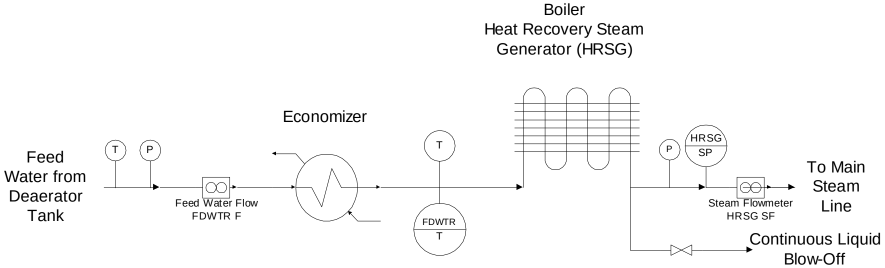
Process Measurements

- Cogeneration Plant
  - ✓Real World Engineering
  - ✓Process Simulation
- Flow
- Temperature
- Pressure

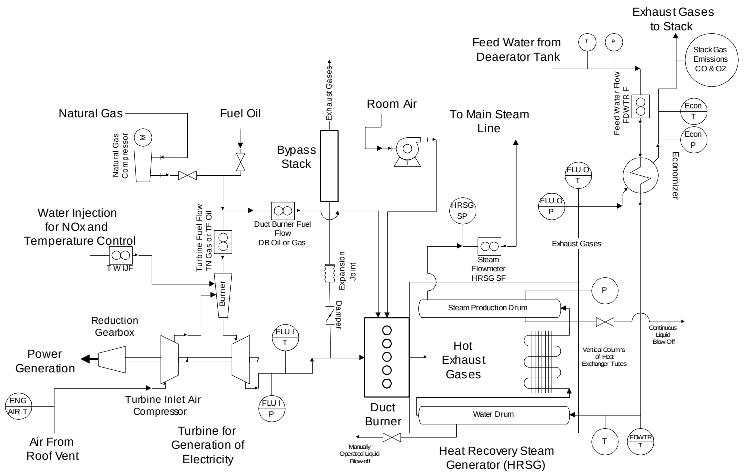
Life in the Day of an Engineer: Week 1

- Tour of Cogeneration Facility
- Process Simulation using HYSYS
- Homework: Heat Duty Calculations



Process Engineering Objectives

- Unit Conversion & Dimensional homogeneity
- Engineering Equations and Calculations
- Energy balances based on readings taken in plant.
- Process Equipment Identification
- Chemical Process Simulation HYSYS
- Describe the process of cogeneration to a high school student.



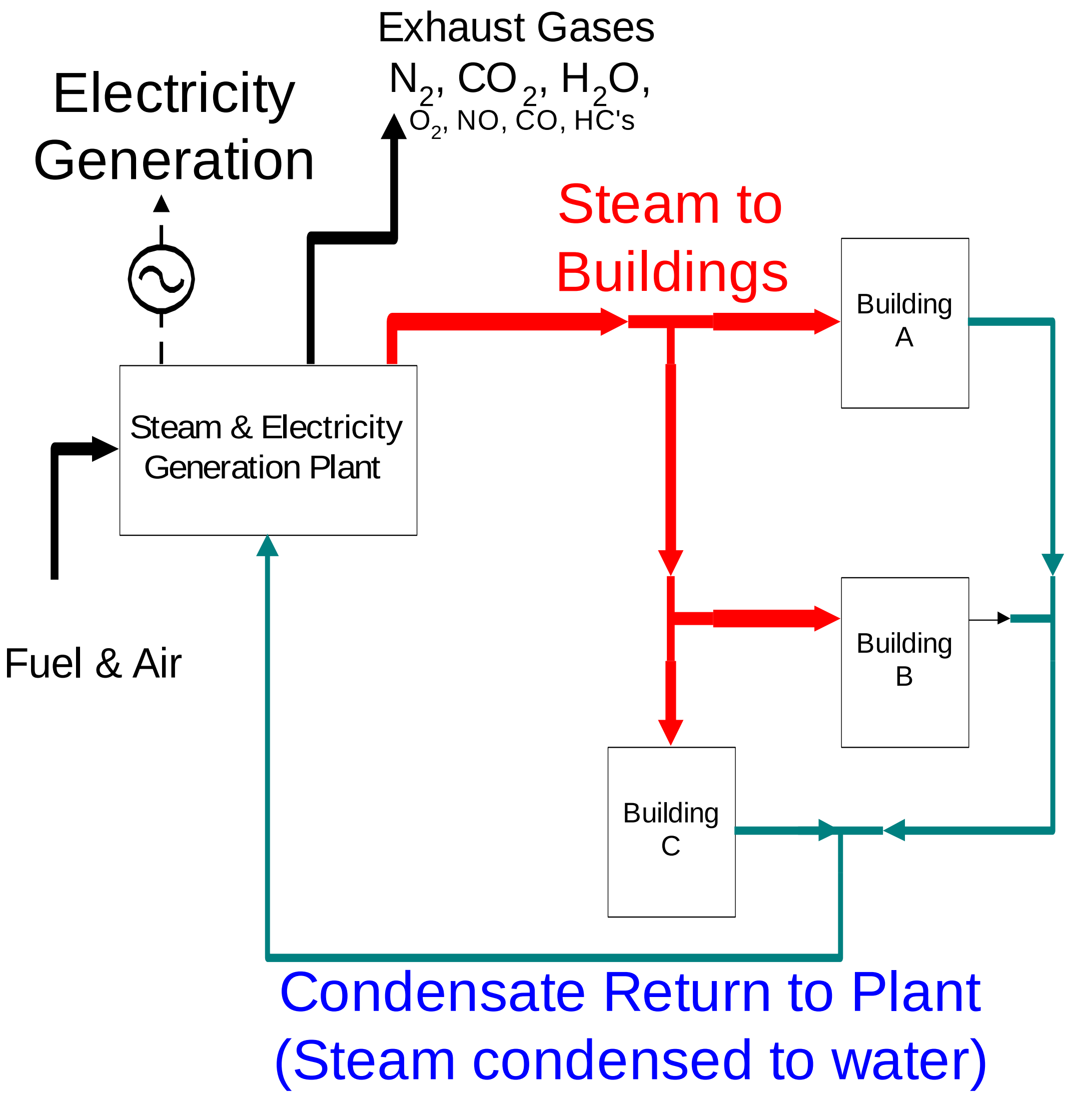
Rowan Cogeneration Plant
Energy Recovery International

