

**44.21** What is the friction loss for 1000cfm being delivered by a 14in × 8in duct? Assume a friction factor of 0.015.

- A. 0.15in wg/100ft
- B. 0.25in wg/100ft
- C. 0.40in wg/100ft
- D. 0.50in wg/100ft

This problem is straightforward using the Frictions Loss chart for ductwork; however, if not supplied within the problem statement, since the chart is not included in the Reference Handbook, a manual solution is required using the **Darcy Equation**.

Calculate the **Circular Equivalent** diameter of a round duct by using the formula in the Reference Handbook under **Rectangular Ducts**. Round up to a nominal duct size.

$$D_e = \frac{1.30 (ab)^{0.625}}{(a + b)^{0.250}}$$

$$D_e = \frac{1.30 [(14in)(8in)]^{0.625}}{(14in + 8in)^{0.250}} = 11.46in \approx 12in$$

Calculate the velocity using the volume flow rate and area:

$$Q = vA \rightarrow v = \frac{Q}{A}$$

$$v = \frac{1000 \frac{ft^3}{min}}{\frac{\pi}{4} (1ft)^2} = 1273 \frac{ft}{min} \left( \frac{1min}{60s} \right) = 21.2 \frac{ft}{s}$$

Find the friction loss per 100 ft, to align with the answer choices:

$$h_f = \frac{fLv^2}{2Dg}$$

$$h_f = \frac{(.015)(100ft) \left( 21.2 \frac{ft}{s} \right)^2}{2(1ft) \left( 32.2 \frac{ft}{s^2} \right)} = 10.5ft \left( \frac{12in}{1ft} \right) = 126in (air)$$

The pressure loss should be measured in inches of water rather than inches of air. To approximate the height of a water column that would support an air column of a given height, multiply by the ratio of the densities of air and water. As an intuitive check, the density of air is about 0.1% of the density of water.

$$h_f = 126in air \left( \frac{.075 \frac{lb}{ft^3}}{62.4 \frac{lb}{ft^3}} \right) = .15in wg$$

**Answer A**

44.22  $30 \frac{lb}{hr}$  of 5psig steam is supplied to a heating coil for an air handler delivering 1000cfm of outside air. The entering outside air is  $50^\circ F$  dry bulb and  $45^\circ F$  wet bulb. The coil bypass factor is 0.1. What is the temperature of the air leaving the heating coil?

- A.  $74^\circ F$
- B.  $75^\circ F$
- C.  $77^\circ F$
- D.  $78^\circ F$

Look up the enthalpy of vaporization for steam at 5psig  $\approx 20psia$  in the steam table, **Properties of Saturated Water**, in the Reference Handbook. Calculate the heat being added by the steam:

$$\dot{Q}_{steam} = \dot{m}\Delta h = \dot{m}h_{fg}$$

$$\dot{Q}_{steam} = \left(30 \frac{lb}{hr}\right) \left(960 \frac{Btu}{lb}\right) = 28,800 \frac{Btu}{hr}$$

The heating coil adds only sensible heat to the air stream. Use the sensible heating rule of thumb to calculate the leaving air temperature i.e. supply air temperature. Assume the coil efficiency is 100% for the time being.

$$\dot{Q}_{steam} = \dot{Q}_{air} = 1.08cfm\Delta T$$

$$1.08(1000)(T_{SA,\eta 100} - 50) = 28,800 \frac{Btu}{hr}$$

$$T_{SA,\eta 100} = 76.7^\circ F (\eta = 100\%)$$

Account for the bypass factor, which is the complement of coil efficiency. The air would be heated to a temperature of  $76.7^\circ F$  if the heating process were 100% efficient; therefore, it is expected that the final supply air temperature will be slightly lower.

$$\eta_{coil} = 1 - BF = 1 - 0.1 = 0.9 = 90\%$$

$$\eta_{coil} = \frac{T_{SA,\eta 90} - T_{EA}}{T_{SA,\eta 100} - T_{EA}}$$

$$0.9 = \frac{T_{SA,\eta 90} - 50^\circ F}{76.7^\circ F - 50^\circ F}$$

$$T_{SA,\eta 90} = 74^\circ F (\eta = 90\%)$$

**Answer A**