



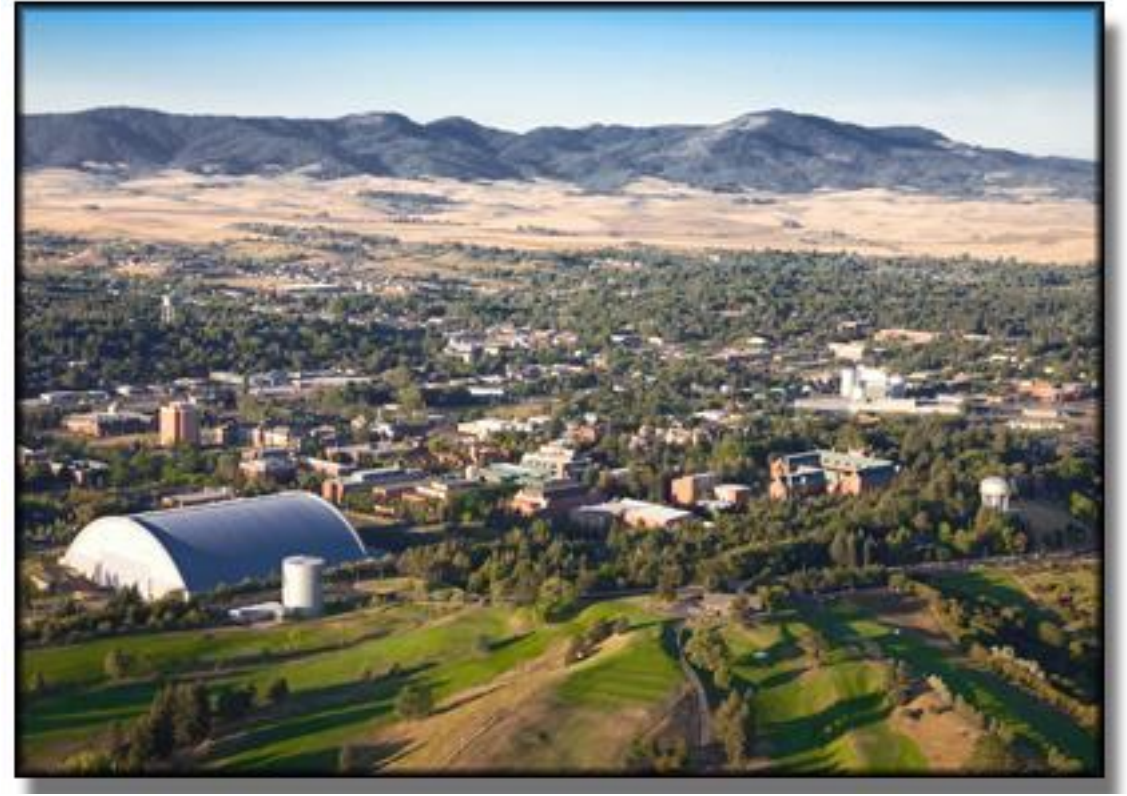
U of I South Campus Chiller Plant (SCCP)

**PRESENTED BY: ALI ALMATER, CHRIS THILMONY, DARVIN THORNTON, AND
PATRICK FROME**

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

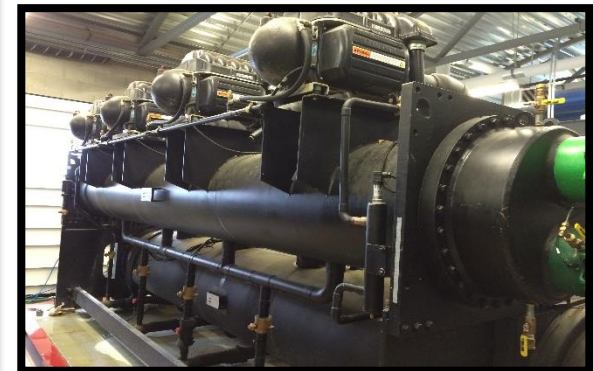
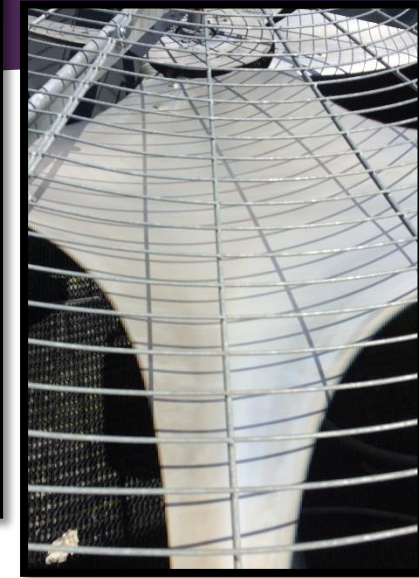
- *“Data collected from the SCCP's current operating condition suggests areas of inefficiencies, leading to unnecessary operating costs”*