Cogeneration

at the Rowan University Central Heating Plant

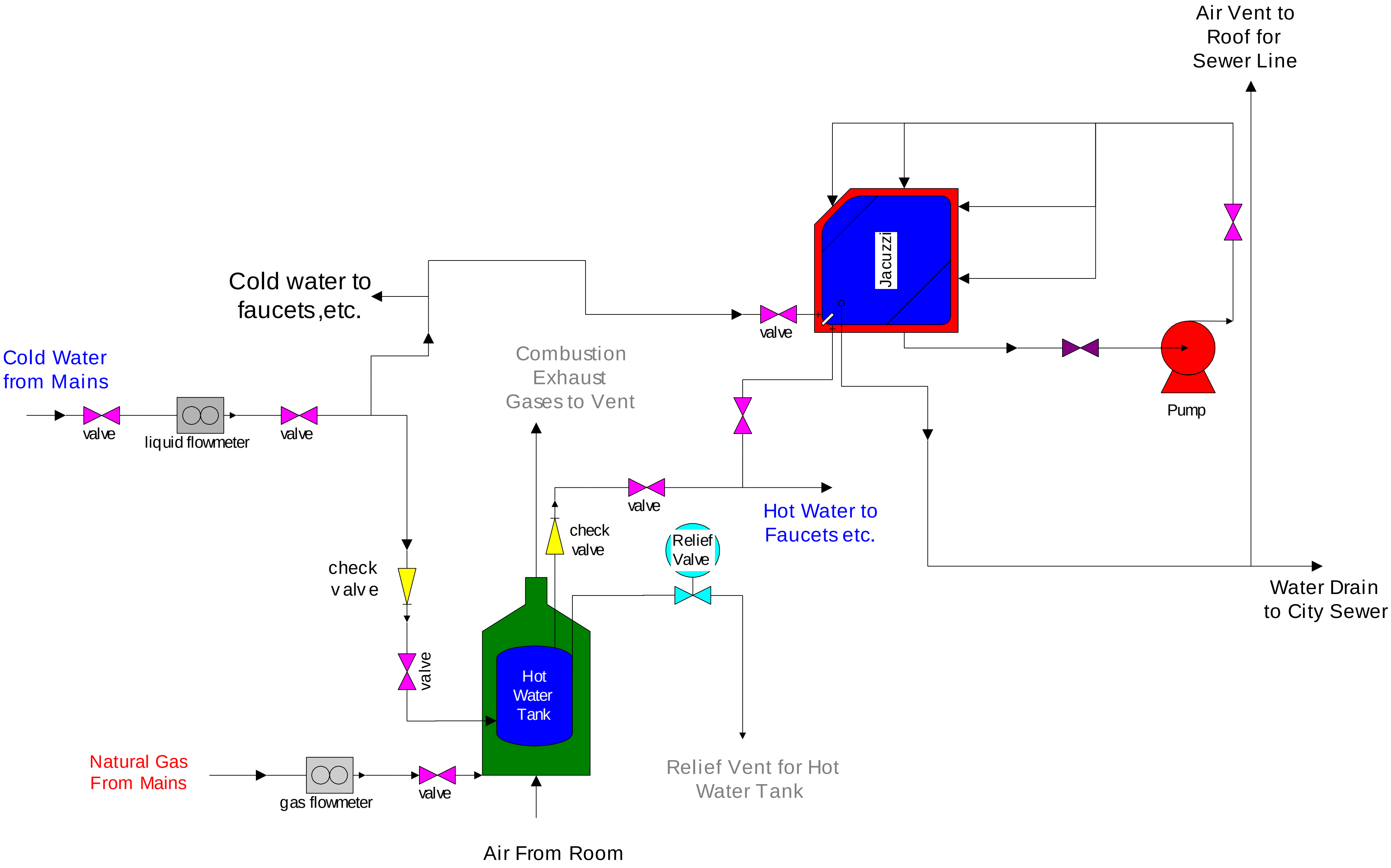
- Useful thermal energy (steam) and electricity
- Heating & Cooling
- Electricity Needs - 60% (1.5 MW)

