



GREENPRINTS

# The Relationship Between Duct Aspect Ratio and Sustainability

(Extracted from Understanding the LEED Commissioning Requirements)

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Sustainable Communities *by Design*





# FLOW

## Relationships

Performance Data

Fan Curves  
Size 21

Figure PD-32 -- 21VVF -- Size 21 Vertical/Trip Front

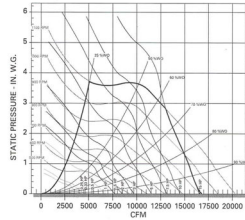


Image courtesy of the Greenheck website

### Fan Laws

Apply to a fixed system

$$\left( \frac{Flow_{New}}{Flow_{Old}} \right) = \left( \frac{Speed_{New}}{Speed_{Old}} \right)$$

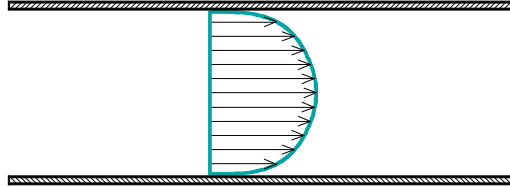
$$\left( \frac{Fan\ Static_{New}}{Fan\ Static_{Old}} \right) = \left( \frac{Flow_{New}}{Flow_{Old}} \right)^2$$

$$\left( \frac{Horsepower_{New}}{Horsepower_{Old}} \right) = \left( \frac{Flow_{New}}{Flow_{Old}} \right)^3$$





# FLOW Relationships



From the Darcy - Weisbach Equation

$$H_L \propto V^2$$

Where:

$H_L$  = Friction loss for fully developed conduit flow

$V$  = Fluid velocity

The Complete Darcy-Weisbach equation is:

$$H_L = f \left( \frac{L}{D} \right) \left( \frac{V^2}{2g} \right)$$

Also, since:

$$Q = VA$$

Where:

$Q$  = Flow rate

$A$  = Area

Then, it can be seen that:

$$H_L \propto Q^2$$

Note that the exponent of 2 is approximate. The actual theoretical number is more like 1.89. But, using 2 is good enough for most HVAC work.



# FLOW Relationships

For fittings:

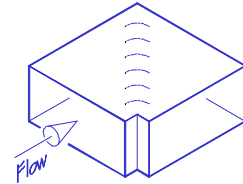
$$\Delta p_{\text{fitting}} = C_o p_{\text{velocity}}$$

Where:

$\Delta p_{\text{fitting}}$  = Fitting pressure loss

$C_o$  = Local loss coefficient

$p_{\text{velocity}}$  = Velocity pressure



Velocity pressure is **VERY** significant:

$$V = 4,005 \sqrt{p_{\text{velocity}}}$$

Therefore:

$$p_{\text{velocity}} = \left( \frac{V}{4,005} \right)^2$$



# FLOW Relationships

*Looking at Different Options for Moving 10,000 cfm at a Nominal .2 in.w.c./100 ft.,  
2 inch Pressure Class Duct*

Duct Size - inches			Aspect Ratio	Cross Sectional Area - sq.ft.	Perimeter - ft.	Ratio of Cross Sectional Area to Perimeter	Gauge	Pounds of Sheetmetal per lineal foot of duct	Velocity - fpm
Height	Width	Diameter							
N/A	N/A	29.0	N/A	4.59	7.59	0.60	24	9.10	2,180
26.5	26.5	N/A	1.0	4.88	8.83	0.55	26	8.00	2,051
18.0	41.0	N/A	2.3	5.13	9.83	0.52	24	11.37	1,951
14.0	56.0	N/A	4.0	5.44	11.67	0.47	24	13.49	1,837
12.0	70.0	N/A	5.8	5.83	13.67	0.43	24	15.80	1,714

Round duct weight information based on spiral construction.

As a general rule, round or low aspect ratio ducts will provide most cost effective solution for moving a given volume of air at a given friction rate.

Note:

- They contain the largest volume per unit of wetted perimeter length.
- They tend to have the lowest weight per contained volume. This is somewhat a function of the specific construction technique used.
- They will tend to be structurally more rigid, especially round ducts.
- Due to the structural rigidity, they will produce less noise, especially drumming.

Also note how the velocities in the round and lower aspect ratio ducts are higher for the same volume and friction rate as compared to ducts with higher aspect ratios. This means that you may need to be more attentive to fitting design and other details where the losses are a function of the velocity pressure.



# FLOW Relationships

*Velocities and Velocity Pressures in Small vs. Large Ducts at Equal Friction Rates*

Duct Size - inches			Aspect Ratio	Cross Sectional Area - sq. ft.	Perimeter - ft.	Ratio of Cross Sectional Area to Perimeter	CFM Capacity at a Friction Rate of .15 in.w.c. per 100 ft.	Velocity - fpm	Velocity Pressure in.w.c.
Height	Width	Diameter							
N/A	N/A	6.0	N/A	0.20	1.57	0.13	130	662	0.03
N/A	N/A	48.0	N/A	12.57	12.57	1.00	32,000	2,546	0.40
6.0	12.0	N/A	2.0	0.50	3.00	0.17	420	840	0.04
24.0	48.0	N/A	2.0	8.00	12.00	0.67	16,500	2,063	0.27

The difference in velocity associated with the same friction rate in a large duct as compared to a small duct can be very significant. The ratio of cross sectional area enclosed to perimeter length is much larger for big ducts. This means that for a large duct, the impact of resistance to flow due to friction with the duct wall is much less significant because a much lower percentage of the enclosed air is in contact with the wall. As a result, the air in a large duct is moving at a much higher velocity than it would in a smaller duct selected at the same friction rate. If the velocities are higher, then the velocity pressures in the larger ducts will also be higher as compared to a smaller duct applied at the same friction rate.

Since fitting pressure drop is related to duct velocity and duct velocity pressure, the impact of a poor fitting solution or design in a large duct can be much more significant than it would be in a smaller duct, even though the friction rate for both ducts is identical. Thus, it is important to pay particular attention to the details of fitting design in large ducts.