STEAM CONDENSATE RECOVERY OPPORTUNITY:

Museum Main Building steam condensate is being discharged to sewer. The plumbing code requires that the condensate be cooled before being discharged to the sewer. This cooling is being done by mixing potable water with the condensate. This cost saving opportunity is to use the water being sent to drain for makeup water in the cooling towers. This opportunity would result in water, and sewer cost savings.

Given Data:

Water Rate $3.81/1000 gallons
Sewer Rate $4.34/1000 gallons
Steam/Energy Rate $20.54/1000 pounds
Electric Rate $0.0553/KWH
Annual Operating Hours (AOH) 8760
Annual Steam Consumed (ASC)
Average Steam Flow 9,178 pounds/hour

$$\$:= ¤$$

$$WaterCost\$:= \frac{3.81 \cdot \$}{1000\ gal}$$

$$SewerCost\$:= \frac{4.34 \cdot \$}{1000 \cdot gal}$$

$$FuelCost\$:= \frac{20.54\ \$}{10^6 \cdot Btu}$$

$$AOH := 8760 \cdot hr$$

Assumptions:

$$ElectricCost\$:= \frac{0.0553\ \$}{kW \cdot hr}$$

1. Condensate is equal to 67% of steam use in 2016-2017 due to steam losses from steam vents and humidification steam and proposed reductions in the number of steam heating coils.
2. Condensate water recovery can be used in cooling towers.
3. Condensate Temperature 180 F.
4. Potable Water Temperature 55 F.
5. Condensate is cooled to 110 F for sewer discharge.
6. Cooling tower condenser water flow rate, 2800 GPM (TFR).
7. Cooling tower cycles of concentration, 3 (C).
8. Cooling tower drift rate, 0.005%, (D)
9. Cooling tower operating power, 0.4 kW/ton, (TP)
10. Evaporation Rate 1% of flow rate.
11. Cooling tower condenser water supply temperature to chiller, 75 F.

$$ASC := 9178 \cdot \frac{lb}{hr} \cdot AOH$$

$$ASC = \left(8.04 \cdot 10^7\right)\ lb$$

$$Condensate := 0.67 \cdot \frac{ASC}{8.34 \cdot \frac{lb}{gal}}$$

$$Condensate = 6458935\ gal$$

$$TFR := 2800 \cdot \frac{gal}{min}$$

$$C := 3 \qquad D := 0.00005$$

$$TP := 0.4 \cdot \frac{kW}{12000 \cdot \frac{Btu}{hr}}$$

Cooling Tower Water Use (TWU):

$Evaporation := 0.01 \cdot TFR$ $Evaporation = 28 \frac{gal}{min}$

$Blowdown := \frac{Evaporation}{(C-1)}$ $Blowdown = 14 \frac{gal}{min}$

$Drift := D \cdot TFR$ $Drift = 0.14 \frac{gal}{min}$

$TWU := Evaporation + Blowdown + Drift$ $TWU = 42.14 \frac{gal}{min}$

Condensate Cooling Water/Sewer (CWS):

Cooling water and sewer required to cool condensate from 180 F to 110 F using potable water at 55 F. Required by plumbing code before condensate can be sent to drain system.

$CWS := \frac{Condensate}{AOH} \left(\frac{180-110}{110-55} \right)$ $CWS = 15.64 \frac{gal}{min}$ $CWS \cdot AOH$

$CWS \cdot AOH = \left(8.22 \cdot 10^{6}\right) gal$

Available Cooling Water plus Condensate (AW):

$AW := CWS + \frac{Condensate}{AOH}$ $AW = 27.929 \frac{gal}{min}$

Annual Water/Sewer Cost Savings:

$WaterSewerCost\$:= WaterCost\$ + SewerCost\$$

$Savings\$:= CWS \cdot AOH \cdot (WaterSewerCost\$) + Condensate \cdot (WaterSewerCost\$)$

$Savings\$ = \left(1.196 \cdot 10^{5}\right) \$$ $119,637.09

Electric cost to run water pumps to pump condensate to tower $ (EC) :

Pump break horsepower, GPM=pump gallons per minute, TDH=pump total dynamic head feet water, SG=specific gravity of water 1 and E= pump efficiency 50 percent

$TDH := 115$ $SG := 1$ $E := 0.5$

$gpm_{avg} := 27.93$ $BHP_{pump} := \frac{gpm_{avg} \cdot TDH \cdot SG}{3960 \cdot E}$ $BHP_{pump} = 1.622$

$EC_{PC} := \left(BHP_{pump}\right) \cdot 0.746\ kW\ AOH \cdot ElectricCost\$$ $EC_{PC} = 586.235\ \$$

$PumpElectric := BHP_{pump} \cdot 0.746 \cdot kW$ $PumpElectric = 1.21\ kW$

Cooling tower energy required for cooling condensate CTE:

$CTE := 27.93 \cdot 500 \cdot (110 - 75) \cdot \frac{Btu}{hr} \cdot TP$ $\quad CTE = 16.293\ kW$

$EC_{CT} := CTE \cdot AOH \cdot ElectricCost\$$ $\quad EC_{CT} = \left(7.893 \cdot 10^{3}\right)\ \$$

Net Annual Cost Savings $ (NAS):

$NAS := Savings\$ - \left(EC_{PC} + EC_{CT}\right) = \left(1.112 \cdot 10^{5}\right)\ \$$ $111,200.00

Net Annual Water and Sewer Savings (Water/Sewer):

$WaterSewer := CWS \cdot AOH + Condensate$ $\quad WaterSewer = \left(1.468 \cdot 10^{7}\right)\ gal$

Net Annual Increase in Electric Use (EU):

$EU := (PumpElectric + CTE) \cdot AOH$ $\quad EU = \left(1.533 \cdot 10^{5}\right)\ kW \cdot hr$

SUMMARY:

ANNUAL COST SAVINGS: $111,200.00
ANNUAL WATER SAVINGS: 14,680,000 GALLONS
ANNUAL SEWER SAVINGS: 14,680,000 GALLONS
ANNUAL INCREASE IN ELECTRIC USE: 153,300 KWH