Overall Schematic of Steam & Electricity Generation

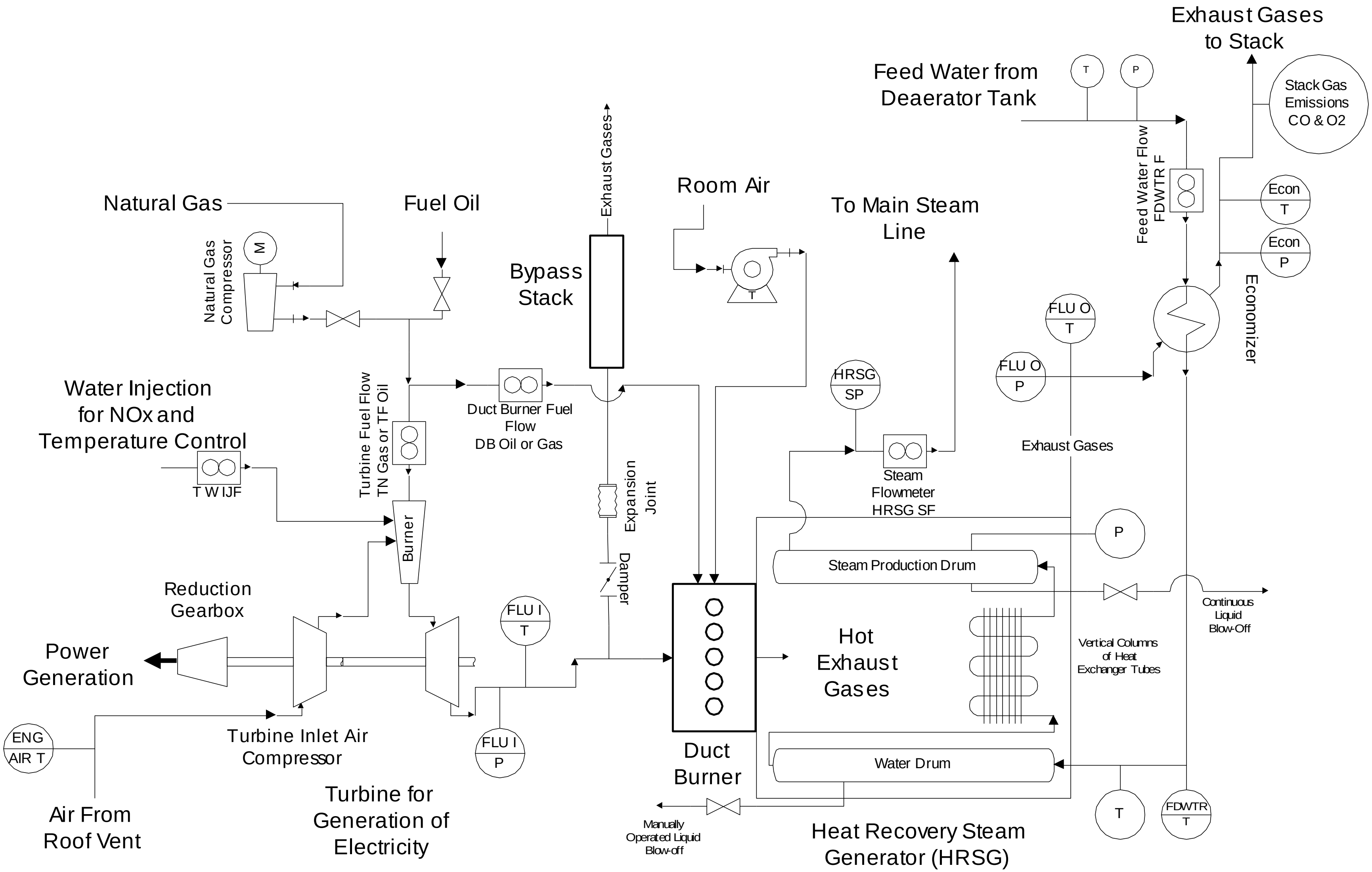


Brainstorm a Process that you are familiar with

- Flows into process
- Flows out of process
- chemical transformations within process
- Process conditions, *T*, *P*, Flowrate, Concentrations

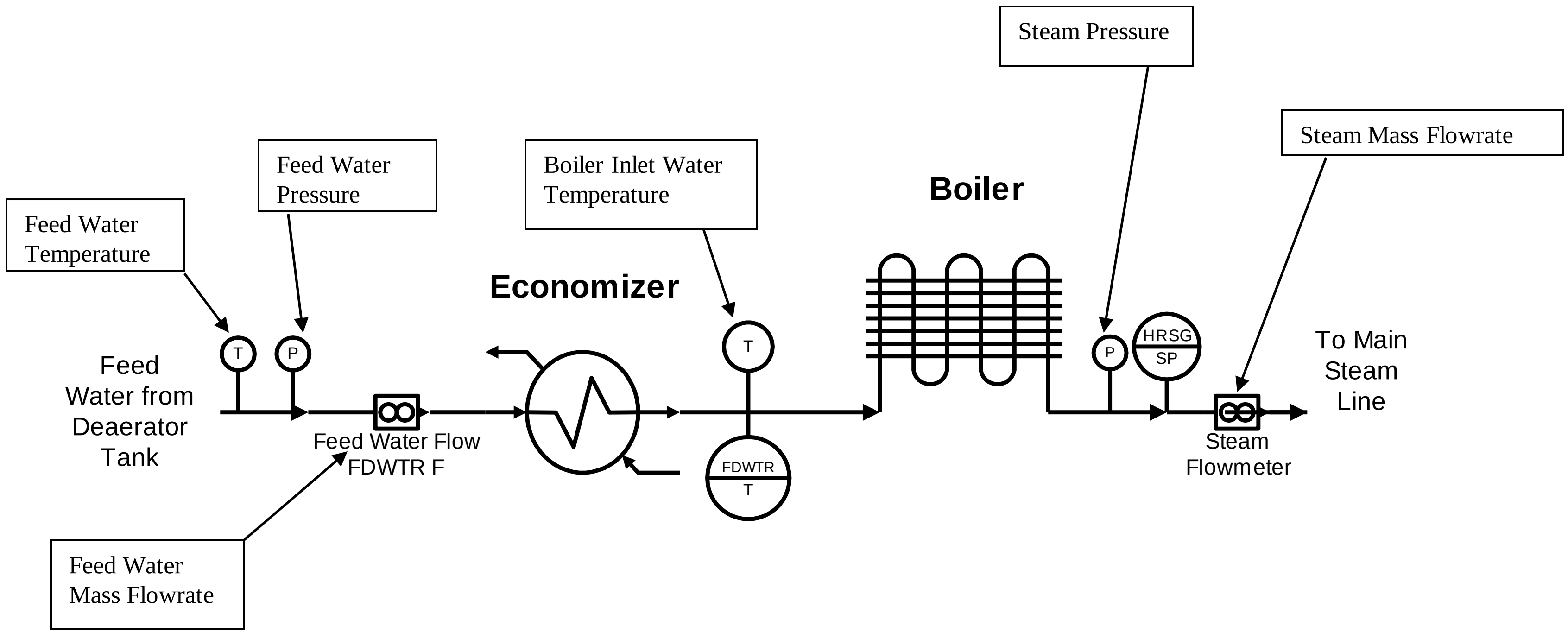


Process Flow Diagram of Hot Water Production for Jacuzzi



Rowan Cogeneration Plant
Energy Recovery International

Cogeneration Process Water Flow Diagram



Entrance of Heating Plant

Straight Ahead

Right

Measurements
on boiler side of cogeneration unit

Steam Pressure

Boiler (HRSG) Temperature

×1000 pph = multiply reading by 1000 to get lb_m/hr

Digital Displays on “Brown Panel”

