U of I South Campus Chiller Plant (SCCP)

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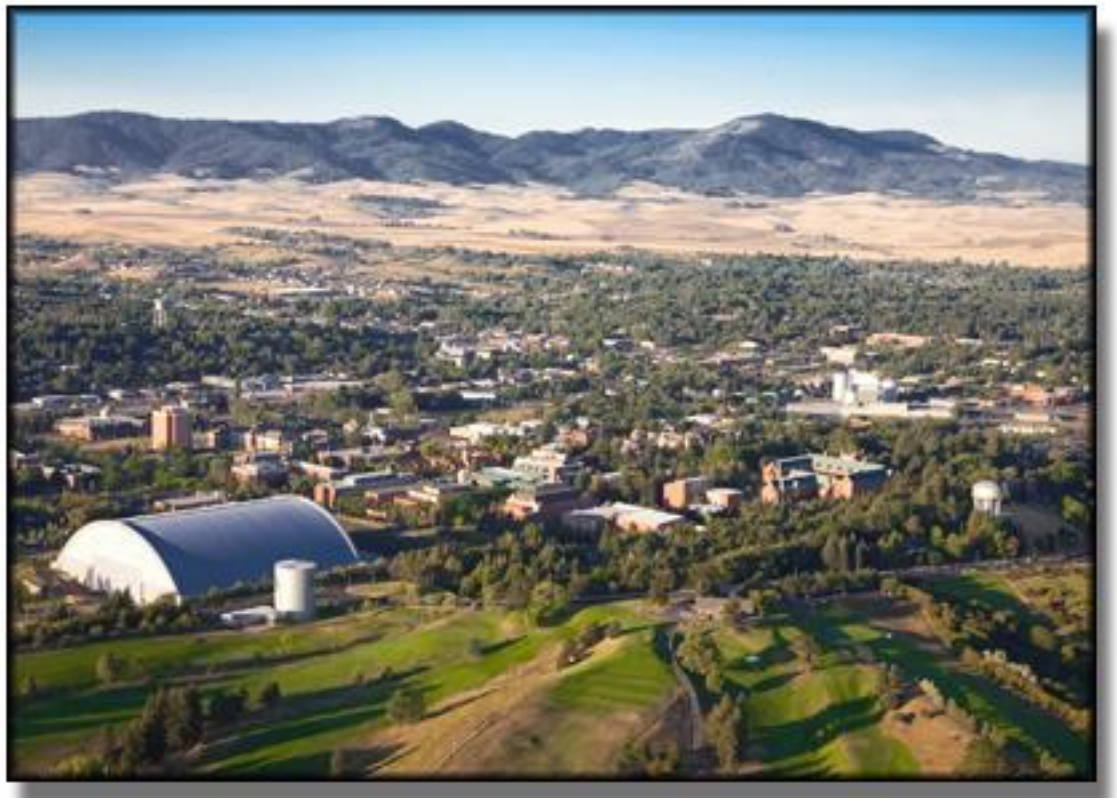
Background

South Campus Chiller Plant (SCCP)

- Produces chilled water for HVAC purposes
- One of two plants on campus
- Located up by U of I Golf Course

