

32.25 A steam heating coil is supplied with $2\frac{lb}{min}$ of $5psig$ saturated steam which leaves the coil with a quality of 0.25 . The coil is used to heat $5000cfm$ of air. What is the maximum increase in air temperature that can be expected?

- A. $5^\circ F$
- B. $16^\circ F$
- C. $17^\circ F$
- D. $21^\circ F$

To find the maximum possible increase in air temperature, assume 100% efficiency for the steam coil. All the heat provided by the steam is added to the air.

$$\dot{Q}_{steam} = \dot{Q}_{air}$$

Write an expression for the steam based on mass flow rate and the change in enthalpy, and express the heat gain by the air using the sensible heating rule of thumb for air. Solve for ΔT for the air.

$$\dot{m}_{steam}\Delta h = 1.08cfm\Delta T$$

$$\Delta T = \frac{\dot{m}_{steam}\Delta h}{1.08cfm}$$

Use the **Properties of Saturated Water and Steam** table by pressure to obtain the change in enthalpy for $5psig$ steam. The steam enters as saturated steam and therefore has enthalpy h_g , and leaves with a quality of $\chi = 0.25$. Remember to convert from $psig$ to $psia$ before selecting enthalpy values and solving for the enthalpy of the leaving steam, h_2 .

$$P = 5psig \approx 20psia$$

$$h_1 = h_g = 1156.2\frac{Btu}{lb}$$

$$h_{fg} = 959.9\frac{Btu}{lb}$$

$$h_f = 196.3\frac{Btu}{lb}$$

$$h_2 = h_f + \chi_2 h_{fg}$$

$$h_2 = 196.3\frac{Btu}{lb} + (0.25)\left(959.9\frac{Btu}{lb}\right) = 436.3\frac{Btu}{lb}$$

Calculate ΔT . Make sure to convert minutes to hours such that the numerator has units of $\frac{Btu}{hr}$. The sensible heating rule of thumb for air guarantees the air side of the equation will align, and the final answer will have units of $^{\circ}F$.

$$\Delta T = \frac{\left(2 \frac{lb}{min}\right) \left(\frac{60 min}{hr}\right) \left(1156.2 \frac{Btu}{lb} - 436.3 \frac{Btu}{lb}\right)}{(1.08) (5000) \frac{Btu}{hr \cdot ^{\circ}F}} = 15.9^{\circ}F$$

Answer B