Orifice Meters for Flowrate & Data Acquistion

Fuel Oil Flowrate

Cogen Steam Flowrate (HRSG SF)

Feed Water Flowrate (FDWTR F)

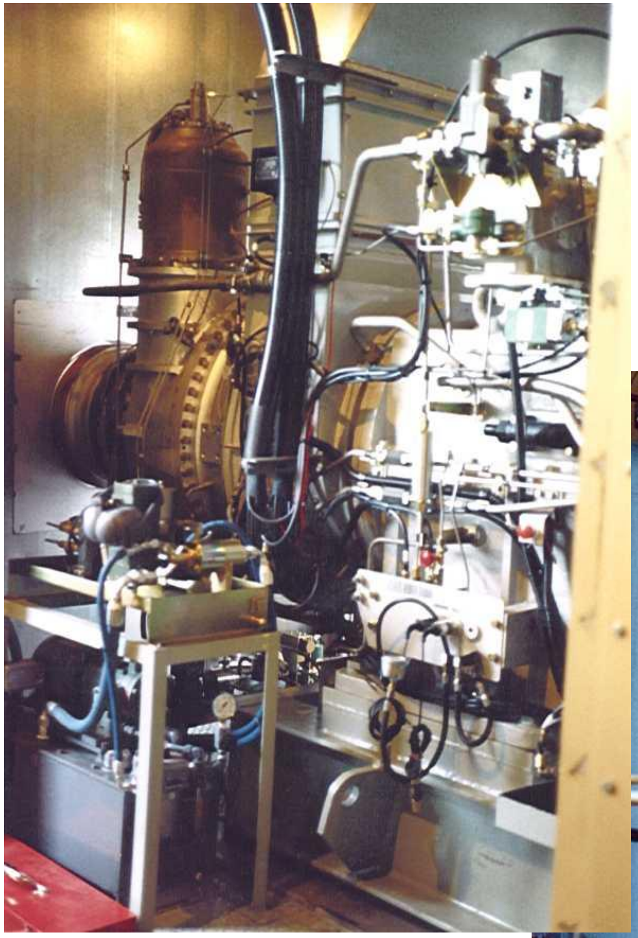
Boiler Water Treatment

Ion - Exchange Unit

Reverse Osmosis Unit

Natural Gas Compressor Room

Cogeneration Unit



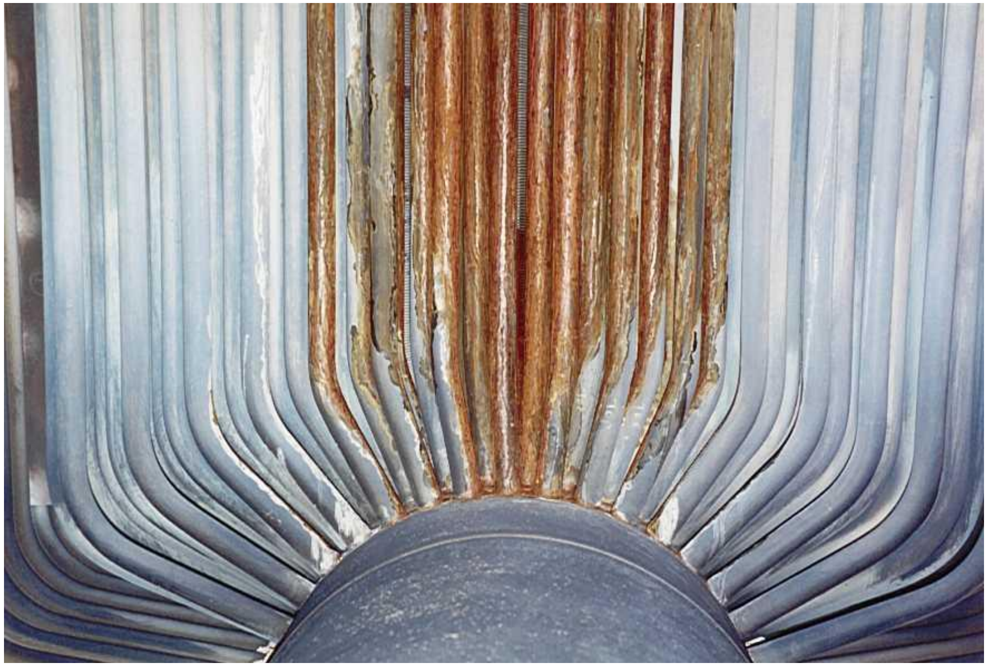
Turbine

Duct Burner

Heat Recovery
Steam Generator
(HRSG) or boiler

Inside the Boiler!

Detail of bottom of boiler tubes



Boiler Tubes

Control Room

Data Acquisition
System
65 Channels!

What a maze of pipes!

Do you know where your liquid is flowing?

•Light Blue	Feed water (mainly from dealkalinizer for pH control)
•Red	Steam
•Orange	Condensate (liquid water condensed from steam)
•Green	Feed water to boilers from deaeration unit
•Yellow	Natural Gas
•Black	Fuel Oil

Condensate
return line

Conventional Boiler Unit

Steam “Mains” Valve
Steam flows from here to the campus via underground pipes.