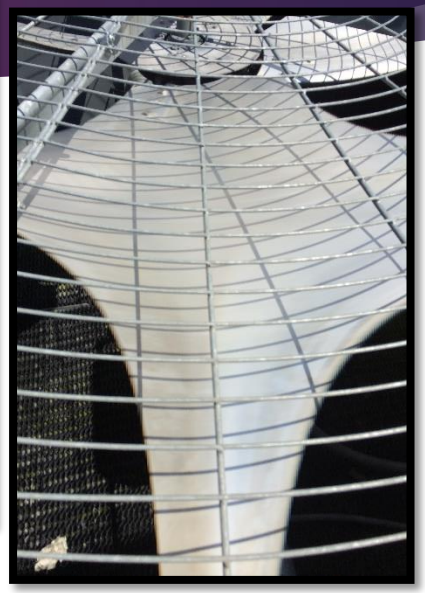


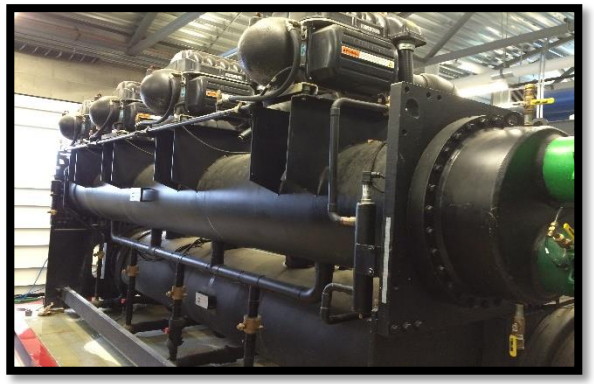
Project Scope

- **Problem Statement**
  - *"Data collected from the SCCP's current operating condition suggests areas of inefficiencies, leading to unnecessary operating costs"*
- **Project Goals**
  - Determine the operating cycle
  - Provide necessary instrumentation to define thermodynamic states
  - Develop a working math model
  - Use the math model to validate inefficiencies
  - Optimize the math model for greatest efficiencies
  - Develop a calculator for simulation purposes

SCCP Equipment

- Armstrong Pumps
- Smardt Chillers
  - Turbocor Compressors
- Evapco Cooling Towers
- Thermal Energy Storage Tank (TES)

