

**37.13** During winter operation, 5,000CFM of outside air at 40°F and 60% relative humidity is pre-heated with a 50KW electric coil, then humidified to 50% relative humidity. What is the total increase in heat?

- A. 46,000  $\frac{Btu}{hr}$
- B. 124,000  $\frac{Btu}{hr}$
- C. 170,000  $\frac{Btu}{hr}$
- D. 300,000  $\frac{Btu}{hr}$

Use the rule of thumb for total heat added to air, including both sensible and latent:

$$Q_t = 4.5cfm\Delta h$$

The entering condition, state 1, is fully defined for the outside air. Use the [Psychrometric Chart](#) to look up the enthalpy:

$$T_{1,db} = 40^\circ F$$

$$\phi_1 = 60\%$$

$$h_1 = 13 \frac{Btu}{lb}$$

Define state 2 as the condition after the sensible heating but before the humidification. Define state 3 as the final condition after the humidification. Only the relative humidity is known for state 3. Therefore, it is necessary to work with state 2 to gather more information that will be relevant for state 3.

The process from 1 → 2 is sensible heating of a known quantity. Use the sensible rule of thumb to determine the dry bulb temperature at state 2. The quantity of heating is the capacity of the electric coil. Convert units from KW to  $\frac{Btu}{hr}$ .

$$Q_s = 1.08cfm\Delta T$$

$$\Delta T = \frac{Q_s}{1.08cfm} = \frac{(50KW) \left(3412 \frac{Btu}{hr \cdot KW}\right)}{(1.08)(5000)} = 31.6^\circ F$$

$$\Delta T = T_2 - T_1 = 31.6^\circ F$$

$$T_2 = T_1 + 31.6^\circ F = 40^\circ F + 31.6^\circ F = 71.6^\circ F$$

The process 2 → 3 is latent heating which is vertically up on the psychrometric chart. Latent heating does not change the dry bulb temperature. Therefore:

$$T_3 = T_2 = 71.6^\circ F$$

Now state 3 is fully defined since the relative humidity was given:

$$\phi_3 = 50\%$$

Look up the enthalpy at state 3 on the psychrometric chart:

$$h_3 = 26.2 \frac{\text{Btu}}{\text{lb}}$$

Substitute and solve the original formula for the total heat gain:

$$Q_t = 4.5 \text{cfm} \Delta h = 4.5 \text{cfm} (h_3 - h_1)$$

$$Q_t = 4.5 (5000) (26.2 - 13) = 297,000 \frac{\text{Btu}}{\text{hr}}$$

**Answer D**