47.79 An apartment complex uses a central domestic hot water heating system to produce $1000gpm$ of $130°F$ hot water. 30% of the supply water is consumed by tenants, and 70% is recirculated. $55°F$ make up water is introduced to the return line to replenish the system. The supply and return piping experience $1,000,000\frac{Btu}{hr}$ and $600,000\frac{Btu}{hr}$ of losses, respectively. What is the temperature of the water entering the heating system?

A. $99°F$

B. $102°F$

C. $105°F$

D. $108°F$

Sketch the domestic heating system and label all given information. Start by analyzing the supply piping. The water leaving the central system starts at a known temperature and experiences a known quantity of heat loss for a fixed volume flow rate. Use the sensible heating/cooling rule of thumb for water to determine the temperature of the hot water at the time it branches off to serve the tenant demand. Consider this point in the system State 1.

$$\dot{Q}_{supply,loss} = 500gpm\Delta T$$

$$1 \times 10^6 = 500\,(1000)\,(130°F - T_1)$$

$$T_1 = 128°F$$

Next, analyze the return piping. The water being recirculated is only 70% of the original *gpm* since 30% was used to serve the load. The heat loss in the return piping is known, and the starting temperature is $T_1 = 128°F$. Use the same rule of thumb to solve for the temperature after the return piping before any make-up water has been mixed in. Consider this point in the system State 2.

$$\dot{Q}_{return,loss} = 500gpm\Delta T$$

$$6 \times 10^5 = 500\,(700)\,(128°F - T_2)$$

$$T_2 = 126.29°F$$

Lastly, perform a mixing calculation between the $700gpm$ of recirculated water and $300gpm$ of make-up water to determine the mixed water temperature prior to entering the heating system. Consider the mixed water condition as State 3.

$$T_3 = \frac{gpm_2 T_2 + gpm_{make-up} T_{make-up}}{gpm_{total}} = \frac{(700gpm)\,(126.29°F) + (300gpm)\,(55°F)}{1000gpm} = 104.9°F$$

Answer C

47.80 A hot water heating system is rated for $200,000\frac{Btu}{hr}$ at sea level. The system includes a fuel gas burner and a combustion intake fan. What would the heating capacity be if the system was installed at an elevation of $4000ft$ above sea level?

A. $173MBH$

B. $189MBH$

C. $200MBH$

D. $231MBH$

Since air is less dense at higher elevation, the fuel's heating value will be reduced at $4000ft$ as compared with sea level operation. The reduction in capacity is proportional to the reduction in air density. Use the Altitude Corrections for Air table to obtain the density factor for $4000ft$. Calculate the new capacity, and convert units to MBH.

$$\dot{Q}_{4000ft} = \dot{Q}_{0ft}\,(Density\,Factor)$$

$$\dot{Q}_{4000ft} = \left(200,000\frac{Btu}{hr}\right)(0.864)\left(\frac{1MBH}{1000\frac{Btu}{hr}}\right) = 172.8MBH$$

Answer A