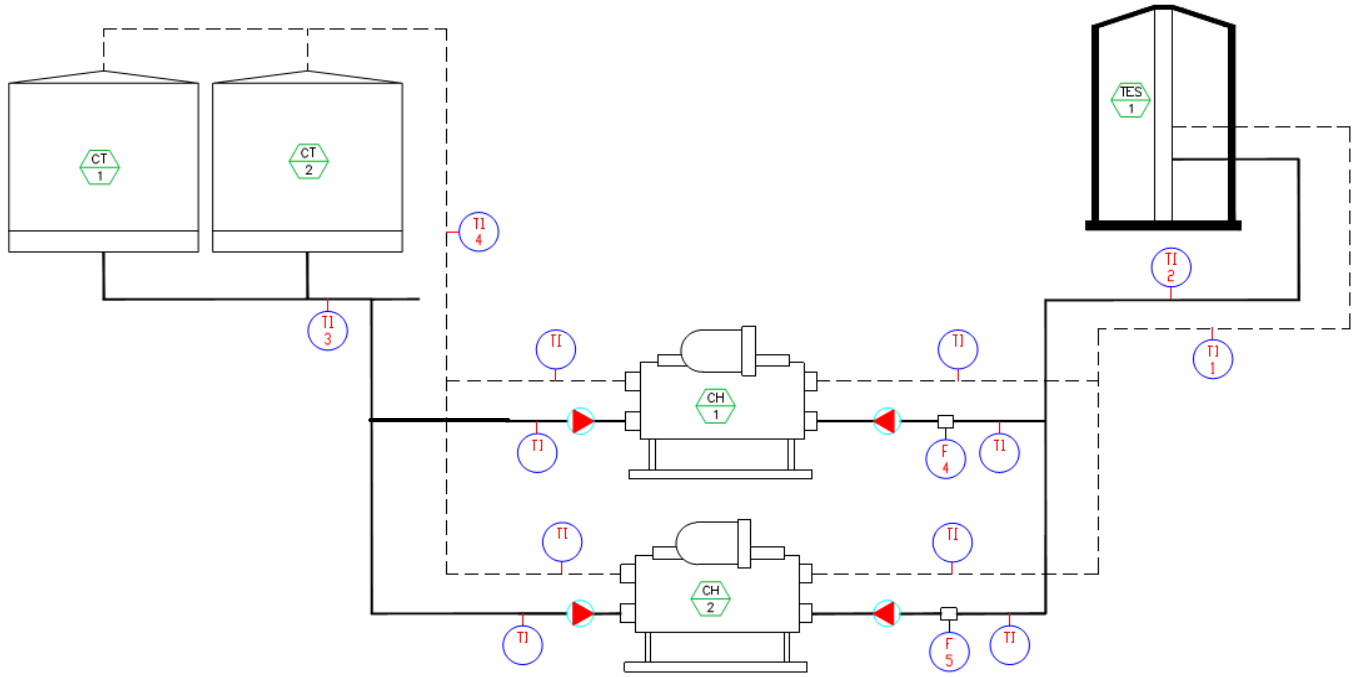




Instrumentation

Existing P&ID

- Existing instrumentation
- Talk about ATS
- What's hooked up to ATS

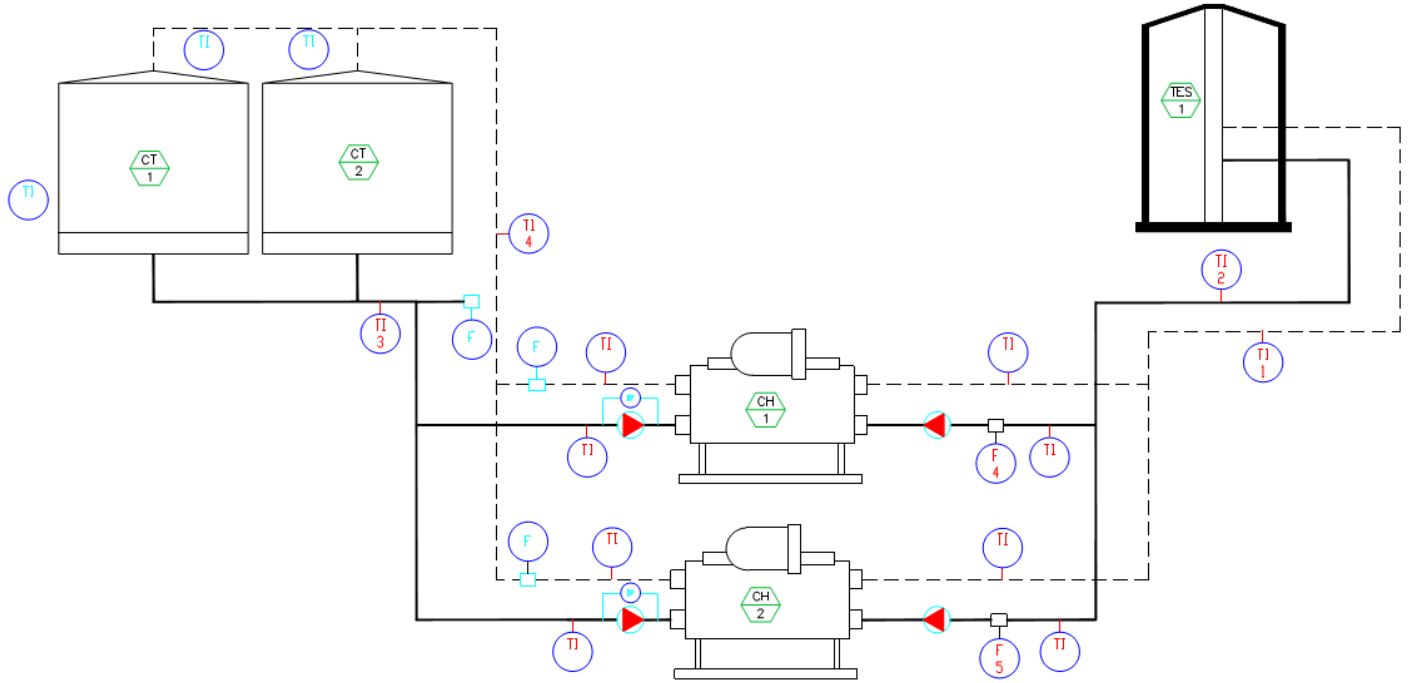


