

43 HVAC

43.1 5000cfm of 76°F air with 60% RH is returned to an air handling unit with a total capacity of 15tons and a design sensible heat ratio of 0.7. The cooling coil is supplied with 43°F chilled water which leaves the coil at 54°F. The supply air conditions are 58°F dry bulb and 56°F wet bulb. What percentage of the sensible cooling capacity is available as spare?

- A. 23%
- B. 46%
- C. 54%
- D. 77%

Convert the total cooling capacity to $\frac{Btu}{hr}$:

$$15 \text{ tons} \left(\frac{12000 \frac{Btu}{hr}}{\text{ton}} \right) = 180,000 \frac{Btu}{hr}$$

Apply the **sensible heat ratio** i.e **SHR** to determine the sensible cooling capacity:

$$(.7) \left(180,000 \frac{Btu}{hr} \right) = 126,000 \frac{Btu}{hr}$$

To find the percentage of *spare* sensible capacity, find the sensible cooling load and subtract from the sensible capacity. Use the sensible cooling rule of thumb to calculate the actual load. Note: only dry bulb temperatures should be used. Units do not need to be noted as long as volume flow rate is in cfm and temperatures are in °F, the final result will be in $\frac{Btu}{hr}$.

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

$$\dot{Q}_s = 1.08 (5000) (76 - 58) = 97,200 \frac{Btu}{hr}$$

Calculate spare capacity:

$$126,000 \frac{Btu}{hr} - 97,200 \frac{Btu}{hr} = 28,800 \frac{Btu}{hr}$$

Change to a percentage:

$$\frac{28,800 \frac{Btu}{hr}}{126,000 \frac{Btu}{hr}} = 22.9\%$$

Answer A

43.2 A 1000 ft^2 walk-in cooler using refrigerant R-134a has a capacity of 4tons. The total heat rejection from the condenser is 57MBH. 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 $\frac{Btu}{hr}$:

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

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:

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

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

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