

41.14 An auditorium has a sensible heat load of $300,000 \frac{Btu}{hr}$ and a moisture load of $100 \frac{lb}{hr}$. Air is supplied at $62^\circ F$ and 50% relative humidity. The space is not to exceed a temperature of $74^\circ F$ or a relative humidity of 60%. What are the return air conditions?

- A. $71^\circ F$, 60% RH
- B. $72^\circ F$, 43% RH
- C. $74^\circ F$, 38% RH
- D. $74^\circ F$, 60% RH

Initially it is not clear whether the CFM will be driven by the sensible cooling demand or the latent cooling demand. One approach is to guess, solve, and then check to make sure the other parameter is satisfied. In this case, assume the sensible heat load drives the required CFM, then check to make sure the room relative humidity does not exceed 60%.

Start with the sensible cooling rule of thumb. Refer to **Heat Gain Calculations** in the Reference Handbook:

$$q_s = 1.08cfm\Delta T \rightarrow cfm = \frac{q_s}{1.08\Delta T}$$

$$cfm = \frac{300,000}{1.08(74 - 62)} = 23,148cfm$$

Look up **latent heat gain** and use the approximate heat content of water vapor to convert the latent heat load into $\frac{Btu}{hr}$:

$$q_L = \left(100 \frac{lb}{hr}\right) \left(1076 \frac{Btu}{lb}\right) = 107,600 \frac{Btu}{hr}$$

Apply the latent heat gain rule of thumb and solve for the humidity ratio of the return air. Use the **psychrometric chart** to look up the humidity ratio for the supply condition:

$$T_{s,db} = 62^\circ F$$

$$\phi_s = 50\%$$

$$\omega_s = 0.0059 \frac{lb_w}{lb_{da}}$$

$$q_L = 4840cfm\Delta\omega = 4840cfm(\omega_r - \omega_s)$$

$$\omega_r = \frac{q_L}{4840cfm} + \omega_s = \frac{107,600}{4840(23,148)} + 0.0059 = 0.0068 \frac{lb_w}{lb_{da}}$$

$$T_{r,db} = 74^\circ F$$

Using the return humidity ratio and the return dry bulb temperature, use the psychrometric chart again to determine the return relative humidity:

$$\phi_r = 38\% < 60\%$$

Since the return relative humidity is less than the allowable maximum of 60%, the initial assumption that the sensible load would drive the CFM was correct.

Answer C

41.15 1000cfm of air at 76°F and 60% relative humidity is removed from a room. 300cfm is cooled to 54°F dry bulb and 52°F wet bulb. The remaining volume bypasses the cooling coil and is mixed with the conditioned air. What is the relative humidity of the discharge air after mixing?

- A. 58%
- B. 63%
- C. 65%
- D. 68%

Let the leaving coil air condition be considered state 1 and the room/return/bypass air condition be state 2. Both states are fully defined. Use the **psychrometric chart** to look up the humidity ratio at both states.

$$T_{1,db} = 76^\circ F$$

$$\phi_1 = 60\%$$

$$\omega_1 = .01154 \frac{lb_w}{lb_{da}}$$

$$T_{2,db} = 54^\circ F$$

$$T_{2,wb} = 52^\circ F$$

$$\omega_2 = .0078 \frac{lb_w}{lb_{da}}$$

Since only 300cfm goes over the cooling coil, the remaining 700cfm is bypassed and mixed with the conditioned air downstream of the cooling coil. For a 1,000cfm fan coil unit, this implies that 30% of the air is cooled and 70% gets bypassed. Perform separate mixing calculations to determine the temperature and humidity ratio of the mixed air being supplied to the room:

$$T_m = (.7)(76^\circ F) + (.3)(54^\circ F) = 69.4^\circ F$$