Low Frequency Noise Considerations In Ventilation Systems

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Low frequency noise in a building due to mechanical services can be difficult to predict, quantify or control. However, by careful consideration of the various factors, at the appropriate time, it can usually be overcome.

Criteria

The vast majority of buildings are specified to have a certain NC or NR level, as the maximum acceptable noise level in the space, based on the CIBSE Guide. While this works well for many situations, there have been several instances where it has limitations. For typical office use these design levels are as follows

Frequency	31.5	63	125	250	Hz
NC 35 =	-	60	52	45	dB
NR 35 =	79	63	52	45	dB

NC There is no specified limit in the 31.5 Hz octave, therefore no requirement to control noise below 45 Hz,

NR A 31.5 Hz octave band value is specified, but experience indicates that these levels are far too high.

It is therefore quite possible for a building to be subjectively unacceptable due to low frequency noise, yet fall within the specified noise criterion. An alternative that has been used in this country to a limited extent is the Preferred Noise Criterion PNC.

PNC 35 =	62	55	50	45	dB

This seems to appreciate the 31.5 Hz problem (17 dB less than the NR 35 equivalent), but also reduces the 63 Hz levels, with significant increase on attenuation and structural requirements.

A compromise would be to use the commonly accepted NC values, and to add a 31.5 Hz limit that is say 7 dB higher than the 63 Hz value.

Although one cannot reasonably perform calculations at these frequencies, problems most certainly do occur, and an effective specification will ensure that they are not dismissed as being outside the noise criterion.

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These problems are often due to poor selection/installation of equipment, and insufficient space to achieve good aerodynamic flow.

Since mechanical noise and vibration can also result in high levels of airborne sound below the 31.5 Hz octave, i.e. below 22 Hz, one could reasonably argue the case for a linear limit also.

Fans

These are the main source of ductborne noise, and will invariably require purpose made in duct attenuators to control it. From a contractual point of view, it is necessary to use the manufacturers data for the final analysis, but it is important to satisfy oneself that the quoted levels are reasonable. The current BS 848 Part II 1985, requires in duct noise levels to be directly measured. However, earlier data was often determined from tests where the outlet duct discharges into a test room. Such results would have to be corrected for end reflection, to achieve 'in duct' levels. Uncertainty over this aspect can lead to under attenuation of a system. If there is doubt, or for low noise installations the actual fan should be noise tested prior to despatch. On site tests invariably cannot be performed to the required Standards, and therefore may not be accepted by the manufacturer, even if they do give a fair representation of the noise level.

The installation of the fan in the system may change its noise level for the worse, particularly where space is very limited. It is these situations which must be spotted and the design changed to ensure a more reasonabe airflow to the fan. Unfortunately, there is inadequate information which quantifies all the effects creating low frequency noise, and the consultant's dilemma is to determine at which point the modified design is acceptable. In extreme cases the fan may have to be tested with the proposed system layout to determine the true 'as installed' level.

Selection of the fan operating point is important to ensure stable conditions. If selected near the top of the curve, pressure fluctuation and excessive low frequency noise may occur.

Different fan types will have varying frequency spectra, and to minimise attenuator size and cost, the one with lowest in duct sound power level in the 63, 125 and 250 Hz bands should be chosen, particularly for low noise areas. For commercial use, this option may not exist as a certain fan type may have to be used for cost/energy considerations, but it will result in a higher attenuator cost.

Ductwork

The conventional ductborne noise calculations to determine noise to the outlets will take off significant losses for high pressure terminal units, natural attenuation and end reflection losses. A duct breakout calculation will show this to be the weaker path.

The subsequent attenuator required to control duct breakout will depend heavily on the type of ductwork employed. Spiral wound circular ducts have very good low frequency control due to their inherent stiffness. On the other hand, rectangular and flat oval ducts have much poorer low frequency breakout control, and their use will often demand attenuators of much greater performance. It is important to achieve the required low frequency attenuation within the plantroom, as it cannot be effectively controlled by duct lagging.

Regenerated Noise

The frequency of the generated noise is dependent on the relative size of the fittings involved. Low frequency noise can therefore be expected in poor airflow in large ducts. High velocities in straight ducts generate fairly low levels of noise, but these significantly increase when the air is forced to abruptly change direction.

Again, this aspect relates very much to obtaining a reasonable layout of the fan, ductwork and fitting to ensure reasonable airflow conditions. Poor layout leads to uneven air distribution, higher pressure losses and subsequently an increase in fan and air noise. Many problems on site can be resolved by careful analysis of the 'as installed' drawings. Unfortunately, they cannot often be overcome by conventional 'noise control techniques', but demand modifications to the ductwork,with all the usual implications.

