# HW 20 - STEAM PLANT TOUR

## 1. AIR COMPRESSOR

* Where and why are heat exchangers deployed in this device?
* What thermodynamic/mechanical principles are used to remove moisture in outlet air?

Calculations:  
The volume flow rate (measured at inlet conditions of 14 psia and 60 °F) is 373 standard cubic feet per minute (scfm). The compressor increase the air pressure by 100 psig.

1. Calculate the power required if you assume the compressor is isentropic with a polytropic exponent of n = cp/cv.
2. Calculate the power required using the air tables.
3. How do the values from a) and b) compare to the actual motor rating of 75 hp?

## 2. FEEDWATER PUMP

* What is a VFD and why is there one on this device?

Calculations:  
From the snapshot on the next page we can see that water enters the pump at 14.3 psig, and leaves at 218 psig. Instantaneous mass flow through the system is also shown on the system diagram (Flow, in units of pph – pounds(mass) per hour).

1. Calculate the power required (hp) to run the feedwater pump. For the sake of simplicity, assume the water enters the pump as saturated liquid (even though it is slightly compressed)

## 3. WOOD BOILER

* What device does water go through just before it enters the boiler? Why is this used?
* What is the purpose of the air preheater? How does it work?

Calculations:  
From the snapshot on the next page we can see the pressure and temperature of the liquid entering the boiler. And you know the pressure of the steam leaving the boiler. The UI steam plant has minimal superheat, so it is a fair assumption that the steam exiting the boiler is a saturated vapor.

1. Calculate the boiler duty [Btu/hr] (the rate of heat transfer to the working fluid in the boiler).
2. The maximum boiler capacity is around 57.5 x 106 Btu/hr. Approximately what fraction of boiler capacity is the plant running during this snapshot?
3. If dry wood chips have a heating value of 7500 BTU/lbm calculate the mass flow rate of dry wood chips at the time of this snapshot. Assume 100% of the fuel energy goes in to heating the water.

## 4. PRV and CO-GENERATION TURBINES

* How does a PRV work? Why would we keep one of these in the system after installing co-generation turbines?
* Draw a simplified system diagram of the current steam loop (showing feedwater pump, boiler, PRV, steam to campus heat, and condensate return).
* On your system diagram, show where the new co-generation turbines would be installed.

Calculations:  
The mass flow through each co-generation turbine would be ~14,000 pph, with an inlet of 190 psia and 390 °F, and an outlet condition of 55 psia, quality of 0.96.

1. Calculate the theoretical power output (kW) of one co-generation turbine.

**Snapshot of UI Steam System Performance – Mid-February 2013**

Feedwater inlet pressure 218 psig  
Boiler outlet pressure is 136 psig  
Massflow of water/steam in the system is 38,482 pph (which is lbm/hr)  
  
Economizer feedwater inlet temp 233 °F  
Economizer feedwater outlet temp 269 °F  
Economizer inlet flue temp 488 °F  
Economizer outlet flue temp 390 °F   
  
Air PreHeater inlet flue temp 390 °F  
Air Pre-Heater outlet flue temp 362 °F  
Combustion air inlet temp 81 °F  
Combustion air outlet temp 210 °F