1 ORIGINAL P&ID
SCALE: NONE

Instrumentation

Edited P&ID

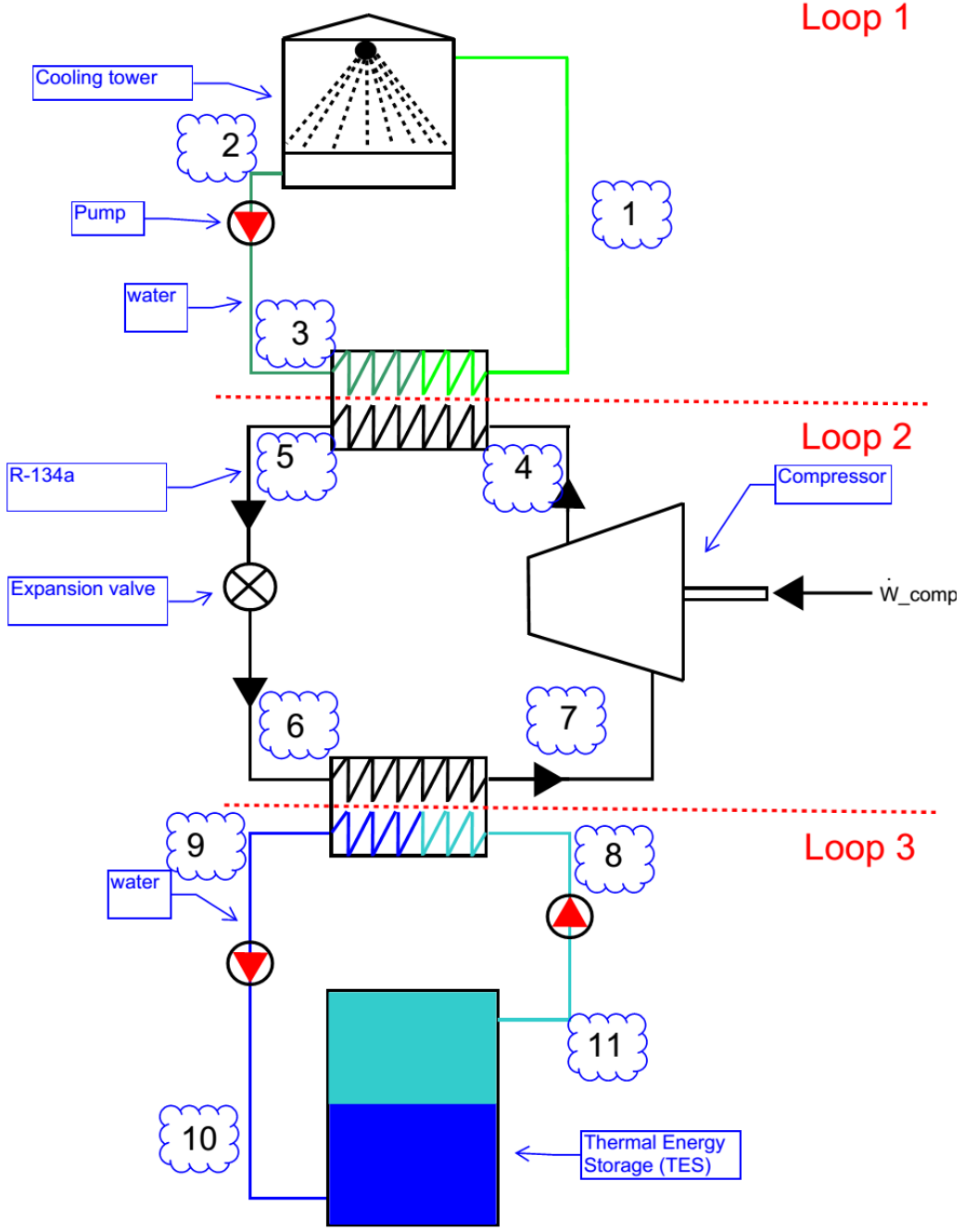
- Temperature sensor
  - Enthalpy
  - Wet bulb/dry bulb
- Flow meter
- Pressure transducer



