

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

44.23 A cooling coil with a sensible capacity of 10tons is designed for a 20°F delta T. The air handler is installed in a facility at 5000ft elevation and must produce a total static pressure of 2.5in wg. Assuming the fan is 92% efficient, what should be the nominal size of the fan motor?

- A. 1½hp
- B. 2hp
- C. 2½hp
- D. 3hp

Convert the sensible capacity to units of $\frac{Btu}{hr}$:

$$\dot{Q}_s = (10tons) \left(12,000 \frac{Btu}{hr \cdot ton} \right) = 120,000 \frac{Btu}{hr}$$

The sensible heating and cooling rule of thumb is not valid due to the elevation; however, the section [Heat Gain Calculations Using Standard Air Values](#) offers a slight adaptation for air at 5,000 ft. Update the constant in the rule of thumb and proceed with calculating the cfm. Note, the section for [Elevation Correction](#) may be useful for other nonstandard elevations.

$$\dot{Q}_s = 0.92cfm\Delta T$$

$$cfm = \frac{\dot{Q}_s}{(.92)(\Delta T)} = \frac{120,000}{(.92)(20)} = 6522cfm$$

Look up [Efficiency of Fan](#) in the Reference Handbook and use the formula right above the search result to calculate the air horsepower needed to provide the required volume flow rate against the pressure drop given. Units need not be shown provided the volume flow rate is in cfm and the pressure drop is in in wg. In a separate step, consider the efficiency to determine the brake horsepower.

$$AHP = \frac{Q_{[cfm]}\Delta P_{[in\ wg]}}{6356}$$

$$AHP = \frac{(6522)(2.5)}{6356} = 2.57hp$$

$$\eta_{fan} = \frac{AHP}{BHP} \rightarrow BHP = \frac{AHP}{\eta_{fan}}$$

$$BHP = \frac{2.57hp}{.92} = 2.79hp$$

Motor sizes are always rated in BHP. Round up to the nearest nominal motor size. For a list of standard motor sizes and efficiencies, look up [Average Efficiencies Representing Typical Electric Motors](#) in the Reference Handbook. 3HP is included in the list.

Answer D