Commissioning

Incorrect or non existent commissioning will often manifest itself as a noise problem. The constant volume controllers used in high velocity systems tend to be fairly accurate, provided they are properly set, and the outlet volumes meet their design. If the system is then left, it is possible that the fan will be overpressuring the system, which can create fan pulsations, and excessive valve noise. Correct commissioning to achieve minimum lift off pressures, will reduce noise levels and also running costs if the fan speed can be reduced.

Blocked filters, poor flexible connections to valves and fans can all be sources of extra noise.

Needless to say, a system cannot be successfully commissioned, if it has not been designed with this in mind. Frustrated attempts to commission inadequate systems are more likely to increase noise.

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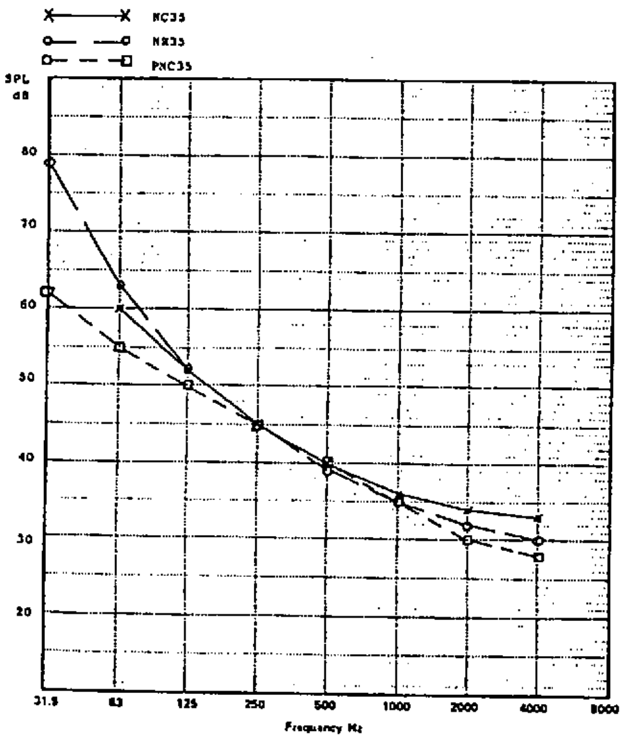
Problems

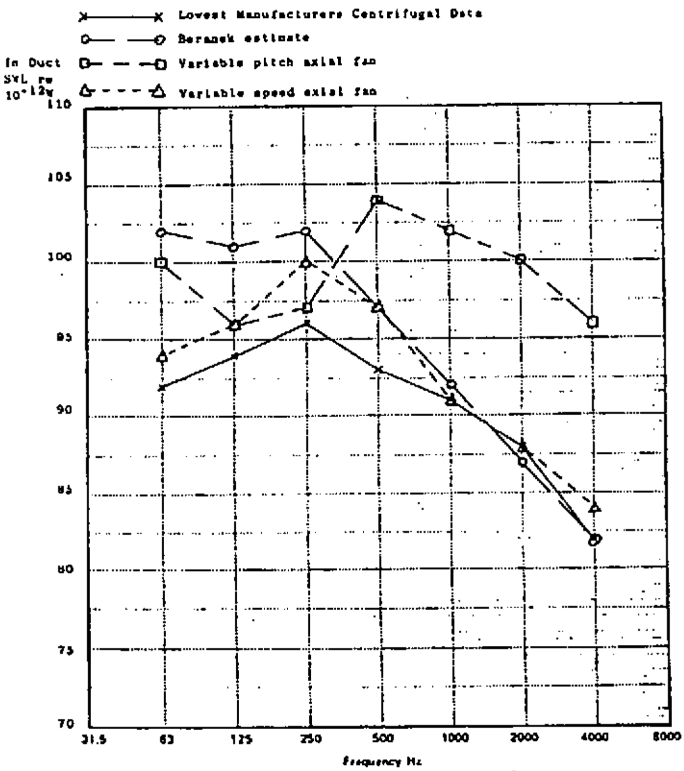
If noise levels are excessive it is important to adopt a methodical approach to solving the problems. Several parameters can be measured, on site, although not to the required standards, i.e. fan noise, attenuator performance, deflection of mounts etc, and they will build a picture of what is happening. Modifying airflow patterns by opening access panels or blanking the fan etc, can all provide very useful data, provided it is quantified by objective frequency related sound measurements.

There will often be parts of a system that do not match the 'text book' approach for good design, but this does not necessarily mean they are the cause of the noise, and much money can be thrown away on abortive remedial work.

VARIATIONS IN LOW FREQUENCY DESIGN REQUIREMENTS



TYPICAL VARIATION OF FAN SOUND POWER LEVEL FOR A DUTY OF 6 m^3/s AT 1200 Pa STATIC PRESSURE



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TYPICAL VARIATION IN LOW FREQUENCY BREAKOUT CONTROL BETWEEN VARIOUS TYPES OF DUCTWORK