

44.7 Due to acoustical considerations, the compressor and condenser for a 2ton refrigerator with a COP of 5 are located remotely in a nearby storage closet. Neglecting lights and other ancillary heat sources, what is the required cooling capacity for the storage closet?

- A. $24,000 \frac{Btu}{hr}$
- B. $25,000 \frac{Btu}{hr}$
- C. $29,000 \frac{Btu}{hr}$
- D. $33,000 \frac{Btu}{hr}$

The cooling system for the closet needs to be able to support the full heat rejection from the system, which includes the compressor and the condenser. As with all refrigeration cycles, the compressor energy is added to the refrigerant, therefore the heat rejection at the condenser is already exhaustive, with the possible minor exception of local heat loss from the compressor due to any inefficiency. However, even in that case, any local heat generation is being added to the room directly rather than the refrigerant loop, and will no longer need to be rejected from the condenser. Ultimately, the sum of the heat generated, and thus the cooling required for the room, is nothing more or less than Q_{out} for the cycle.

Apply the **Coefficient of Performance** (COP) for a refrigerator to calculate the compressor power:

$$COP_R = \frac{\dot{Q}_{in}}{\dot{W}_{in}} \rightarrow \dot{W}_{in} = \frac{\dot{Q}_{in}}{COP_R} = \frac{2tons}{5} = .4tons$$

Calculate the heat rejection from the condenser, and convert to $\frac{Btu}{hr}$:

$$\dot{Q}_{out} = \dot{Q}_{in} + \dot{W}_{in} = 2tons + .4tons = 2.4tons$$

$$\dot{Q}_{out} = 2.4tons \left(\frac{12,000 \frac{Btu}{hr}}{ton} \right) = 28,800 \frac{Btu}{hr}$$

Answer C

44.8 A counterflow heat exchanger is used to remove heat from steam condensate prior to discharge and for pre-heating cold water. Cold water enters at $50^{\circ}F$ and leaves at $70^{\circ}F$. Condensate enters at $160^{\circ}F$ and leaves at $100^{\circ}F$. What is the log mean temperature difference?

- A. $62^{\circ}F$
- B. $68^{\circ}F$
- C. $76^{\circ}F$
- D. $90^{\circ}F$

For a counterflow heat exchanger, the hot stream enters on the opposite side from the cold stream such that the ΔT along the length is close to the average ΔT . (Contrast this with the temperature profile for a parallel flow heat exchanger which varies dramatically along the length.) Arbitrarily call the hot entering end “Side A” and cold entering end “Side B.” Calculate the temperature differences at both ends. It may be useful to draw the temperature profile on a *Temperature vs. Length* diagram.

$$\Delta T_A = 160^{\circ}F - 70^{\circ}F = 90^{\circ}F$$

$$\Delta T_B = 100^{\circ}F - 50^{\circ}F = 50^{\circ}F$$

Look up **Log Mean Temperature Difference** (LMTD) in the Reference Handbook. Consider applying the simplified version of this formula initially introduced during in the Heat Transfer section of this book:

$$LMTD = \frac{\Delta T_A - \Delta T_B}{\ln\left(\frac{\Delta T_A}{\Delta T_B}\right)} = \frac{90^{\circ}F - 50^{\circ}F}{\ln\left(\frac{90^{\circ}F}{50^{\circ}F}\right)} = 68^{\circ}F$$

Answer B