Deaerator Unit

at the top of the steps!

Liquid Level Indicator Remember ρgh!

Dial Temperature Gauge

On the Catwalk

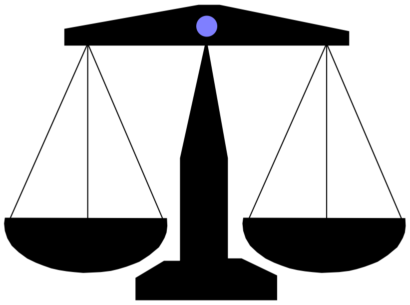
Economizer

Best View of an orifice flowmeter (fuel oil)

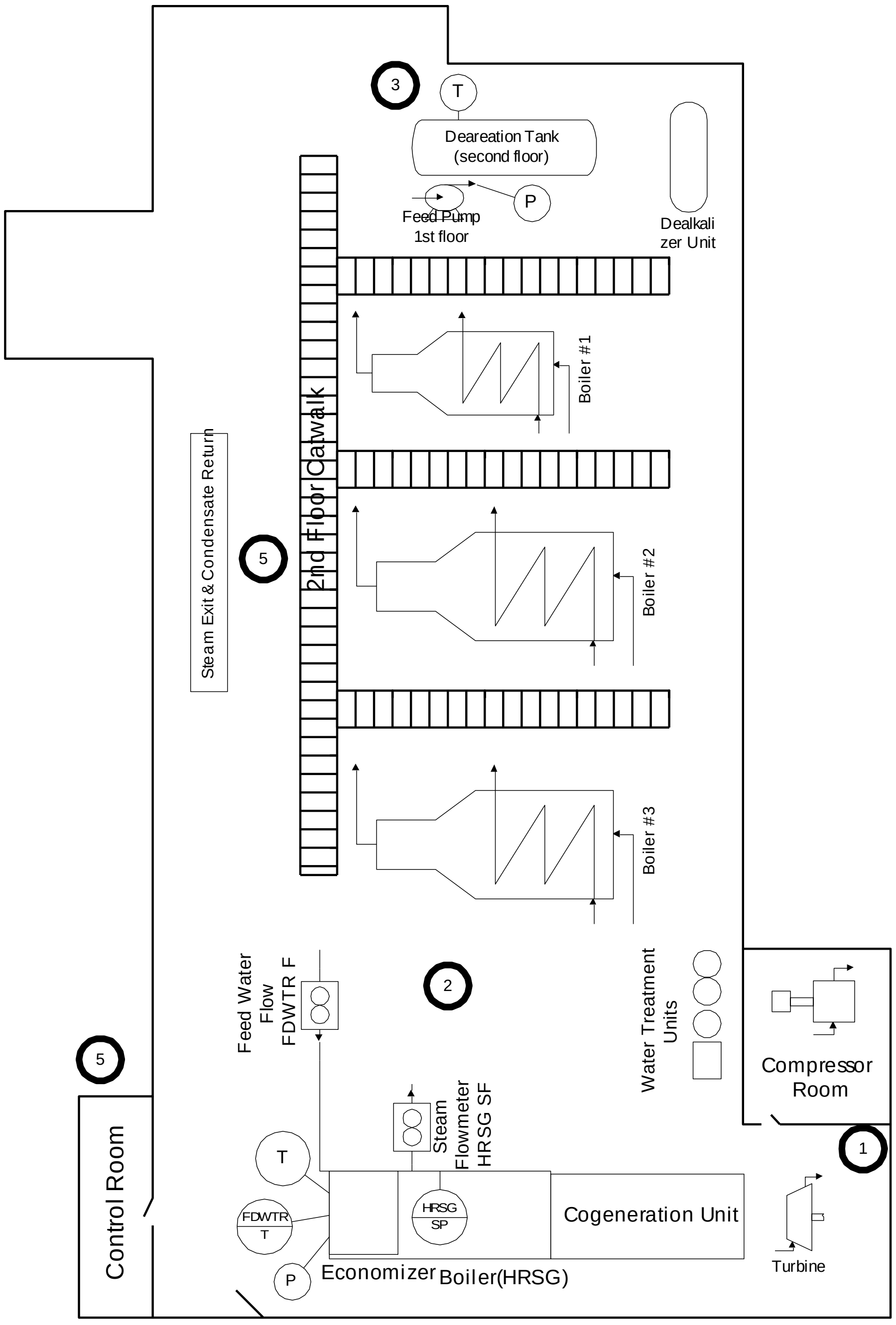
Steam Orifice Flowmeter

Steam Production Valve

Safety First!

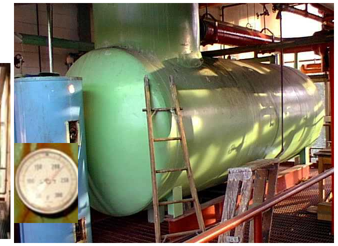


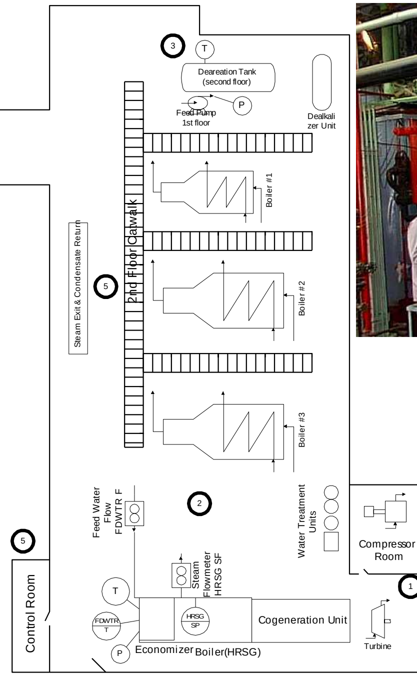
- Pipes and Tanks may be hot!
- Wear Hard Hats - High Bay Area
- Eye Protection
- Hearing Protection is optional

