

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.

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

Determine the mass flow rate of water being added to the air.

$$\dot{m}_w = \left(152.7 \frac{\text{lb}_{da}}{\text{min}}\right) \left(0.0155 \frac{\text{lb}_{h2o}}{\text{lb}_{da}} - 0.0037 \frac{\text{lb}_{h2o}}{\text{lb}_{da}}\right) = 1.8 \frac{\text{lb}_m}{\text{min}}$$

Answer A

46.14 Water traveling at 2fps in a nominal 5in pipe is combined with water traveling at 5fps in a nominal 3in pipe at a tee connection. Downstream of the tee, the piping has a nominal 6in diameter. What is the velocity downstream of the tee?

- A. 1.3fps
- B. 1.9fps
- C. 2.7fps
- D. 3.9fps

Sketch and label the tee connection with the given information. Designate the entering flows as 1 & 2 and the exiting flow as 3. The volume flow rate exiting the tee is equal to the sum of the volume flow rates entering the tee.

$$Q_1 + Q_2 = Q_3$$

Apply the **Continuity Equation** and replace the volume flow rates with the products of their respective velocities and areas.

$$Q = Av$$

$$A_1v_1 + A_2v_2 = A_3v_3$$

Solve for the the velocity downstream of the tee, v_3 .

$$v_3 = \frac{A_1v_1 + A_2v_2}{A_3}$$

Express area as a function of internal diameter for each connection to the tee and substitute accordingly, cancelling the $\frac{\pi}{4}$ which is common to all terms.

$$A = \frac{\pi}{4}D^2$$

$$v_3 = \frac{\frac{\pi}{4}D_1^2v_1 + \frac{\pi}{4}D_2^2v_2}{\frac{\pi}{4}D_3^2} = \frac{D_1^2v_1 + D_2^2v_2}{D_3^2}$$

Gather inside diameter values from the table by searching **Schedule 40 Steel Pipe**. Substitute and solve for the velocity, v_3 .