

36.12 A cooling tower cools 150gpm of condenser water maintaining a 15°F delta T. On a design day, air enters the cooling tower at 90°F dry bulb and 75°F wet bulb and leaves at 105°F dry bulb and 80% relative humidity. What volume flow rate of air through the cooling towers is required?

- A. 8,100CFM
- B. 12,500CFM
- C. 69,400CFM
- D. 119,700CFM

The quantity of heat removed from the air is added to the condenser water. Therefore:

$$Q_a = Q_w$$

The sensible heating of the condenser water can be determined using the rule of thumb, where the flow rate and differential temperature are known:

$$Q_w = 500\text{gpm}\Delta T = 500(150)(15) = 1,125,000 \frac{\text{Btu}}{\text{hr}}$$

The heat removed from air in a cooling tower is driven by a substantial amount of evaporation; therefore, use the rule of thumb for *total* cooling of air (including both sensible and latent) should be used:

$$Q_a = 4.5\text{cfm}\Delta h$$

where the volume flow rate of air is unknown. To specify the change in enthalpy, use the **Psychrometric Chart** to look up the enthalpy values for entering and leaving conditions, both of which are fully defined. Use of the **High Temperature** psychrometric chart is required for State 2.

State 1: Entering Air	State 2: Leaving Air
$T_{1,db} = 90^\circ F$	$T_{2,db} = 105^\circ F$
$T_{1,wb} = 75^\circ F$	$T_{2,wb}$
ϕ_1	$\phi_2 = 80\%$
$h_1 = 38.4 \frac{\text{Btu}}{\text{lb}}$	$h_2 = 69.4 \frac{\text{Btu}}{\text{lb}}$

Calculate the change in enthalpy:

$$\Delta h = h_2 - h_1 = 69.4 \frac{\text{Btu}}{\text{lb}} - 38.4 \frac{\text{Btu}}{\text{lb}} = 31 \frac{\text{Btu}}{\text{lb}}$$

Use the fact that $Q_a = Q_w$ to solve for the unknown volume flow rate. Note that by using the rule of thumb selected, the units will automatically come out in *cfm* provided the enthalpy is in $\frac{\text{Btu}}{\text{lb}}$ and the heat transfer is in $\frac{\text{Btu}}{\text{hr}}$.

$$\text{cfm} = \frac{1,125,000}{(4.5)(31)} = 8065\text{cfm}$$

Answer A