BASICS OF DUCT DESIGN

A Further Word By Murray Mason, M.AIRAH

Abstract:

In the October 2002 issue of EcoLibrium,™ an article on the Basics of Duct Design by JJW Siganto was publ current article presents some additional basics in an effort to add to the information presented in the

Duct Sizing Methods

[illegible] easily balanced when commissioned.

The T-Method Optimisation optimises the duct design on the basis of system capital cost and the present worth of energy. It is described in detail in the ASHRAE Fundamentals Handbook. The author is not aware of this method being used in Australia.

Fitting Losses

Whilst fitting losses can be allowed for by allowing an equivalent length, more reliable and comprehensive data is available in the form of loss coefficients (k). Care must be taken when using this data however because different texts base loss coefficients on different velocities in the fitting eg. the branch path pressure loss for a divided flow fitting can be expressed as a k factor based on the branch duct velocity or based on the main or upstream duct velocity. These different loss coefficients are related by:

$k_u = k_B.(V_B / V_u)^2$

Where:

k_u = the loss coefficient based on the upstream velocity

k_B = the loss coefficient based on the branch velocity

V_u = the upstream duct velocity

V_B = the branch duct velocity

Hence the pressure loss through the branch path is:

$$1/2p \times k_u \times V_u^2 = 1/2p \times k_B \times V_B^2$$

(where p = density of air = 1.2 kg/m^2)

Designers should also be aware that for a number of fittings,

Another important consideration with fitting losses is that

particularly in an S configuration, in practice this often cannot be avoided, eg when ducts have to drop under beams. Clauses 6-40 to 6-120 of DA3 discuss the effects of fitting interaction and also the effects of poorly configured fan layouts.

Duct Attenuation

Published data on lined duct attenuation is generally very sparse. Much of the data is for only a limited set of sizes making interpolation for intermediate sizes extremely difficult. Duct attenuation is not linear, ie if you keep increasing the length of duct, the attenuation does not keep increasing in proportion. This is because of self-generated noise in the duct. Suppliers attempt to account for this by publishing attenuation for different lengths of duct. Thus we get the anomalous situation where two lengths of two metre duct either side of a transition gives (apparently), a higher attenuation to that of a four meter length of straight duct.

To determine the attenuation accurately, account must therefore be taken of self-generated noise in the duct. The same applies to fittings. The noise level in a duct system does not progressively decrease away from the fan until it reaches zero. There is a lower limit caused by self-generated noise.

Self-Generated Noise

Self-generated noise is generally proportional to velocity to the sixth power (pressure is proportional to the square of velocity), the duct cross sectional area, a characteristic dimension in the case of fittings and the frequency. The formulas though not excessively complex, do mean that a complete duct design including an acoustic analysis is very tedious and generally necessitates the use of a computer. If noise criteria of NR 25 or even NR 30 are to be achieved, a full acoustical analysis is essential.

Acoustical Analyis of a Ductwork System

The acoustical analysis of a ductwork system is normally carried out by calculating the sound power level along the ductwork system, starting with the fan. Taking account of the attenuation and self generated noise of ducts and fittings, the sound power at each air terminal is calculated. Some of this sound is reflected back up the duct leading to the terminal. The reflected noise is a function of the diameter of the duct at the connection to the terminal (the terminal neck diameter) and the frequency and design charts are available to determine this.

The noise emanating from the duct (after deducting the end reflection loss) is then added (logarithmically) to the noise generated by the air terminal to give the total noise entering the room at this point.

The sound pressure level at any “listener” position in the room is then calculated from the acoustical properties of the room (expressed as the room constant R), the directionality of the noise from the terminal (expressed as the directivity factor Q) and the distance (r) from the terminal to the listener position. Hence:

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