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THE EFFECT OF DUCT SYSTEM DESIGN AND FINAL BALANCING ON AIRFLOW GENERATED NOISE IN AIR CONDITIONING SYSTEMS

R F Willmott

Sound Research Laboratories Limited, The Coach House,
49 East Street, Colchester, Suffolk, CO1 2TG

A ducted system is really a collection of dynamic elements which interact with each other and modify each other's performance. The physical relationship of each of the elements of the system is important in assessing the overall acoustic performance of the system. When designing a duct system to give low noise levels engineers should consider the equipment selection, the location of the various components and method of commissioning to ensure a satisfactory result. Ducted systems are generally made up of the following components -

Fans
Attenuators
Duct Sections
Bends and Branches
Dampers
Grilles
Terminal Units

Each of these components has its own aerodynamic characteristics which will be modified in different ways by adjacent items.

Fans

Fans fall into two basic groups.

Axial - which use aerodynamic principles to generate pressure differentials across a rotating aerofoil.

Centrifugal - which use the centrifugal force exerted by a volume of air within a rotating cage.

The location and proximity of elements of the services system can affect the sound power output of the fan. Axial fans are sensitive to flow disturbance on the inlet such as drive motor bodies (Form A running and loose flexibles) and on the discharge due to attenuators and turning vanes. Selection of the operating point of the fan system can also dramatically affect the low frequency noise output of the fan. The fan characteristics are not linear throughout their operating range and exhibit a flattening of the pressure volume characteristic at high operating pressures. If the fan operating point is selected close to this unstable operating point an unstable oscillation can occur.

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A momentary build up of pressure within the duct system causes the operating point of the fan to move up the pressure-volume operating characteristic to the point where the characteristic is negative. A flow collapse then occurs rapidly depressurizing the system and reverting the fan operating point to the start. The process then restarts and a sinusoidal oscillation having a peak pressure equal to the fan maximum operating pressure is set up. Thus from a fan system developing say 10"wg peak sinusoidal pressures of over the 100dB may be generated. The frequency of oscillation depends on a combination of the fan and system pressure volume characteristic.

Attenuators

Absorptive splitter or circular attenuators are used to reduce fan noise to an acceptable level for the ducted system. The acoustic attenuation of these units is usually selected by considering two noise transfer paths.

1) To the conditioned room

2) To other areas through which the duct system passes

but the passage of air through the attenuator and particularly the air turbulence at the attenuator discharge can make the unit itself a significant aerodynamic noise source in the sytem - particularly if the high velocity airstream associated with the attenuator reacts with other duct system elements (e.g. Bends and Turning Vanes).

This noise may then be propagated to the conditioned zones either by breakout from the duct walls or by airborne transmission through the system. Correct sizing of the attenuator to give low passage velocities or redesign of the duct system is the remedy.

Bends and Branches

Noise generation from Bends and Branches can be assessed accurately from formulae derived from laboratory test data but the data assumes that the flow onto the fitting is uniform and undisturbed. This is sometimes not the case and the designer should ensure that at least 5 duct diameters exist between fittings to ensure adequate flow settling.

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Diffusers

Manufacturers test data is based on linear, steady airflow to diffusers but again this rarely happens in practice. An increase of up to 20dB on manufacturer's data can be achieved by very poor inlet conditions.

System Balancing

When the system has been correctly designed and the correct location of the system elements has been established the final noise levels will be dependent on effective commissioning.

Low velocity duct systems are sized using the constant friction or velocity reduction methods and this means that the total system pressure will be absorbed along the index run (usually the point furthest from the fan). At intermediate points dampers will be necessary to absorb the excess pressure available and to thus regulate airflow.

Dampers are a source of noise in ventilation systems and so it is essential that the minimum pressure loss, consistent with airflow regulation, is maintained at each of the balancing dampers. The only way to achieve this is to regulate the system using the proportional balancing method. Using this method the major pressure losses occur at dampers closest to the fan and in this way the aerodynamic noise generated will benefit from system attenuation en route to the conditional space.

The basis of the proportional balancing system is to regulate adjacent terminals in proportion to each other and to work from the perimeter of the system towards the fan. Not only does this result in the quietest system but it is also the easiest and quickest to perform. High velocity systems, with the exception of induction unit systems, do not require manual regulation. But it may well be found that excessive pressure is available at the terminal units, due to oversizing of fans. This will result in excessive noise levels at terminal units and excessive energy consumption at fans. The correct procedure for commissioning high velocity systems therefore consists of determining the minimum operating fan pressure and reducing fan speed to give just sufficient pressure to operate the system.