Math Model: Initial

Initial Thermodynamic Model

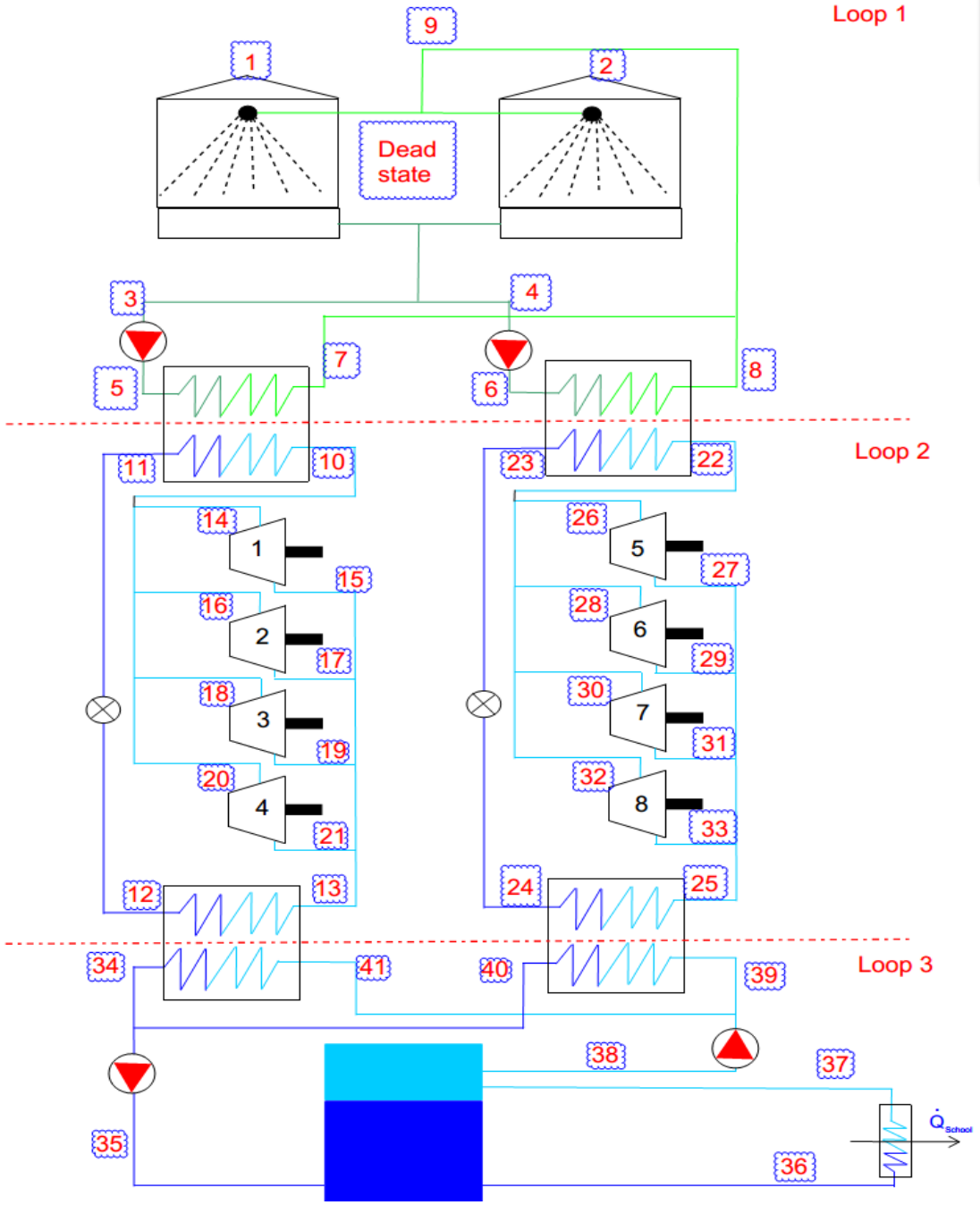
- Contents
  - One Chiller
  - One Compressor
  - One Cooling Tower
- Three Thermodynamic Loops
- First Law
- Steady State Analysis



Math Model: Expansion

Realistic Thermodynamic Model

- Expansion of Initial Model
  - Two Chillers
  - Four Compressors per Chiller
  - Two Cooling Towers
- First Law
- Steady State Analysis



