41 Psychrometrics

41.1 The discharge air temperature from a fan coil unit is $53°F$ dry bulb and $51°F$ wet bulb. The space is maintained at $74°F$ and 45% relative humidity. What is the dew point in the space?

A. $50°F$

B. $51°F$

C. $55°F$

D. $60°F$

The discharge conditions are not required to answer the question. Use the psychrometric chart to locate the state point for the space conditions based on known temperature and relative humidity. Follow a horizontal line the the left to locate the Dew Point Temperature:

$$T_{DP} = 51.5°F$$

Answer B

41.2 An outside air handling unit is equipped with a hot water coil to temper the fresh air intake during winter operation. The heating coil is sized for $80,000\frac{Btu}{hr}$. The outside conditions are $20°F$ and 50% relative humidity. What is the humidity ratio after heating? Assume that the degree of saturation is roughly equivalent to relative humidity.

A. $0.001\frac{lb_w}{lb_{da}}$

B. $0.002\frac{lb_w}{lb_{da}}$

C. $0.003\frac{lb_w}{lb_{da}}$

D. $0.004\frac{lb_w}{lb_{da}}$

The humidity ratio after heating is the same as the humidity ratio before heating because the heating process is purely sensible only, i.e. there is no moisture being added or removed by the heating coil. Therefore, the problem can be distilled down to finding the humidity ratio of the outside air based on known temperature and relative humidity. Although the state is fully defined, the psychrometric chart only goes down to $35°F$ and no low temperature psychrometric chart is provided in the Reference Handbook.

As an alternative, search for the table Thermodynamic Properties of Moist Air and note the humidity ratio at saturation (100% relative humidity):

$$@T = 20°F \rightarrow \omega_s = 0.002153\frac{lb_w}{lb_{da}}$$

The humidity ratio at any other level of humidity can be calculated by using the degree of saturation, μ. As an approximation, it is acceptable to assume the degree of saturation is roughly equivalent to the relative humidity. This is not strictly true but works well in a pinch. Solve for the humidity ratio using μ.

$$\phi \approx \mu \approx 50\%$$

$$\mu = \frac{\omega}{\omega_s} \rightarrow \omega = \mu\omega_s$$

$$\omega = (.5)\left(0.002153\frac{lb_w}{lb_{da}}\right) = 0.00108\frac{lb_w}{lb_{da}}$$

Answer A

41.3 A $12ft$ by $15ft$ room with a $9ft$ ceiling has a relative humidity of 25% and a dry bulb temperature of $70°F$. A humidifier is turned on and run continuously adding $0.04gal$ of water per hour to the room. Assuming the additional moisture content has no impact on the dry bulb temperature and the room is sealed, how long will it take to achieve 50% relative humidity?

A. $0.75hrs$

B. $1hr$

C. $1.5hrs$

D. $2.75hrs$

Use the psychrometric chart to determine the humidity ratio and specific volume for the initial state:

$$T_1 = 70°F$$

$$\phi_1 = 25\%$$

$$\omega_1 = 0.00388\frac{lb_w}{lb_{da}}$$

$$v_1 = 13.49\frac{ft^3}{lb_{da}}$$

Also determine the humidity ratio for the final state, after humidification:

$$T_2 = 70°F$$

$$\phi_2 = 50\%$$