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Duct Design



What you will learn in this lesson

- Physics of air movement
- Reading pressure maps
- Duct system losses
- System curves
- Equal friction method of duct design

Ducts

- The term duct is taken from the Latin word “*ducere*” which means “to lead”. It is defined as a tube or canal by which a gas or liquid is conducted or conveyed
- Ducts have two main characteristics
 - Hold pressure with minimal leakage
 - Transport fluid with minimal energy loss

Bernoulli Principle

- Bernoulli's principle is named after the Dutch-Swiss mathematician Daniel Bernoulli who published his principle in his book *Hydrodynamica* in 1738.
- **Bernoulli's principle** states that for an inviscid flow*, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy
- This is the conservation of energy

*An inviscid flow is the flow of an ideal fluid that is assumed to have no viscosity.

Bernoulli Equation

$$\frac{V^2}{2} + \frac{P}{\rho} + g * z = C$$

Doesn't Change

Where:

V = streamline (local) velocity, fps

g = acceleration due to gravity , 32.2 lb_m-ft/lb_f

P = absolute pressure, lb_f/ft²

ρ = density, lb_m/ft³

z = elevation, ft

C = a constant, ft-lb_f/lb_m

Doesn't Change

Total Pressure

- Total pressure is the sum of velocity pressure and static pressure
- $TP = VP + SP$
- or: $VP = TP - SP$
- Remember: Velocity pressure will only be exerted in the direction of airflow and always be positive.

Pressure

- There are two forms of pressure within a duct
 - Velocity pressure
 - Static pressure
- Velocity pressure is a function of the velocity and density of air (dependant on altitude)
- Static pressure is a function of the quantity of air in an enclosed space

$$p_v = \rho \left(\frac{V}{1096} \right)^2$$

Pressure

- If we assume that air has a standard density of $0.075 \text{ lb}_m/\text{ft}^3$
- Then the equation reduces to:

$$p_v = \left(\frac{V}{4005} \right)^2$$

Velocity Pressure

- Velocity pressure cannot be measured directly in a duct but must be calculated
- Use a pitot tube

Losses in a System

- Friction losses
- Leakage
- Eddy currents

Losses in a System

- ASHRAE did a study of losses in different fittings
- R-Return
- S-Supply
- C-Common (Either R or S)

Losses in a System

- Once C_o is found, this value can be put into:

$$p_{\text{loss}} = p_v * C_o$$

Where:

p_{loss} = pressure loss through the fitting

p_v = velocity pressure going *into* the fitting

C_o = coefficient corresponding to the fitting

System Curve Equation

$$h=k*q^2$$

Where:

h = static pressure (head) provided by the fan

q = amount of flow in the system

k = system constant

- k will remain constant only if the system remains constant
- Quadratic equation → it can be solved!

Equal Friction Method

- **Find the critical path**-this determines your fan parameters!
- Select a unit pressure loss coefficient (Ex. use 0.1 in. of water/ 100ft²)
- Determine the required terminal pressure
 - Diffuser pressure drop
 - VAV box requirement
- Determine any restrictions on the depth of duct runs
- Measure lengths and determine air flow rates for entire run
- Establish maximum aspect ratio

Equal Friction Method

- Use charts, graphs or programs to find the friction loss
- If you use a friction loss chart, calculate the equivalent round duct size with the equation:

$$De = \frac{1.30 a b^{0.625}}{a + b^{0.250}}$$

- Where:
 - De = circular equivalent of rectangular duct for equal length, fluid resistance, and airflow, in.
 - a = length of one side of duct, in.
 - b = length of adjacent side of duct, in.

End of Lesson

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Questions?