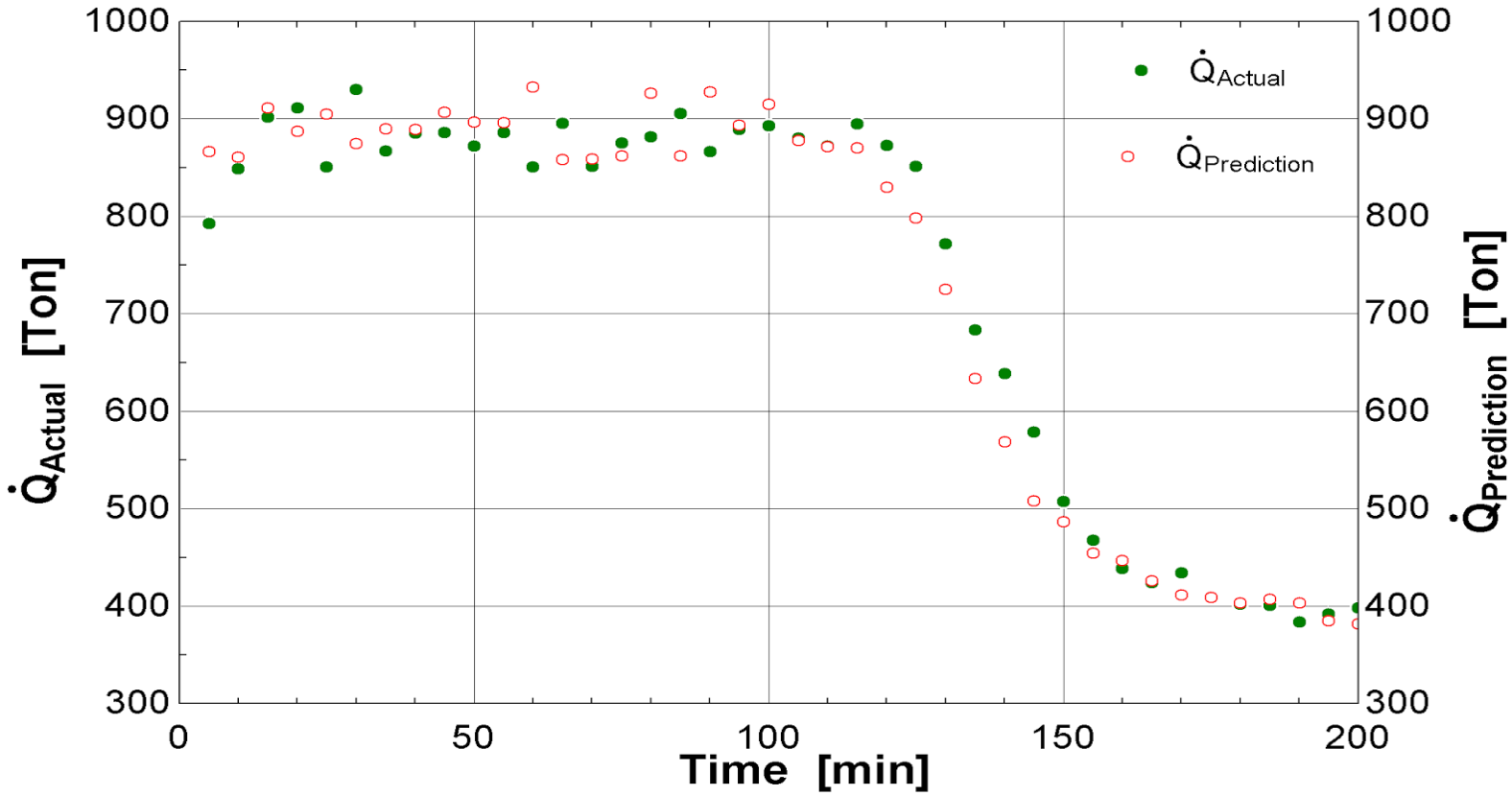
U of I SCADA Data

Data Acquired

- How it's collected?
- How we selected data?

Chiller 1																
Power																
Comp1				Comp2				Comp3				Comp4				
Time	748-SCCP-(	Events		Time	748-SCCP-	Events		Time	748-SCCP-	Events		Time	748-SCCP-	Events		
8/1/2014 3:38	59.2	""		8/1/2014 3:38	59.7	""		8/1/2014 3:38	61.9	""		8/1/2014 3:38	59.5	""		
8/1/2014 3:43	58	""		8/1/2014 3:43	58.4	""		8/1/2014 3:43	61.1	""		8/1/2014 3:43	58.9	""		
8/1/2014 3:48	57.9	""		8/1/2014 3:48	59.1	""		8/1/2014 3:48	61.2	""		8/1/2014 3:48	58.7	""		
8/1/2014 3:53	58.2	""		8/1/2014 3:53	58.9	""		8/1/2014 3:53	61.2	""		8/1/2014 3:53	58.7	""		
8/1/2014 3:58	58.9	""		8/1/2014 3:58	59.9	""		8/1/2014 3:58	62.2	""		8/1/2014 3:58	59.7	""		
8/1/2014 4:03	58.2	""		8/1/2014 4:03	59.4	""		8/1/2014 4:03	61.5	""		8/1/2014 4:03	59.1	""		
8/1/2014 4:08	58.7	""		8/1/2014 4:08	60.4	""		8/1/2014 4:08	61.6	""		8/1/2014 4:08	59.9	""		
8/1/2014 4:13	58.6	""		8/1/2014 4:13	59.2	""		8/1/2014 4:13	61.9	""		8/1/2014 4:13	59.4	""		
8/1/2014 4:18	57.4	""		8/1/2014 4:18	58.7	""		8/1/2014 4:18	60.9	""		8/1/2014 4:18	57.9	""		
8/1/2014 4:23	58.2	""		8/1/2014 4:23	59.2	""		8/1/2014 4:23	61.1	""		8/1/2014 4:23	59.2	""		
8/1/2014 4:28	57.4	""		8/1/2014 4:28	57.7	""		8/1/2014 4:28	59.6	""		8/1/2014 4:28	57.7	""		
8/1/2014 4:33	58.9	""		8/1/2014 4:33	59.6	""		8/1/2014 4:33	62.1	""		8/1/2014 4:33	60.2	""		
8/1/2014 4:38	57.5	""		8/1/2014 4:38	58.5	""		8/1/2014 4:38	60.7	""		8/1/2014 4:38	58.1	""		
8/1/2014 4:43	58.7	""		8/1/2014 4:43	59.2	""		8/1/2014 4:43	61.7	""		8/1/2014 4:43	59	""		
8/1/2014 4:48	58.1	""		8/1/2014 4:48	58.9	""		8/1/2014 4:48	61.2	""		8/1/2014 4:48	58.7	""		
8/1/2014 4:53	57.7	""		8/1/2014 4:53	58.7	""		8/1/2014 4:53	61	""		8/1/2014 4:53	58.2	""		

