THE REDUCTION OF NOISE FROM A CEMENT KILN STACK

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INTRODUCTION

This paper describes the design and operational performance of an attenuator built into a 3 metre diameter stack to reduce fan noise from a cement kiln. The attenuator was carefully designed to withstand the problems associated with high temperatures and the ingress of dust particles.

After installation it was possible to carry out a sound transmission loss test using a wide band noise source within the stack. The results of this test are discussed and comparisons made with the predicted attenuator performance.

Tests had previously been carried out to establish that noise from two centrifugal fans at the cement works were the source of complaints from nearby residents. Each fan had an associated discharge stack, approximately 3 metres in diameter designed to give the correct efflux velocity and it was decided to build an attenuator into each of the two stacks. The attenuator for the main kiln extract fan was built into a horizontal length of duct which proved convenient for carrying out an acoustic transmission loss test and this paper concentrates on the design of the attenuator for this particular fan. The attenuator for the other fan was built into a vertical section of duct and it was therefore not possible to carry out a transmission loss test.

DESIGN PARAMETERS

Having determined the sources of complaints to be the fan and associated stack, it was then possible to establish the basic design parameters for attenuation equipment. The principal noise was for blade passing frequency in the 125Hz octave band with harmonies in higher octaves. The 125Hz low frequency required attenuation of approximately 25dB while 35dB was required at 1KHz. The air volume of 475000 m^3|hr could reach temperatures of 150°C and there was a limit of 80 pascal water guage allowable back pressure. In addition the air would contain dust and it was therefore required to minimise the ingress of particles into any absorbing medium.

The initial approach to the problem was to consider a rectangular splitter type attenuator. The required attenuation could be achieved in a length of 4.5 metres with a cross section of 4 metres x 4 metres. This would obviously require transition pieces from the 3 metre diameter duct to the 4 metre square attenuator, giving a total length of 7.5 metres. The casing of the attenuator and transition piece would be constructed from at least the same thickness material as the circular duct and the combined attenuator and transition piece weight would therefore be in the region of 25 tonnes.

The practicalities of installing such an attenuator in this particular stack led to an alternative approach that in the end turned out to be far more practical and reduced the manufacturing cost by half.

Normally for a given length of attenuator, a rectangular design is more versatile than a cylindrical design. However, in this case there was already an existing substantial length of cylindrical duct such that length was not necessarily a restriction. The approach, therefore, was to consider converting the cylindrical duct into an attenuator by adding circumferential absorptive lining, and, if necessary, a central pod. This would have the obvious advantage of utilising the existing duct as the attenuator casing and, perhaps more importantly, not having to replace the sections of circular duct with larger sections of rectangular duct that would have serious design implications on the structure and its support.

ATTENUATOR DESIGN

Having decided to approach the problem with a cylindrical attenuator, the acoustic design simplified itself to one of optimisation within the parameters. The duct diameter was fixed and up to 30 metres were available in which to create the attenuator in the horizontal section. The design was evolved from extrapolation of laboratory determined data and ultimately an attenuator length of 15 metres was selected. This was equivalent to 5 diameters in length and it was necessary to utilise a small centrally positioned pod to achieve the required broad band attenuation. The introduction of the circumferential lining and the pod gave a slight increase in duct velocities resulting in a calculated additional resistance of 80 pascal at the maximum flow rate. The predicted attenuation for the attenuator is shown in Figure 3.

Once the size of attenuator had been determined, attention then turned to the practicalities of building it into the duct. Prior to this project, there had been no direct access into the horizontal section and it was therefore necessary to cut a single leaf access door into the wall, through which all components had to pass. As every item had to be manhandled into position, the attenuator was built in modular sections, the weight of each section not exceeding 35 kilograms.

The absorptive elements were protected by a layer of stainless steel cadisch mesh and an outer skin of perforated stainless steel. The function of the cadisch was twofold - it helped to reduce the ingress of dust into the absorptive medium and it retained the fibres when exposed to the high duct velocities. The circumferential lining was built up with six elements, each element being 0.5 metres long. The pod was also built from short elements and suspended from three arms that allowed for expansion under the expected operating temperatures.

The attenuator was installed during a kiln shutdown over a one week period.

