

46.11 10,000cfm of air enters a cooling coil at 78°F and 60% relative humidity and exits at 58°F db / 54°F wb. At what rate is condensate removed?

- A. $0.5 \frac{gal}{hr}$
- B. $6 \frac{gal}{hr}$
- C. $23 \frac{gal}{hr}$
- D. $190 \frac{gal}{hr}$

Consider the air entering the coil as State 1 and the air leaving the coil as State 2. Both states are fully defined. Use the **Psychrometric Chart** to look up the humidity ratio for both states. Also obtain the specific volume for the entering air condition.

$$T_{1,db} = 78^\circ F$$

$$\phi_1 = 60\%$$

$$\omega_1 = 0.01235 \frac{lb_w}{lb_{da}}$$

$$v_1 = 13.88 \frac{ft^3}{lb_{da}}$$

$$T_{2,db} = 58^\circ F$$

$$T_{2,wb} = 54^\circ F$$

$$\omega_2 = 0.00798 \frac{lb_w}{lb_{da}}$$

Use the formula under **Moist-Air Cooling and Dehumidification** to quantify the mass flow rate of water vapor being condensed from the air stream as it flows through the cooling coil.

$$\dot{m}_w = \dot{m}_a (\omega_1 - \omega_2)$$

Express the mass flow rate of air entering the coil as the product of the density and volume flow rate. Substitute for density using $\rho_1 = \frac{1}{v_1}$.

$$\dot{m}_a = \rho Q = \frac{Q}{v_1} = \frac{10,000 \frac{ft^3}{min}}{13.88 \frac{ft^3}{lb_{da}}} = 720.46 \frac{lb_{da}}{min}$$

Substitute and solve for the mass flow rate of condensate removed. Convert *minutes* to *hours* and lb_w to gal .

$$\dot{m}_w = \left(720.46 \frac{lb_{da}}{min} \right) \left(\frac{60min}{1hr} \right) \left(0.01235 \frac{lb_w}{lb_{da}} - 0.00798 \frac{lb_w}{lb_{da}} \right) \left(\frac{1gal}{8.34lb_w} \right) = 22.65 \frac{gal}{hr}$$

Answer C

46.12 $55^{\circ}F$ chilled water at 150psig enters a 10ton cooling coil and leaves at $65^{\circ}F$ and 135psig after passing through the coil and the control valve located on the return side. Under these conditions, the cooling coil control valve is backed off by 50% and the coil is providing half of its rated capacity. The pressure drop through the coil is 10ft of water. What is the required control valve flow coefficient?

- A. 1.1
- B. 2.4
- C. 3.7
- D. 5.4

The total pressure drop is the sum of the pressure drop through the coil and the pressure drop through the valve. Solve for the pressure drop through valve only. Use the conversion factor rule of thumb for water to align units to psi .

$$\Delta P_{total} = \Delta P_{coil} + \Delta P_{valve}$$

$$\Delta P_{valve} = \Delta P_{total} - \Delta P_{coil} = 15\text{psi} - (10\text{ft}) \left(\frac{1\text{psi}}{2.31\text{ft}} \right) = 10.67\text{psi}$$

Use the formula under **Valve Flow Coefficient** which depends on the volume flow rate and pressure drop.

$$C_v = \frac{Q}{\sqrt{\Delta P}}$$

Use the sensible cooling rule of thumb for water to determine the volume flow rate. Since the coil is operating at half its rated capacity, use 5tons rather than 10tons . Provided \dot{Q} is in $\frac{\text{Btu}}{\text{hr}}$ and the temperature range is in $^{\circ}F$, the volume flow rate will be in gpm as required and units need not be written.

$$\dot{Q} = 500\text{gpm}\Delta T$$

$$\text{gpm} = \frac{\dot{Q}}{500 \cdot \Delta T} = \frac{5(12,000)}{500(65 - 55)} = 12\text{gpm}$$

Solve for the valve flow coefficient, C_v . The volume flow rate must be in gpm and the pressure drop must be in psi . C_v is unitless.

$$C_v = \frac{12}{\sqrt{10.67}} = 3.67$$

Answer C