Output from Math Model



Performance Calculator

Purpose

- Easy to run a on the fly calculation
- Help run scenarios to find optimal running conditions
- Simulates cost of running chillers under various conditions

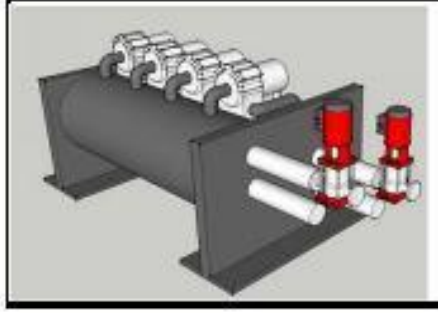
Performance Calculator Snapshot

Chiller 1 & 2 Full

Chiller Capacity	890.11	[tons]
SCCP Output	21362.54	
Combined Cost	930.624	[$]
Cost Efficiency	0.04	[$/ton-hr]

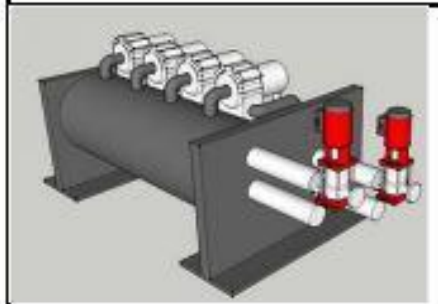
Avista	0.08	[$/kW-hr]
Hours operation	24	[Hours]

Chiller 1



Flow rate	802	[GPM]	Power Chiller 1			Chiller capaci	445.05	[tons]
T_in	54.2	[F]	Comp 1	57.8	[kW]	Power total	234.2	[kW]
T_out	40.9	[F]	Comp 2	57.8	[kW]			
$\dot{m}$	401430.19	[lb_m/hr]	Comp 3	60.3	[kW]			
ρ	62.40	[lb_m/ft^3]	Comp 4	58.3	[kW]			
h_in	22.25	[Btu/lb_m]						
h_out	8.95	[Btu/lb_m]						

Chiller 2



Flow rate	802	[GPM]	Power Chiller 2			Chiller capaci	445.05	[tons]
T_in	54.2	[F]	Comp 1	62.3	[kW]	Power total	250.5	[kW]
T_out	40.9	[F]	Comp 2	61.4	[kW]			
$\dot{m}$	401430.19	[lb_m/hr]	Comp 3	64.1	[kW]			
ρ	62.40	[lb_m/ft^3]	Comp 4	62.7	[kW]			
h_in	22.25	[Btu/lb_m]						
h_out	8.95	[Btu/lb_m]						

