**41.12** **$2000cfm$ of air at $72°F$ dry bulb and $58°F$ wet bulb is cooled and humidified by an air washer with a bypass factor of 20%. What is the humidity ratio of the leaving air?**

A. $0.007\frac{lb_w}{lb_{da}}$

B. $0.008\frac{lb_w}{lb_{da}}$

C. $0.010\frac{lb_w}{lb_{da}}$

D. $0.011\frac{lb_w}{lb_{da}}$

An air washer simultaneously cools and humidifies entering air. This is called evaporative cooling. An air washer's efficiency is a function of the entering air wet bulb temperature.

$$\varepsilon = \frac{(T_1 - T_2)}{(T_1 - T_s^{'})}$$

where $T_1$ is the entering air dry bulb temperature, $T_2$ is the leaving air dry bulb temperature, and $T_s^{'}$ is the wet bulb temperature of the entering air. As the leaving air dry bulb temperature, $T_2$, approaches the entering air wet bulb temperature, $T_s^{'}$, the saturation efficiency approaches 100%.

If some of the entering air does not make contact with the water spray, it is called *bypass*, and no water is evaporated into this portion of the air stream, nor is it cooled in the process. More bypass implies reduced efficiency. If there was zero bypass, the saturation efficiency would be 100%. The bypass factor can be expressed as:

$$BF = 1 - \varepsilon = 20\%$$

$$\varepsilon = 1 - .2 = .8 = 80\%$$

Since the entering air dry bulb temperature, the entering air wet bulb temperature, and the saturation efficiency are known, the leaving air dry bulb temperature can be calculated:

$$\varepsilon = \frac{(T_1 - T_2)}{(T_1 - T_s^{'})} \rightarrow \varepsilon\left(T_1 - T_s^{'}\right) = (T_1 - T_2) \rightarrow T_2 = T_1 - \varepsilon\left(T_1 - T_s^{'}\right)$$

$$T_2 = 72°F - (.8)\,(72°F - 58°F) = 60.8°F$$

The leaving condition is now fully defined. Use the psychrometric chart to look up the humidity ratio at state 2:

$$T_{2,db} = 60.8°F$$

$$T_{2,wb} = 58°F$$

$$\omega_2 = 0.0096\frac{lb_w}{lb_{da}}$$

**Answer C**

**41.13 Air at $90°F$ dry bulb and $75°F$ wet bulb enters a cooling tower and leaves at $80°F$ saturated. What is the change in moisture content per cubic foot of air?**

A. $0.0005\frac{lb_w}{ft^3}$

B. $0.007\frac{lb_w}{ft^3}$

C. $0.4\frac{lb_w}{ft^3}$

D. $5.2\frac{lb_w}{ft^3}$

Refer to the entering air condition as state 1 and the leaving air condition as state 2. Both states are fully defined. Use the psychrometric chart to find the humidity ratio for both states, then calculate the difference. Also find the specific volume for state 1.

$$T_{1,db} = 90°F$$

$$T_{1,wb} = 75°F$$

$$\omega_1 = 0.0153\frac{lb_w}{lb_{da}}$$

$$v_1 = 14.2\frac{ft^3}{lb_{da}}$$

$$T_{2,db} = 80°F$$

$$T_{2,wb} = 80°F$$

$$\omega_2 = 0.0223\frac{lb_w}{lb_{da}}$$

$$\Delta\omega = \omega_2 - \omega_1 = 0.0223\frac{lb_w}{lb_{da}} - 0.0153\frac{lb_w}{lb_{da}} = .007\frac{lb_w}{lb_{da}}$$

In order to express the humidity per unit volume rather than per unit mass of dry air, divide $\Delta\omega$ by the specific volume of the entering air, $v_1$. The reference handbook calls this the absolute humidity or water vapor density, $d_v$.

$$d_v = \frac{.007\frac{lb_w}{lb_{da}}}{14.2\frac{ft^3}{lb_{da}}} = 0.0005\frac{lb_w}{ft^3}$$

**Answer A**