ACOUSTIC TRANSMISSION LOSS TEST

The attenuator built into the horizontal section of the duct presented an excellent opportunity to carry out a transmission loss test to determine its acoustic performance. The test was conducted during a kiln shutdown, shortly after installation. A wide band noise source was positioned three metres from the leading edge of the attenuator. This section of unlined duct created a strong reverberant, diffuse noise field. Octave band SPL's were taken at the noise source and progressively down the length of attenuator at one quarter length intervals (3.75 metres). The lower perforated sections of the lining had been deliberately strengthened to allow a man to walk between the central pod and the duct lining. The final position at the end of the attenuator was close to the large vertical section of stack and the noise measurements were affected by the background noise created by the induced draught. It was decided, therefore, to reverse the test and place the noise source at this end and determine the attenuation in the direction that would be against the flow under operating conditions.

The octave band levels at the measurement positions with the direction of flow are shown in Figure 1 and against the direction of flow in Figure 2. It is interesting to note the high SPL level at 125Hz with the noise source in the duct, as shown in Figure 1. This band is significantly higher than other octaves and it was suspected that there was a duct resonance in this octave. This resonance was easily excited and was apparent in other ways, for example when talking within the duct.

From the levels shown in Figure 1 and 2 the average transmission loss of the attenuator has been calculated and shown in Figure 3, together with the predicted performance. The shape of the graphs are very similar and, in view of the innovative nature of the prediction, considered to be very acceptable. The measured transmission loss does show an unexpected attenuation peak at 125Hz. However, this can be explained by the duct resonance being attenuated by damping as well as absorption.