Project Summary

Project Deliverables

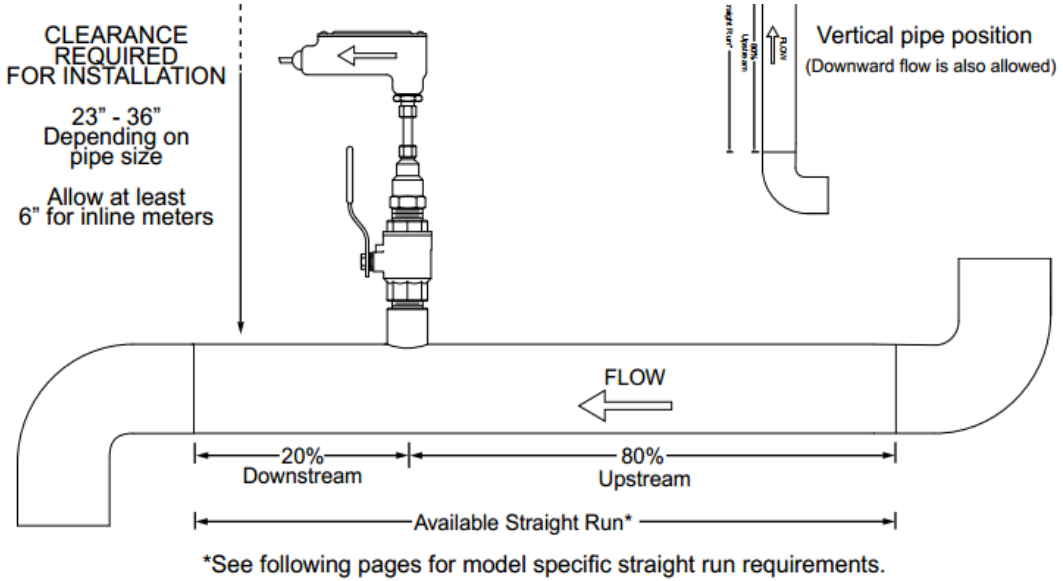
- Added further trending capability to SCCP through flow/pressure/temperature instrumentation
- Developed and validated a working math model for the SCCP
- Developed a performance calculator for SCCP operators to simulate various operating conditions

Recommendations

Flow Meter & VFD Controller

Possible Causes

- Flow meter error due to location
- 20% voltage error



Recommendations

- Implement a correction factor
- Calibrate according to manufacturer

Recommendations

Pressure Losses

Possible Causes

- Sensor error
- Fouling

Recommendation

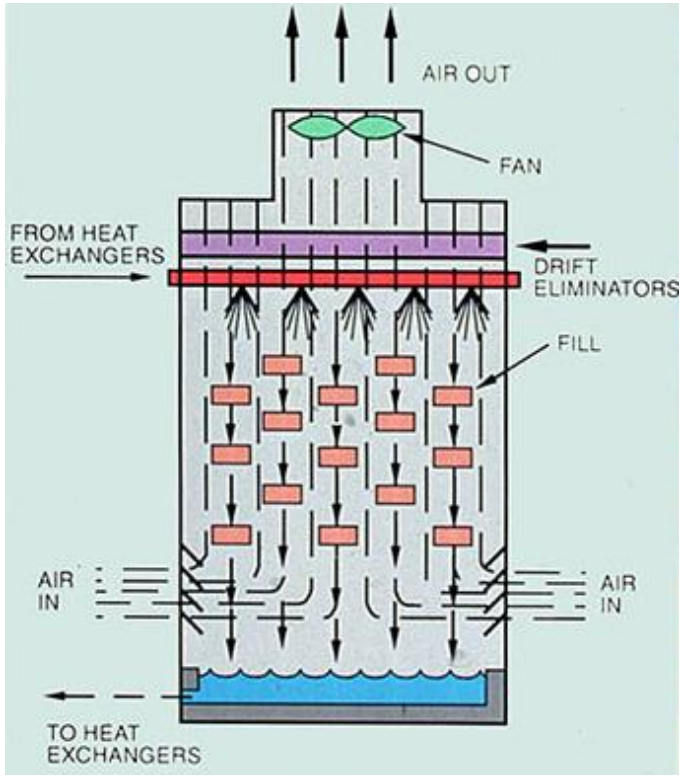
- Perform sensor diagnostics
- Consider a maintenance schedule and fouling factors for R134a

R134a Fouling Factors
Gases & vapors: 0.002
Liquids: 0.001

Recommendations

Cooling Tower Efficiency

- When the air has been heated to saturation, no extra fan power is required



Recommendations

- Perform psychrometric study to determine when saturation occurs
- Use only the power required to reach saturation
- Test temperature sensors after winter season

Looking Forward

Future Capstone Project Ideas

- Verify causes and recommendations
- Develop a control system strategy to anticipate cooling demands

Thank You!