44.26 On a day with outside conditions of $80°F$ dry bulb and 50% relative humidity, a cooling tower operates with an effectiveness of 70%. The return condenser water enters the tower at $96°F$. What is the approach?

A. $9°F$

B. $15°F$

C. $21°F$

D. $29°F$

Use the outside conditions and the Psychrometric Chart in the Reference Handbook to obtain the wet bulb temperature.

$$T_{OA,db} = 80°F$$

$$\phi_{OA} = 50\%$$

$$T_{OA,wb} = 66.6°F$$

Use the cooling tower effectiveness to solve for the leaving water temperature (condenser water supply).

$$\varepsilon = \frac{EWT - LWT}{EWT - T_{wb}}$$

$$.7 = \frac{96°F - LWT}{96°F - 66.6°F}$$

$$LWT = 75.4°F$$

Look up Cooling Tower Approach, which is defined as the difference between the cooling tower leaving water temperature and the entering air wet bulb temperature. Apply this definition to find the approach.

$$Approach = LWT - T_{wb} = 75.4°F - 66.6°F = 8.8°F$$

Note, another term worth knowing is the range of a cooling tower which is the difference between the entering and leaving water temperatures. In this case, $Range = EWT - LWT = 96°F - 75.4°F = 10.6°F$.

Answer A

44.27 An energy efficiency initiative being evaluated for a $2500ton$ chiller plant running 24/7 is expected to improve the total average annualized COP from 4 to 5. The project budget is $800,000. Capital can be borrowed at an interest rate of 5%. Electricity costs are estimated at $0.14 per kwH. What is the loan duration that should be used if the initiative is required to be cash flow neutral?

A. 17 months

B. 18 months

C. 19 months

D. 20 months

The electricity to run the chiller plant consists of the power to run the compressors, which is $\dot{W}_{in}$ in the Coefficient of Performance (COP) formula. Rearrange the COP and solve the input power before and after the initiative. Arbitrarily call these Option 1 and Option 2. Convert units to KW.

$$COP_R = \frac{\dot{Q}_{in}}{\dot{W}_{in}} \rightarrow \dot{W}_{in} = \frac{\dot{Q}_{in}}{COP_R}$$

$$\dot{W}_{in,1} = \frac{(2500tons)\left(12,000\frac{Btu}{hr \cdot ton}\right)}{(4)\left(3412\frac{Btu}{hr \cdot KW}\right)} = 2198KW$$

$$\dot{W}_{in,2} = \frac{(2500tons)\left(12,000\frac{Btu}{hr \cdot ton}\right)}{(5)\left(3412\frac{Btu}{hr \cdot KW}\right)} = 1758KW$$

Calculate the annual cost savings associated with the reduction in demand. Multiply by time and the rate of electricity.

$$Annual\,Cost\,Savings = (2198KW - 1758KW)\,(8760hr)\left(\frac{\$0.14}{KW \cdot hr}\right) = \$539,600$$

Look up Economic Factor Conversions and find the option for Capital Recovery which converts to A given P, where A is an annualized payment and P is a lump sum of principal borrowed. The value of the conversion factor is a function of the interest rate and term length and is written as $(A/P, i\%, n)$. Since A and P are known, solve for the value of the factor.

$$A = (A/P, 5\%, n)\,P$$

$$(A/P, 5\%, n) = \frac{A}{P} = \frac{\$539,600}{\$800,000} = .6739$$

Set the value of the factor equal to the expression used for calculating when both interest rate and term are known. In this case, the interest rate is known and the term length needs to be determined.

$$(A/P, 5\%, n) = \frac{i\,(1+i)^n}{(1+i)^n - 1} = .6739$$