

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 $\frac{Btu}{hr}$ 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

46.13 2000cfm of 55°F conditioned air with 40% relative humidity enters a kitchen where it collects heat and moisture before being extracted as 80°F air with 70% relative humidity. What is the rate of moisture removal from the kitchen?

- A. $1.8 \frac{lb_m}{min}$
- B. $2.4 \frac{lb_m}{min}$
- C. $2.8 \frac{lb_m}{min}$
- D. $3.4 \frac{lb_m}{min}$

Let state 1 be the entering air conditions and state 2 be the leaving air conditions. Use the [Psychrometric Chart](#) to find the humidity ratio for both states. Note the specific volume for the entering air condition.

$$T_1 = 55^\circ F$$

$$\phi_1 = 40\%$$

$$\omega_1 = 0.0037 \frac{lb_{h_2o}}{lb_{da}}$$

$$v_1 = 13.1 \frac{ft^3}{lb_{da}}$$

$$T_2 = 80^\circ F$$

$$\phi_2 = 70\%$$

$$\omega_2 = 0.0155 \frac{lb_{h_2o}}{lb_{da}}$$

Although this problem is about adding moisture to air, the formula found by searching [Moist-Air Cooling and Dehumidification](#) can be used with the expectation that the humidity ratio for the leaving air at state 2 will be greater than that of the entering air at state 1. It is valid to interchange ω_2 and ω_1 to reflect this understanding.

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

The mass flow rate of dry air entering at state 1 can be expressed as volume flow rate times density or volume flow rate divided by specific volume.

$$\dot{m}_{da} = \rho Q = \frac{Q}{v_1} = \frac{2000 \frac{ft^3}{min}}{13.1 \frac{ft^3}{lb_{da}}} = 152.7 \frac{lb_{da}}{min}$$