# 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 published. This current article presents some additional basics in an effort to add to the information presented in the original article.**

### Duct Sizing Methods

There is no single duct sizing method that will inherently give the 'best' duct design. Whilst most people are aware of the constant pressure gradient, constant velocity and static regain methods, there is a further method known as the balanced pressure drop method and yet another more recent method known as the T-Method Optimisation.

The balanced pressure drop method is described in the AIRAH Application Manual DA3 and involves sizing the duct layout using the constant pressure gradient or static regain method, determining the index run (the path with the greatest pressure drop) and then reducing the duct sizes in all other paths (without exceeding velocity limits) such that the out of balance pressure drop in each path is minimised. The objective of this method is to achieve a more nearly balanced system thereby reducing noise and making the system more 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, notably bends, the published data must be corrected for the angle of turn of the bend and also there is a Reynolds Number correction. This can give a significant increase in pressure drop at higher velocities (Refer clause 6-30 of DA3)

### Fitting Interaction

Another important consideration with fitting losses is that fittings in close proximity can have a higher (and in some cases lower) combined pressure loss. Whilst it is reasonable to say that fittings should not be located close together, 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

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