

The evaporator capacity must be converted to tons, which introduces time units that are needed in order to specify a volume flow *rate*.

$$.042 \frac{ft^3}{Btu} \left(\frac{(12,000 \frac{Btu}{hr}) (\frac{1hr}{60min})}{1ton} \right) = 8.4 \frac{ft^3}{min \cdot ton}$$

Answer C

39.20 A heat pump with a 3KW compressor has a heating capacity of $50,000 \frac{Btu}{hr}$ and a cooling capacity of $40,000 \frac{Btu}{hr}$. What is the COP when the unit is operated in heating mode?

- A. 1.0
- B. 3.9
- C. 4.9
- D. 5.0

Since we are only interested in the **Coefficient of Performance** when the unit is operated as a **Heat Pump**, select the formula below and ignore the cooling capacity:

$$COP_{HP} = \frac{Q_H}{W}$$

Substitute and solve, converting all units such that they cancel and the *COP* is unitless.

$$COP_{HP} = \frac{Q_H}{W} = \frac{50,000 \frac{Btu}{hr}}{(3KW) (3412 \frac{Btu}{hr \cdot KW})} = 4.9$$

Note the COP for a heat pump is always slightly greater than for the same device operating as a refrigerator under the same conditions because the compressor energy provides useful heating, whereas in cooling mode the waste heat must be rejected and therefore reduces the system efficiency.

If the heat pump were in cooling mode, the COP would be:

$$COP_R = \frac{Q_L}{W} = \frac{40,000 \frac{Btu}{hr}}{(3KW) (3412 \frac{Btu}{hr \cdot KW})} = 3.9$$

$$COP_R + 1 = COP_{HP}$$

Answer C

39.21 An R-410 refrigeration cycle operates between 25.5psia and 135psia with 20°F of superheat and 20°F of subcooling. The compressor efficiency is 88% . What is the coefficient of performance?

- A. 4.3
- B. 4.8
- C. 5.1
- D. 5.3

In the reference handbook lookup [Pressure Versus Enthalpy Curves for Refrigerant 410A](#) and work around the cycle accounting for superheating, subcooling, and compressor efficiency. Find the enthalpy for each state.

State 1, Follow a horizontal line at the low pressure condition (evaporator) to the right until the boundary with the superheated region, and then continue horizontally to the right at constant pressure accounting for an additional 20°F of superheat.

The refrigerant temperature at 25.5psia is -40°F . There is *additional* superheating of 20°F . To find the temperature at State 1 accounting for the superheating, add 20°F to -40°F , which gives a temperature of -20°F at State 1. The enthalpy should be looked up for this value.

$$P_1 = 25.5\text{psia}$$

20°F of superheat

$$T_1 = -20^\circ\text{F}$$

$$h_1 = 118 \frac{\text{Btu}}{\text{lb}}$$

State 2(ideal), Under ideal conditions, we would assume the compression is isentropic, therefore $s_2 = s_1$ and we can follow a line of constant entropy. We will make this assumption initially; however we must later account for the *actual* efficiency of the compressor.

$$P_2 = 135\text{psia}$$

$$s_2 = s_1$$

$$h_2 = 138 \frac{\text{Btu}}{\text{lb}}$$