43.2 A $1000 ft^2$ walk-in cooler using refrigerant R-134a has a capacity of $4 tons$. The total heat rejection from the condenser is $57 MBH$. At full load, what is the COP?

A. 4

B. 5

C. 6

D. 7

The Coefficient of Performance (COP) for a refrigerator is defined as:

$$COP_R = \frac{Q_L}{W}$$

where Q_L is the heat absorbed by the evaporator (sometimes written as Q_{in} or Q_{evap}), and W is the work done by the compressor, (sometimes written as W_{in} or W_{comp}).

Express Q_L in $\frac{Btu}{hr}$:

$$Q_L = 4\, tons \left(\frac{12000 \frac{Btu}{hr}}{ton} \right) = 48,000 \frac{Btu}{hr}$$

The heat rejected from the condenser, Q_H (sometimes Q_{out} or Q_{cond}), is the sum of the heat absorbed by the evaporator and the energy added by the compressor. This relationship is best remembered, but could be gleaned from the Reference Handbook section Basic Cycles, under Thermodynamic Cycles.

Rearrange to isolate W and solve, converting MBH to $\frac{Btu}{hr}$ as required:

$$Q_H = Q_L + W \rightarrow W = Q_H - Q_L$$

$$W = 57 MBH \left(\frac{10,000 \frac{Btu}{hr}}{MBH} \right) - 48,000 \frac{Btu}{hr} = 9000 \frac{Btu}{hr}$$

Solve for the COP_R:

$$COP_R = \frac{Q_L}{W} = \frac{48,000 \frac{Btu}{hr}}{9000 \frac{Btu}{hr}} = 5.3$$

Answer B

43.3 A $1000cfm$ fan coil unit installed for dehumidification maintains an apparatus dew point of $40°F$ and has a coil bypass factor of 10%. The entering air is $80°F$ dry bulb and 50% relative humidity. What quantity of total cooling is provided?

A. $3.2tons$

B. $3.6tons$

C. $5.4tons$

D. $6.0tons$

The bypass factor is the portion of the air flow that gets by the coil without being cooled. The bypass factor is the complement of the coil efficiency. When the bypass factor is 0, the coil is 100% efficient. In this case,

$$BF = 1 - \eta_{coil} = .1$$

$$\eta_{coil} = .9$$

The coil efficiency can be expressed as a ratio of the reduction in dry bulb temperature actually achieved as compared with what could possibly be achieved by the supply air temperature converging with the apparatus dew point i.e. the physical temperature of the coil. Let T_1 represent the entering air condition, T_2 represent the supply air condition, and ADP represent the coil condition. Write an expression for the coil efficiency:

$$\eta_{coil} = \frac{T_1 - T_2}{T_1 - T_{ADP}} = .9$$

Substituting known entering conditions and coil conditions, solve for the supply air temperature leaving the coil:

$$\frac{80 - T_2}{80 - 40} = .9 \rightarrow T_2 = 44°F$$

If the problem were asking for the quantity of sensible cooling provided, we would now have enough information since only the dry bulb temperatures would be needed. However, in order to find the total cooling provided, the supply air condition must be fully defined.

Use the psychrometric chart to look up the enthalpy and humidity ratio for the entering air:

$$T_1 = 80°F$$

$$\phi_1 = 50\%$$

$$h_1 = 31.2\frac{Btu}{lb}$$

$$\omega_1 = 76.4\frac{gr}{lb}$$