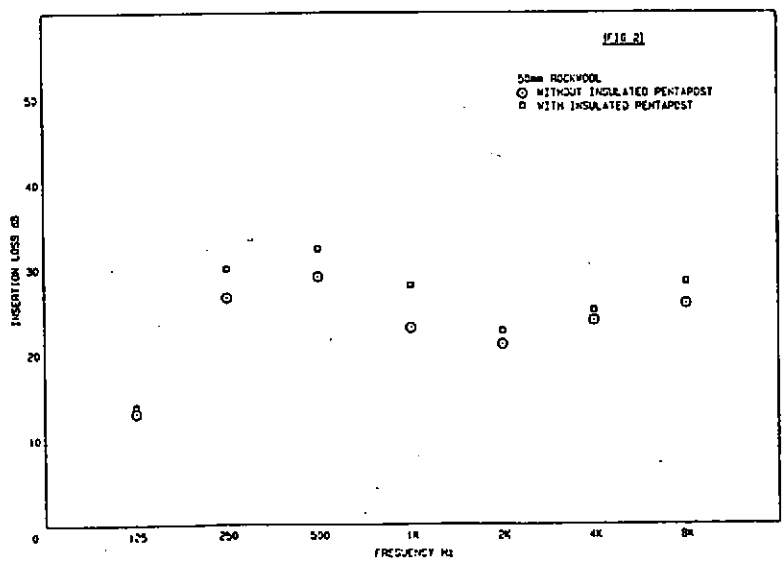
unresponsive to the addition of the foam insulant.



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## CONCLUSIONS

The main problem with trying to determine the IL spectrum of an enclosure stems from the fact that we have no effective means of measuring the sound incident on a panel once the enclosure is in place. Given this, one must assume that inter-reflection propagated within the void can only add to the overall pressure and because of this make our IL spectra less than they otherwise should be. Directionality of a sound source can be assessed when it is allowed to propogate unhindered, but it cannot be convincingly estimated when an enclosure is in place. For this reason, watering down of results takes place, weeding out rogue figures which disturb an otherwise uniform IL distribution for no easily quantifiable reason. In our test the insertion loss for the back panel was 9.3dB at 1KHz during the fibreglass/no Armaflex case. It stood out because all the other panels IL's ranged from 20.9dB to 25.6dB. We must therefore assume that the directionality of the sound in the enclosure is propagating a sound pressure level much larger than the one measured at 90.7dB without the enclosure.

Bearing this difficulty in mind helps us to rationalise the results of the tests. Where we found that although foam insulation in the pentapost reduces free volume it does not appear to alter the overall IL spectrum characteristic. It does, however, seem to dampen the sound pressure level spectrum increasing the IL spectrum throughout the range, though more specifically in the mid-range frequencies.

REFERENCES: 1) E J O'Keefe and D R Stewart, ''Insertion Loss Measurements of Small Rectangular Enclosures'', Noise Control Engineering, July/August 1980.