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BUILDING SERVICES NOISE CONTROL - SITE AS A LABORATORY

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One of the most important calculations in building services noise control is that concerned with the ductwork system carrying out air distribution over the total building. The prime source of noise and power in such systems is most obviously the fan - centrifugal, axial or mixed flow - and this fan is located in the plantroom at the heart of the air-conditioning system.

Over the years, many ductborne calculation techniques have evolved and have settled down into two main formats:-

a) Starting with the sound power level at the fan working through the system, allowing the modified sound power level to radiate from the outlet diffuser into the system and applying room corrections. This room corrected sound pressure level is then compared with the specification to determine the required additional ductborne attenuation - the silencer or attenuator.

b) An alternative approach is to start with the required room criteria as the sound pressure level and to "feed it back" into the system via the room correction, the outlet diffuser, the duct distribution system up to the face of the fan, at which stage it is by now sound power level. This, then, suggests an allowed sound power level which can be tolerated, as it were, in the plantroom, and the necessary silencer or attenuator must be placed on the fan to reduce any given fan sound power level down to this allowed sound power level.

In their simplest form, both these calculations do not take into account the fact that noise will be generated en route by the presence of flow - flow generated noise. The most familiar source of flow generated noise is the outlet diffuser, but every duct feature such as take-offs, plenums, filters, coils, turning vanes, bends, generate their own flow noise. Even the attenuator must not be considered free from this problem, and its flow generated noise - sometimes known as self-noise - must be included in the calculation as a flow noise corrected insertion loss. Traditionally, the insertion loss of an attenuator is measured without the presence of airflow. Separately, the pressure loss and the flow generated sound power level is determined as a function of airflow. Hence, the self-noise due to flow can be established to correct the insertion loss. This is all covered in British Standard BS4718. The measurement of the true insertion loss in the presence of flow is included in the American Standard, but it has been considered by the British Standards committee that for flow velocities appropriate to building services situations - passage velocities less than 20m/s - the correction required is outside the measuring tolerances of the test technique. Nevertheless, this feature of dynamic insertion loss is currently being addressed by the current committee reviewing the British Standard.

Returning to the natural features of the duct alone, including all its fixtures and fittings - not only do they generate noise due to flow, but they also attenuate noise by impedance mismatching and dissipative loss processes. In this case is included the considerable loss of ductborne noise by the long lengths of ductwork itself. Some of this loss is by genuine energy dissipation and a large amount is by breakout from the duct, which nevertheless appears as a loss process to the contained ductborne power levels.

In tackling the calculation sheets - either method - the value of these natural attenuation features needs to be established. At the moment the trade uses data which is now quite old and best considered as guidance. Nevertheless, the cumulative loss, especially of the many natural loss mechanisms, accounts for a major loss of fan sound power level and hence determines the additional unitary attenuator requirements. Such is the dubious accuracy of this traditional data that 5dB tolerance in the calculation sheet cumulative process is most certainly optimistic - except, perhaps, for exceedingly short duct runs free of significant duct accessories.

The Salex Group of Companies addressed themselves to this problem several years ago and can see two prime approaches. The first approach would be an attempt to assess accurately the attenuating loss factors for the ductwork and its various elements using laboratory test rigs. This is quite a huge undertaking when one takes into account the size variations, gauge variations and construction formats for the range of about 10 different elements. Remember this is only considering the natural attenuation and not yet getting involved in the self-generated noise problem mentioned above. Also, it does not take into account the possibility of interaction between elements which modify their parameters, i.e., the natural duct parameter or the flow generated noise parameter. However, this laboratory approach to the situation remains available for consideration.

A few years back the Salex Group undertook the accurate laboratory evaluation of ductborne breakout and the effects of various lagging techniques on rectangular ductwork. Various sizes and gauges were considered, albeit surrounding the particular construction technique adopted at that time by Sound Attenuators Ltd. This experience made us fully aware of the timescale required to cover a reasonably representative number of parameters and put us in a good position to predict the cost of the laboratory based project for the ductwork and its fittings with respect to natural attenuation. This breakout testwork was incorporated as part of the ASHRAE programme handled by Istvan Ver and now published in the ASHRAE Guide.

In contrast, the concept of collating the considerable amount of site data, which is sometimes measured as a result of problem shooting, should also enable us to evaluate some of the parameters actually being obtained on site. Of course, in this situation the accuracy is generally considered to be of a lower standard than that of the laboratory and we have to try and uncouple the natural attenuation and flow generated noise if at all possible. Certainly, we would have the advantage of real application situations with interplay between units.

When searching back through the large quantity of site data with such inaccurate and not inconsiderable amount of trouble-shooting information, one found that it was inappropriately documented, as the problem in hand had necessarily led to many short-cuts and key information being omitted. Nevertheless, the indicators that the technique could be useful if appropriately monitored led us to the concept

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The author is fully aware of the dangers and shortcomings behind the proposal and would like to just dwell, as it were, on the philosophy behind it.

The idea was to obtain a vast quantity of data, generally in a site situation. This is not at all difficult. Obviously techniques would have to be optimised to more especially distinguish between flow noise and genuine natural attenuation, and subsidiary experiments would usually be performed in which the flow was throttled to minimise flow noise effects, albeit somewhat falsely. Also, the use of supplementary loudspeaker noise sources without flow in the region of the fan and other key noise generating sites would be incorporated in this correlation of data. It would be most necessary to record as much data as was sensible to plug the weaknesses of the trouble-shooting data mentioned before. This would, of course, lead to similar duct features being measured with a different interplay on the approach and exit from the unit, e.g., coils just before bend, coils just after bend, coils in substantially straight lengths of duct, etc..

It was also realised that there would be a large uncertainty in the measurement technique with respect to probing around in a duct cross-section with a microphone, this being the case even without the presence of flow. Nevertheless, it should be remembered that the accuracy of reverberation chamber measurements is not to be overrated, with ±2dB being quite respectable for a single investigatory concept. The interplay between concepts would necessarily increase this uncertainty, most probably towards ±4dB. So the author is not that convinced that one should get too paranoich about the useless uncertainty of site measurements, especially if one is approaching them with a sincere desire to unravel the information in a constructive manner to yield first-class applied guidance. It is realised that despite all these good intentions there will be unforeseen weaknesses.

So contrasting the two techniques, i.e., the laboratory approach and the site approach, the laboratory approach goes for a limited amount of fastidiously monitored accurate information, but, unfortunately, not as fully in the applied situation as we would perhaps desire. In contrast, the laboratory as a site technique was intended to establish a large portfolio of, let's say, less reliable data, from which a statistical approach would be able to set down some very clear guidance with realistic uncertainty expectancies from real-life situations.

To this end, a pilot scheme was undertaken by the author over a period of three days at the Student Union Building, Surrey University, Guildford. The lecture will present the findings of this 'outing', together with slide illustrations of the site situations and techniques involved. Certainly, everything did not go according to plan, and certainly contradictory results were achieved. Nevertheless, the usefulness of the technique was clearly demonstrated and with something like one hundred times as much information in various situations, could clearly have led to some most worthwhile practical applications guidance as is currently much required.