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FIGURE 1

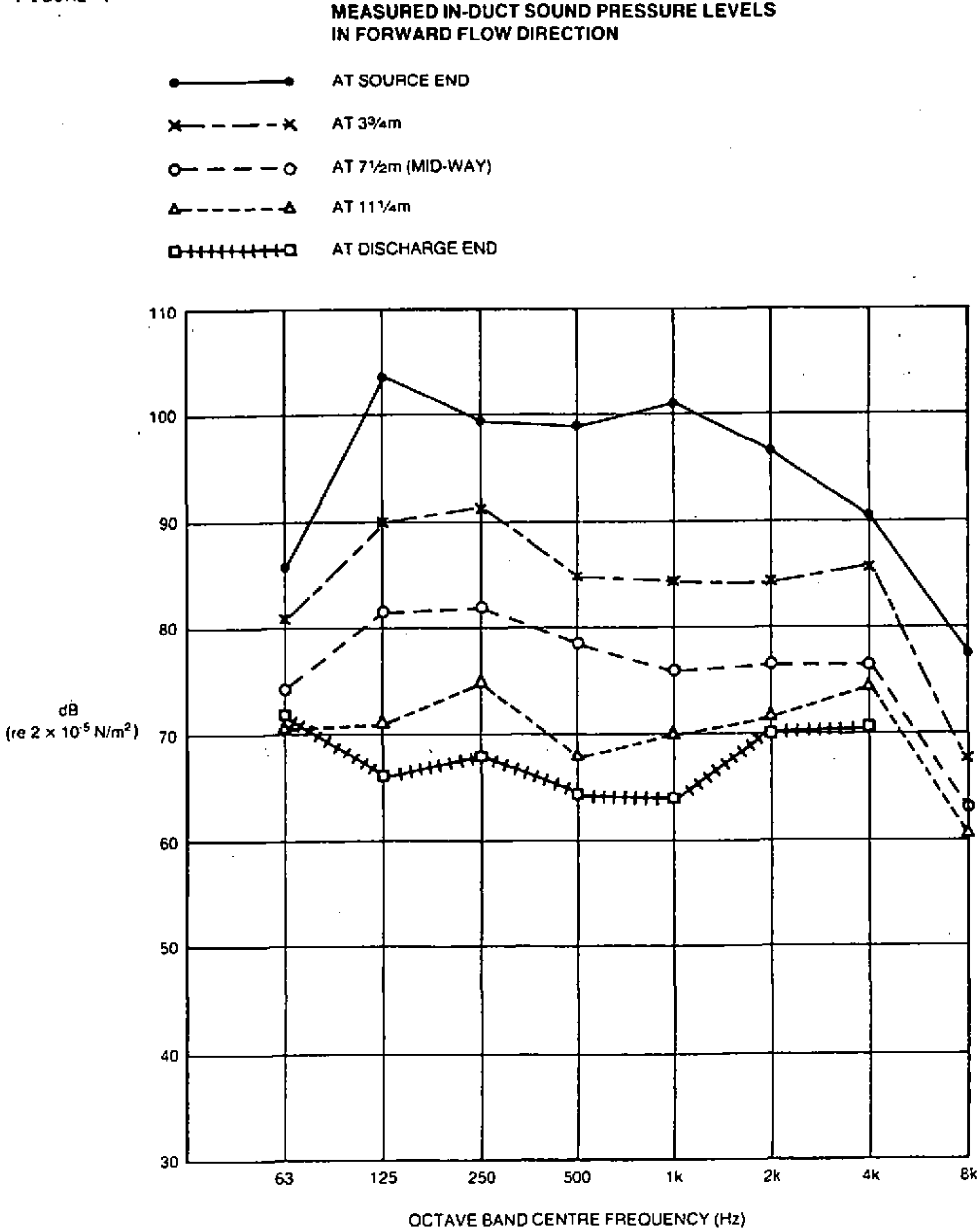

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FIGURE 2

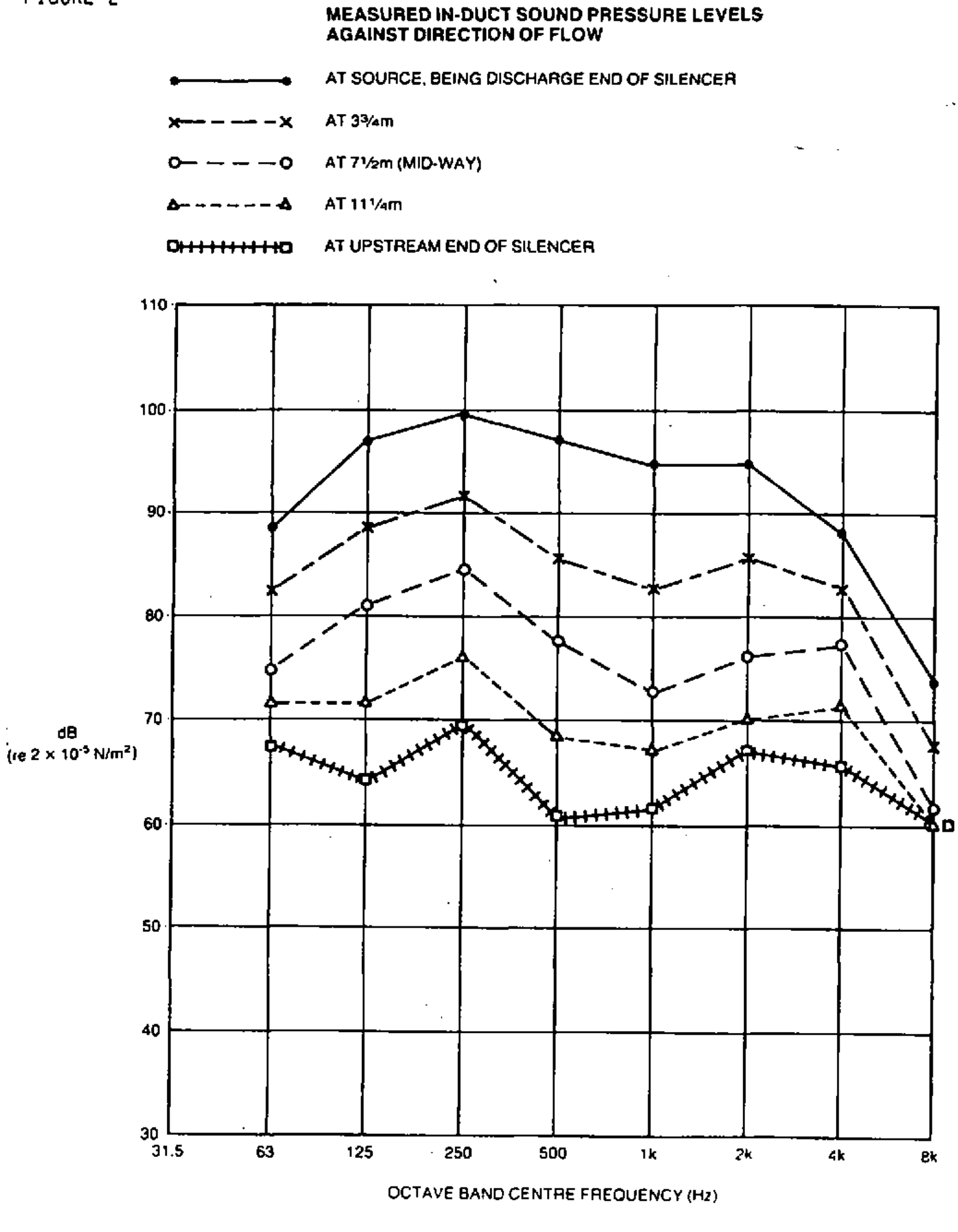

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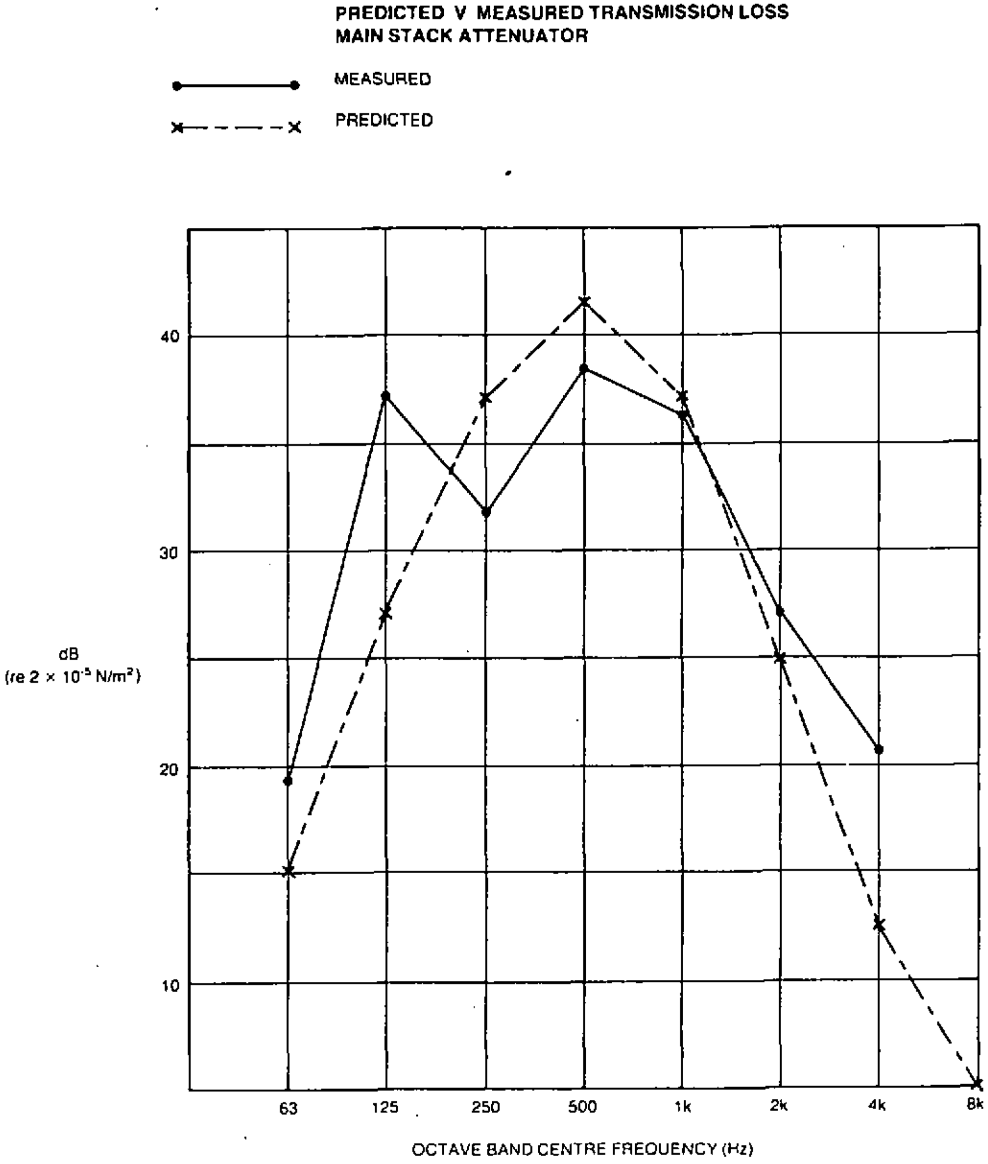
FIGURE 3



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SUMMARY

The attenuator has been installed and operational for 18 months and reports indicate that it has been effective in reducing the fan noise. Levels are being monitored carefully to determine if there is any increase in noise over a period of time. Meanwhile the attenuator lining is regularly cleaned during kiln shutdown to reduce the build-up of dust.

The installation has therefore been considered successful both in reducing noise and in its operational performance. The principle of building an attenuator within the duct to meet the required acoustic performance specification was, in this case, certainly the most economical and practical.