43.7 An elevator control room houses four $10hp$ motors with 92% efficiency, $30ft$ of linear LED lighting drawing $5W/ft$, and one computer workstation consuming $300W$. The room is supplied with $74°F$ air using a transfer fan. During peak elevator usage, what is the maximum flow rate needed to maintain $80°F$ in the room?

A. $360cfm$

B. $1500cfm$

C. $15,000cfm$

D. $16,000cfm$

Calculate the heat gain from the elevator motors by using the electrical motor efficiency. Most of the electrical power is converted to mechanical power to drive the elevators; only the losses are converted to waste heat. Convert units to $\frac{Btu}{hr}$.

$$\dot{Q}_{motors} = (4)(10hp)\left(745.7\frac{W}{hp}\right)\left(\frac{3.412\frac{Btu}{hr}}{W}\right)(.08) = 8142\frac{Btu}{hr}$$

Calculate the heat gain from the LED lighting:

$$\dot{Q}_{lights} = (30ft)\left(\frac{5W}{ft}\right)\left(\frac{3.412\frac{Btu}{hr}}{W}\right) = 512\frac{Btu}{hr}$$

Convert the heat gain from the computer to $\frac{Btu}{hr}$:

$$\dot{Q}_{comp} = (300W)\left(\frac{3.412\frac{Btu}{hr}}{W}\right) = 1024\frac{Btu}{hr}$$

Determine the total heat load from all sources.

$$\dot{Q}_{total} = \dot{Q}_{motors} + \dot{Q}_{lights} + \dot{Q}_{comp}$$

$$\dot{Q}_{total} = 8142\frac{Btu}{hr} + 512\frac{Btu}{hr} + 1024\frac{Btu}{hr} = 9678\frac{Btu}{hr}\ (sensible)$$

Since the heat load is entirely *sensible* heat gain, use the sensible heating rule of thumb to determine the required flow rate:

$$\dot{Q}_s = 1.08cfm\Delta T \rightarrow cfm = \frac{\dot{Q}_s}{1.08\Delta T}$$

$$cfm = \frac{9678}{1.08(80-74)} = 1494cfm$$

Answer B

43.8 A single family house is maintained at $70°F$ in the winter when the outside design temperature is $10°F$. The roof area is $2000 ft^2$ and the R-value is R-32. The wall area is $2500 ft^2$ and the R-value is R-15. There are (12) $3ft \times 4ft$ double pane glass windows with R-value R-3. Infiltration and ventilation account for $100 cfm$ of air exchange. What is the design heat load?

A. $6500 \frac{Btu}{hr}$

B. $10,000 \frac{Btu}{hr}$

C. $17,000 \frac{Btu}{hr}$

D. $23,000 \frac{Btu}{hr}$

To calculate the heat gain through interior surfaces, use the equation from the reference handbook: $\dot{Q} = UA\Delta T$.

Recall from Heat Transfer that the overall coefficient of heat transfer, U, is the reciprocal of the total resistance, R.

$$U = \frac{1}{R_T}$$

It is implied that the R-values given are the resistances for the roof, walls, and windows, respectively.

Calculate the heat gain through the roof:

$$\dot{Q}_{roof} = \frac{\left(2000 ft^2\right)\left(70°F - 10°F\right)}{\left(32 \frac{hr ft^2 °F}{Btu}\right)} = 3750 \frac{Btu}{hr}$$

Calculate the heat gain through the walls:

$$\dot{Q}_{walls} = \frac{\left(2500 ft^2\right)\left(70°F - 10°F\right)}{\left(15 \frac{hr ft^2 °F}{Btu}\right)} = 10,000 \frac{Btu}{hr}$$

Calculate the heat gain through the windows:

$$\dot{Q}_{windows} = \frac{\left[\left(12 ft\right)\left(12 ft\right)\right]\left(70°F - 10°F\right)}{\left(3 \frac{hr ft^2 °F}{Btu}\right)} = 2880 \frac{Btu}{hr}$$

Determine the heat gain due to infiltration and ventilation using the sensible heating rule of thumb:

$$\dot{Q}_{oa} = 1.08 cfm \Delta T = 1.08\left(100\right)\left(70 - 10\right) = 6480 \frac{Btu}{hr}$$

Find the sum of the heat gain through the surfaces and the heat gain due to outside air:

$$\dot{Q}_{total} = \dot{Q}_{roof} + \dot{Q}_{walls} + \dot{Q}_{windows} + \dot{Q}_{oa}$$