41.11 **$8000cfm$ of air cooled by a coil to $50°F$ dry bulb and $48°F$ wet bulb is mixed with $4500cfm$ of bypass air at $75°F$ and 45% relative humidity. What is the dew point of the mixture?**

A. $46°F$

B. $49°F$

C. $52°F$

D. $53°F$

Call the leaving coil condition state 1 and the bypass condition state 2. Both states are fully defined. Use the psychrometric chart to look up the humidity ratio for each state:

$$T_{1,db} = 50°F$$

$$T_{1,wb} = 48°F$$

$$\omega_1 = 0.0066\frac{lb_w}{lb_{da}}$$

$$T_{2,db} = 75°F$$

$$\phi_2 = 45\%$$

$$\omega_2 = 0.0084\frac{lb_w}{lb_{da}}$$

Perform a mixing calculation to determine the humidity ratio of the mixture. For the highest precision, looking up the density for each state and changing the volume flow rates to mass flow rates would be expected. However, the density is reasonably close between states 1 and 2, and it is customary to use the volume flow rates as a reasonable approximation for a mixing calculation of this nature. It also saves valuable time.

$$\omega_{mixed} = \frac{(8000cfm)\left(0.0066\frac{lb_w}{lb_{da}}\right) + (4500cfm)\left(0.0084\frac{lb_w}{lb_{da}}\right)}{8000cfm + 4500cfm} = .00725\frac{lb_w}{lb_{da}}$$

Using the psychrometric chart again, draw a horizontal line from the mixed air humidity ratio and follow horizontally to the left until reaching the saturation curve. Read off the dew point temperature:

$$T_{dp,mixed} = 49°F$$

Answer B

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