44.28 An engineer is specifying a $1000 cfm$ dedicated outside air unit for a 24 hour gym which is to be maintained at $72°F$ with 50% relative humidity by supplying $55°F$ saturated supply air. The average outdoor conditions for the region are $88°F$ and 55% relative humidity. The unit manufacturer offers an option to include an enthalpy wheel with 60% effectiveness for an additional cost of $10,000. If it costs the tenant $0.50 per ton hour to produce chilled water, what is the simple payback for the enthalpy wheel? Neglect maintenance and assume installation and commissioning add no additional upfront cost.

A. 3 months

B. 10 months

C. 2 years

D. 3 years

An enthalpy wheel is capable of recovering both sensible and latent heat. Contrast this with an air-to-air heat exchanger which captures only sensible heat. The enthalpy wheel provides the opportunity to cool and dehumify the entering outside air by rejecting heat and moisture to the room air being exhausted. If the enthalpy wheel had 100% effectivenss, the enthalpy of the air supplied by the enthalpy wheel would be equal to the enthalpy of the room air. Further cooling and dehumfication would always have to be provided by the outside air handling unit's cooling coil. Therefore, the effectiveness of the enthalpy wheel, and thus the opportunity to produce savings, applies only to the enthalpy differential between the outside air and the room air. The OAHU discharge conditions are to be ignored.

Consider the outside air as State 1 and the room air as State 2. Use the Psychrometric Chart to look up the enthalpy for both states. Use the total cooling rule of thumb to calculate the amount of energy removed by the enthalpy wheel if it was 100% effective, and take 60% of that value to account for the given effectiveness.

$$T_1 = 88°F$$

$$\phi_1 = 55\%$$

$$h_1 = 38.4\frac{Btu}{lb}$$

$$T_2 = 72°F$$

$$\phi_2 = 50\%$$

$$h_2 = 26.4\frac{Btu}{lb}$$

$$\dot{Q}_t = 4.5 cfm \Delta h$$

$$\dot{Q}_t = (0.6)(4.5)(1000)(38.4 - 26.4) = 32,400 \frac{Btu}{hr}$$

This is the total avoided cooling load. Convert this value to $refrigeration\, tons$ and calculate the annual $ton \cdot hours$:

$$Avoided\, Cooling\, Demand = \left(32,400 \frac{Btu}{hr}\right) \left(\frac{1 ton}{12,000 \frac{Btu}{hr}}\right) (8760 hours) = 23,652 ton \cdot hours$$

Calculate the annual cost savings:

$$Cost\, Savings = (23,652 ton \cdot hours) \left(\frac{\$0.50}{ton \cdot hour}\right) = \$11,826$$

Calculate the simple payback:

$$Simple\, Payback = \frac{\$10,000}{\$11,826} = 0.8456 years \left(\frac{12 months}{1 year}\right) = 10.1 months$$

Answer B