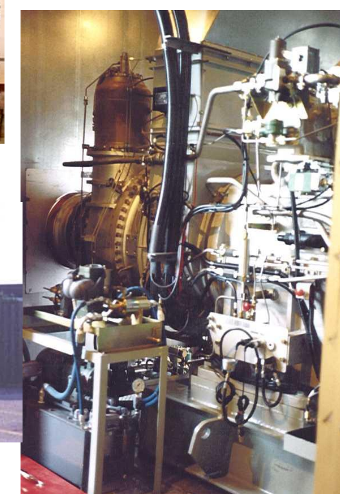


Walk over to the Cogen Plant

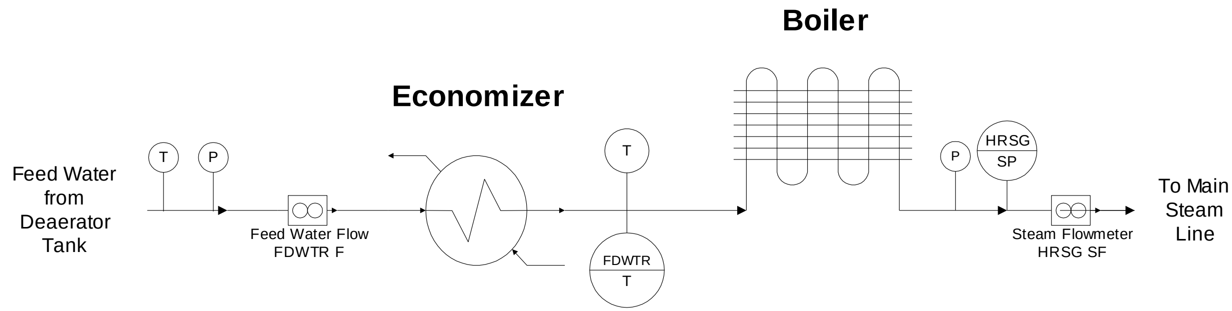
Cogen Tour Guide

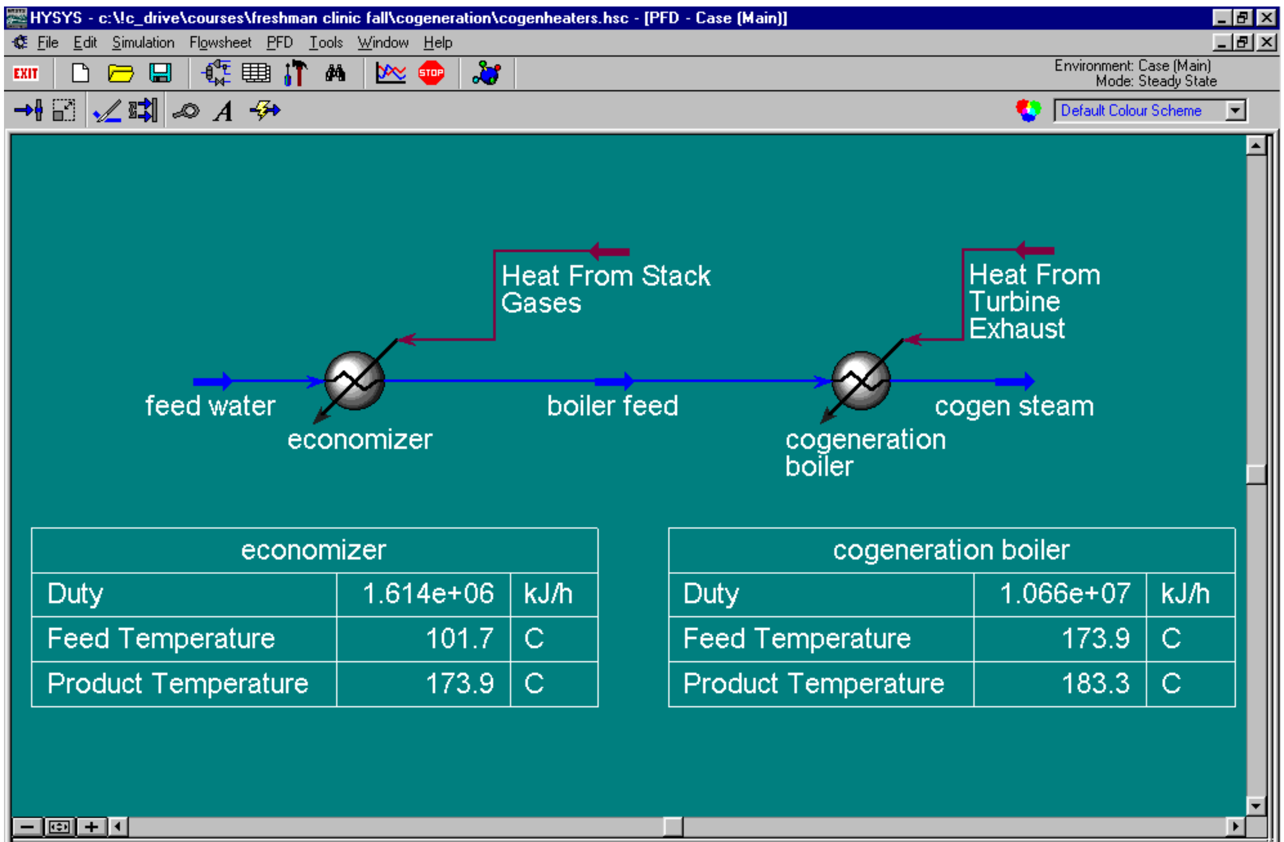






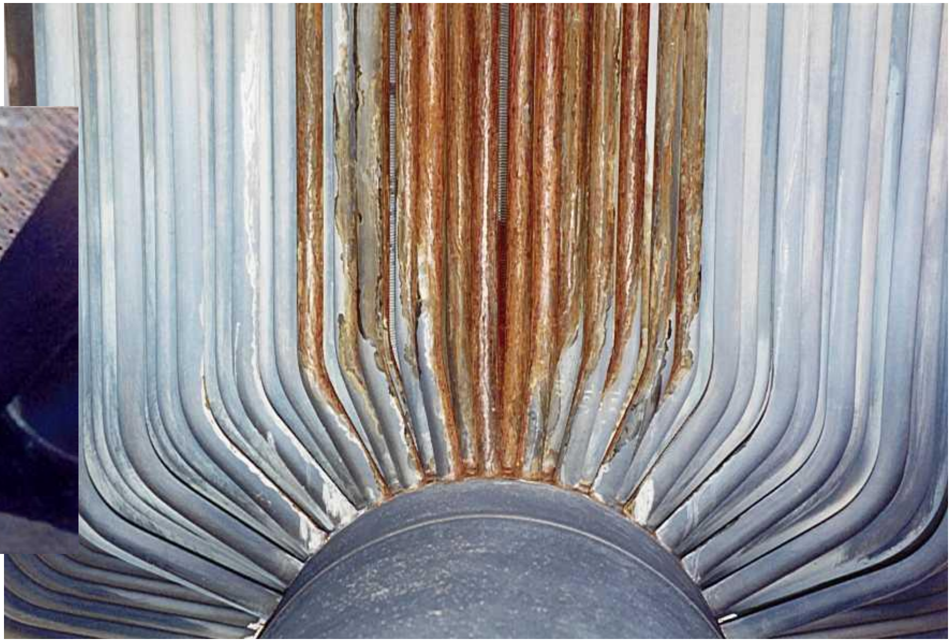
Process Simulation HYSYS

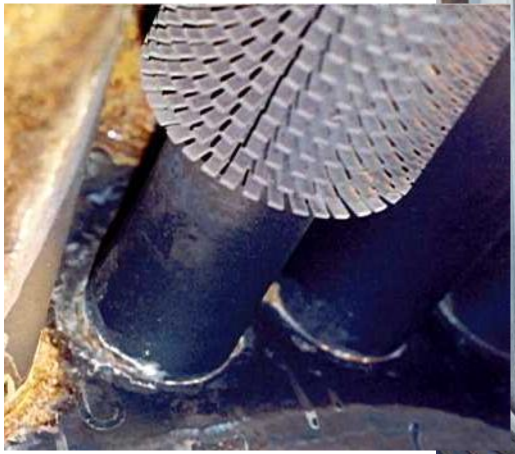




Homework Assignment

- Calculate duty on both heat exchangers
- Compare hand calculations to process simulation results





Answers given in the process simulation results!

Engineering Equations

- Mass Balance

$$\dot{m}_{FW} = \dot{m}_{steam} \; ?$$

- Thermodynamics
  - Enthalpy

$$\hat{H}^{liquid} = C_p^{liquid}\left(T - 273.16\text{K}\right)^2$$

  - Heat Capacity

$$C_p^{liquid} = 4788.26\frac{\text{J}}{\text{kgK}} - 3.4297\frac{\text{J}}{\text{kgK}^2}T + 4.885\times10^{-3}\frac{\text{J}}{\text{kgK}^3}T^2$$

  - Vapor-Liquid Equilibrium of Saturated Steam

$$\frac{1}{T_{steam}} = -2.075\times10^{-4}\frac{1}{\text{K}}\ln\left(\frac{P_{steam}}{1.01325\times10^5\,\text{Pa}}\right) + 2.683\times10^{-3}\frac{1}{\text{K}}$$

