44.4 An unoccupied $3000ft^2$ technology room with $12ft$ ceilings is located at the perimeter of a building and experiences excessive infiltration from the outdoors amounting to $2ACH$. On a summer design day the outside conditions are $95°F$ dry bulb and 80% RH. The equipment load is $50KW$ sensible and the space is to be maintained at $72°F$ and 50% RH. What is the total cooling demand?

A. $2tons$

B. $13tons$

C. $14tons$

D. $27tons$

To determine the infiltration load, use the Psychrometric Chart to obtain the enthalpy for the outside air and the enthalpy for the internal space, both of which are fully defined.

For the outside air, State 1:

$$T_1 = 95°F$$

$$\phi_1 = 80\%$$

$$h_1 = 54.83\frac{Btu}{lb}$$

For the internal space, State 2:

$$T_2 = 72°F$$

$$\phi_2 = 50°F$$

$$h_2 = 26.43\frac{Btu}{lb}$$

Calculate the change in enthalpy required to condition the outside air:

$$\Delta h = h_1 - h_2 = 54.83\frac{Btu}{lb} - 26.43\frac{Btu}{lb}$$

Based on the ACH and dimensions of the space, find the volume flow rate for the infiltration:

$$\dot{V} = \left(3000ft^2\right)(12ft)\left(\frac{2\,air\,changes}{hr}\right)\left(\frac{1hr}{60min}\right) = 1200cfm$$

Use the total heating/cooling rule of thumb for air to determine the cooling load due to infiltration:

$$\dot{Q}_{infiltration} = 4.5cfm\Delta h$$

$$\dot{Q}_{infiltration} = 4.5\,(1200)\,(28.4) = 153,360\frac{Btu}{hr}$$

Determine the total cooling load including the internal heat load as well as the infiltration. Align units to $\frac{Btu}{hr}$, then convert to refrigeration tons:

$$\dot{Q}_{total} = \dot{Q}_{infiltration} + \dot{Q}_{internal}$$

$$\dot{Q}_{total} = 153,360\frac{Btu}{hr} + (50KW)\left(3412\frac{Btu}{hr \cdot KW}\right) = 323,960\frac{Btu}{hr}$$

$$\dot{Q}_{total} = 323,960\frac{Btu}{hr}\left(\frac{1ton}{12000\frac{Btu}{hr}}\right) = 27tons$$

Answer D

44.5 A pumping system delivers water to a factory through a standard weight steel piping supply line (surface roughness $C = 120$) with 3 outlets delivering $100gpm$ to each outlet. The main pipe initially has a $5in$ nominal diameter, reducing to $4in$ and $3in$ after each branch outlet. The first outlet is located $50ft$ from the pumping station; the second outlet is $100ft$ downstream of the first, and the third outlet is $100ft$ downstream of the second. What is the pressure loss for the system? Ignore minor losses.

A. $7ft$

B. $10ft$

C. $14ft$

D. $20ft$

The pressure loss is based on the flow rate, diameter, surface roughness, and the length of the pipe. Break the problem into 3 sections and use the Steel Pipe Friction Tables to look up the head loss per 100 ft for each section. The surface roughness may be considered at the end.

For the 5 inch section:

$$D = 5in$$

$$L = 50ft$$

$$Q = 300gpm$$

$$h_{d.loss} = 3ft/100ft$$