$$\dot{Q}_{total} = 3750\frac{Btu}{hr} + 10,000\frac{Btu}{hr} + 2880\frac{Btu}{hr} + 6480\frac{Btu}{hr} = 23,110\frac{Btu}{hr}$$

Answer D

43.9 In an effort to allow for increased ceiling heights, a design engineer specifies a 3:1 aspect ratio for a duct that delivers $500cfm$. The velocity is to be kept under $400fpm$. What is the dimension of the long side of the duct?

A. $13in$

B. $14in$

C. $23in$

D. $24in$

Solve for the minimum area required to keep the velocity under the maximum:

$$Q = VA$$

$$A = \frac{Q}{V} = \frac{500\frac{ft^3}{min}}{400\frac{ft}{min}} = 1.25ft^2\left(\frac{12in}{1ft}\right)^2 = 180in^2$$

Let the short side of the duct have length x and the long side have a length of $3x$ to achieve a 3:1 aspect ratio. Write an expression for the area and solve for the length of the short side, x.

$$3x^2 = 180in^2$$

$$x = 7.74in$$

The duct dimensions must be integers. Since $7 < 7.74 < 8$, the short side may be $7in$ or $8in$ in length. Generate several possible sets of dimensions for consideration:

$$7 \times 23 \rightarrow A = 161in^2 < 180in^2\ (insufficient)$$

$$7 \times 24 \rightarrow A = 168in^2 < 180in^2\ (insufficient)$$

$$8 \times 23 \rightarrow (not\, 3:1\, ratio)$$

$$8 \times 24 \rightarrow A = 192in^2 > 180in^2,\ 3:1\, ratio\ OK,\ V < 400fpm$$

The long side is $24in$.

Answer D

43.10 The pressure loss in a duct is $1.2 in\,wg$ when the flow rate is $2500 cfm$. If the fan slows down to $2000 cfm$, what is the new pressure under reduced speed conditions?

A. $0.8 in\,wg$

B. $1.0 in\,wg$

C. $1.5 in\,wg$

D. $1.9 in\,wg$

Look up Fan Affinity Laws in the Reference Handbook and see the table called Fan Laws. Choose Law #3b:

$$P_1 = P_2 \times \left(\frac{D_2}{D_1}\right)^4 \left(\frac{Q_1}{Q_2}\right)^2 \left(\frac{\rho_1}{\rho_2}\right)$$

There is no indication that the fan diameter is being changed. Therefore assume $D_1 = D_2$. The density of the air under the new conditions may also be assumed to be unchanged. Therefore assume $\rho_1 = \rho_2$. Simplify:

$$P_1 = P_2 \times \left(\frac{Q_1}{Q_2}\right)^2$$

Note: It may be advisable to memorize some common uses of the fan laws where only one parameter is being adjusted. It is common to recall that pressure is a function of the volume flow rate squared.

For convenience, swap the subscripts and make a quick table to ensure proper handling of knowns and unknowns. Let condition 1 be the existing fan and condition 2 be for reduced speed.

$$P_2 = P_1 \times \left(\frac{Q_2}{Q_1}\right)^2$$

Parameter	Condition 1	Condition 2
$Q_{[cfm]}$	2500	2000
$P_{[in\,wg]}$	1.2	P_2

Solve for P_2 :

$$P_2 = 1.2 in\,wg \times \left(\frac{2000 cfm}{2500 cfm}\right)^2 = .77 in\,wg$$

Note there is a nonlinear reduction in pressure. This should be consistent with intuition as pressure changes with the square of the speed (and volume flow rate).

Answer A