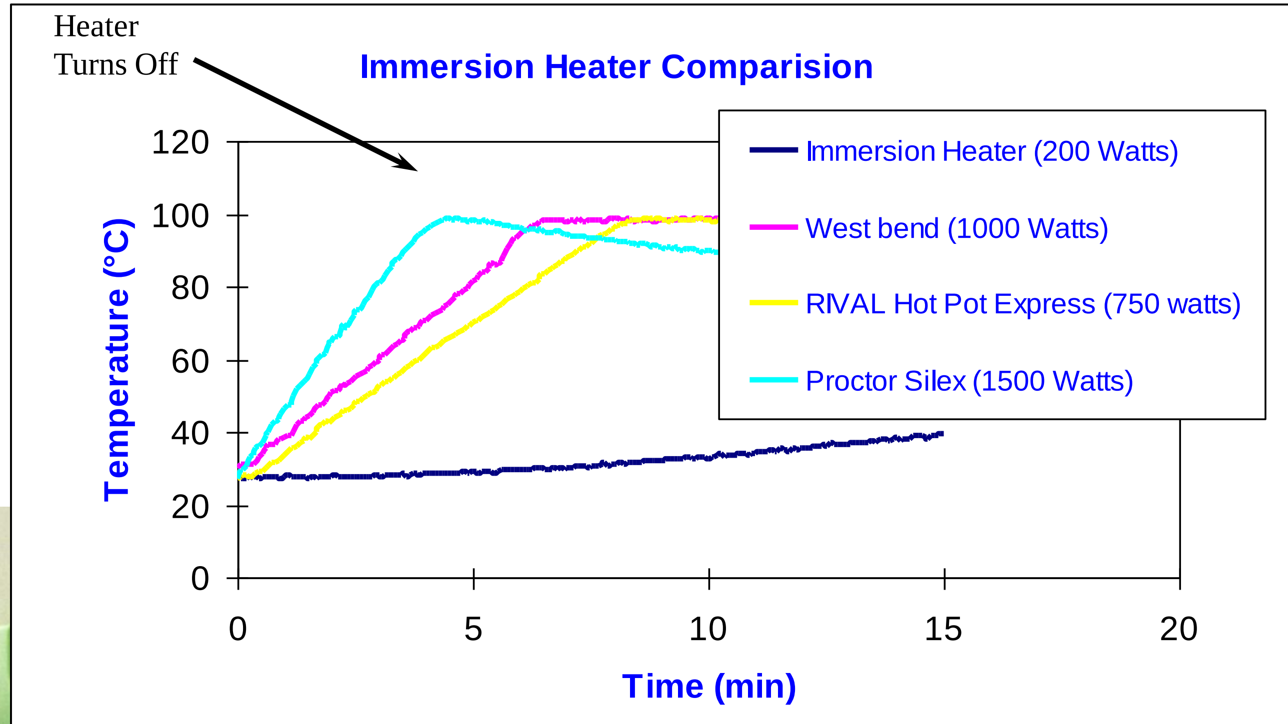
- Energy Balances

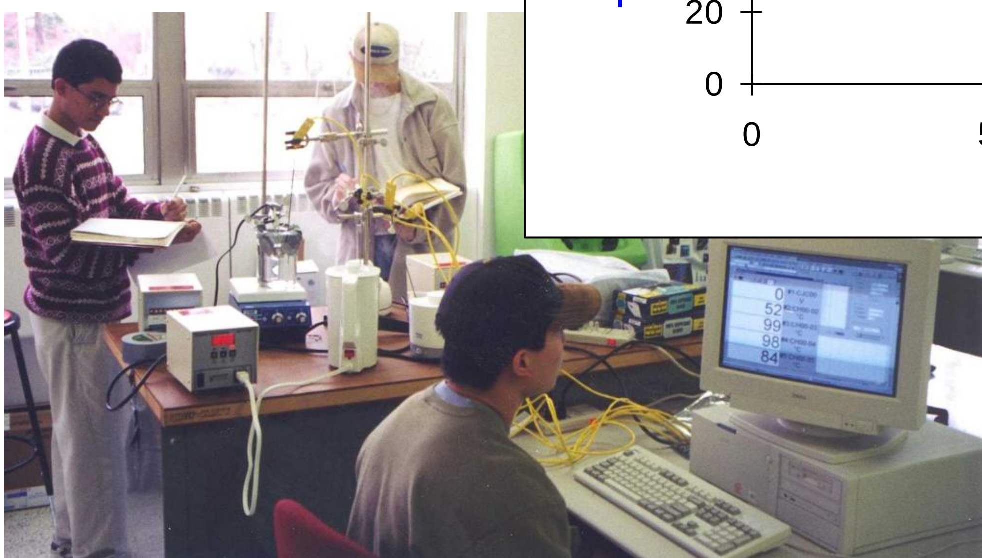
$$Q_{economzer} = \hat{H}_m^{liq}\dot{m}_{liq} - \hat{H}_{in}^{liq}\dot{m}_{liq}$$

$$Q_{boiler} = \hat{H}_{out}^{gas}\dot{m}_{gas} - \hat{H}_m^{liq}\dot{m}_{liq}$$

Week 2: Process Engineering

- Immersion Heaters
- Rotameter Calibration

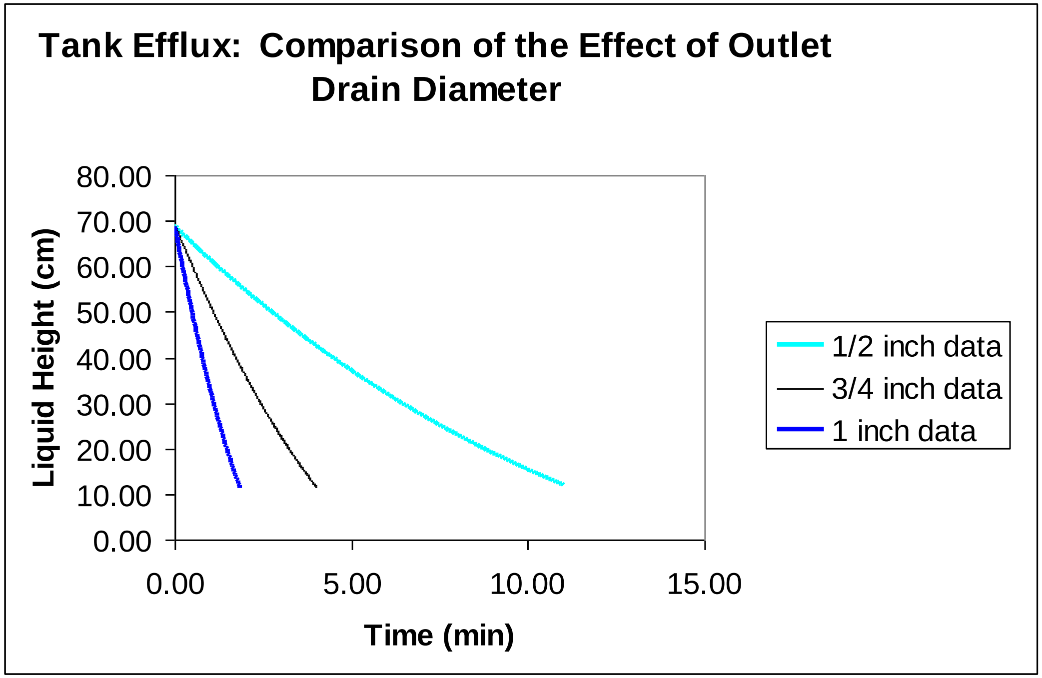




$$mC_p^{liq}\frac{\mathrm{d}T}{\mathrm{d}t} = Q_{in} - 0$$

Week 3: Process Engineering

- Tank Efflux
- 2-L Soda Bottle Implosion



$$\frac{\mathrm{d}m_{\tan k}}{\mathrm{d}t} = \frac{\mathrm{d}\left(\rho A_{\mathrm{tank}} h\right)}{\mathrm{d}t} = -\dot{m}_{out}$$