► 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

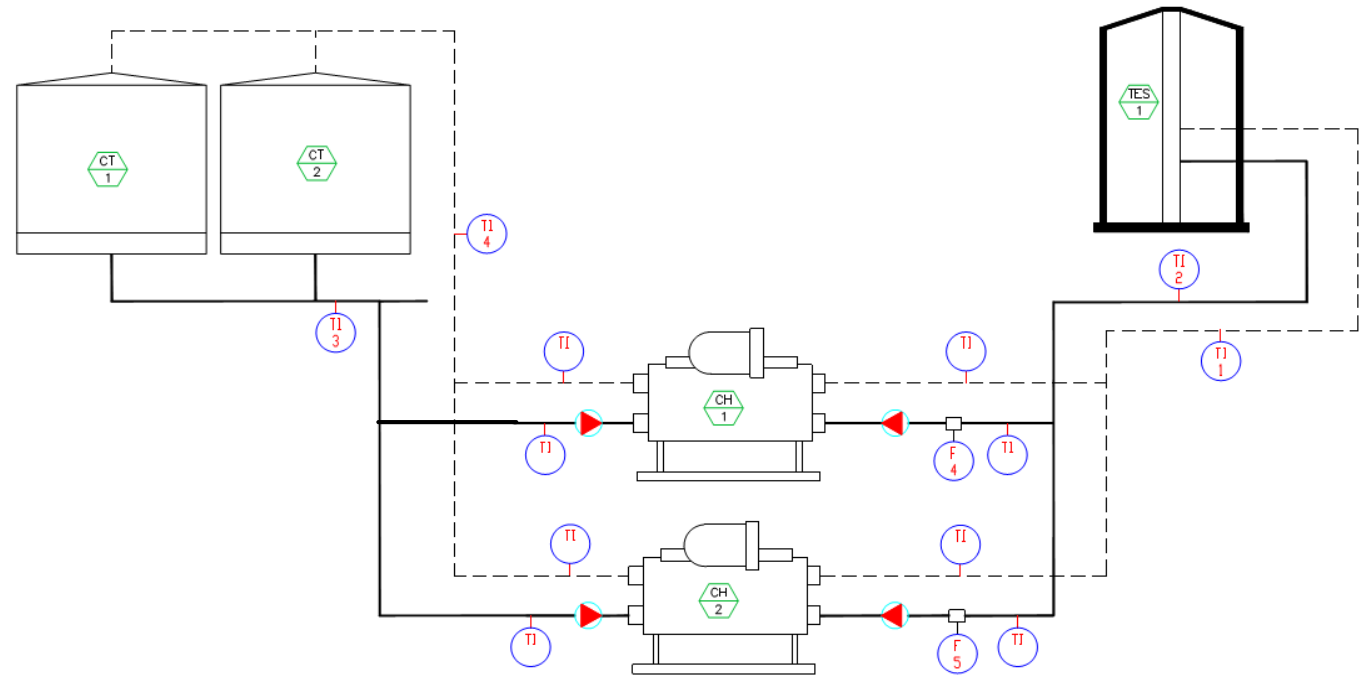
- ▶ Armstrong Pumps
- ▶ Smardt Chillers
 - ▶ Turbocor Compressors
- ▶ Evapco Cooling Towers
- ▶ Thermal Energy Storage Tank (TES)



Instrumentation

Existing P&ID

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



1

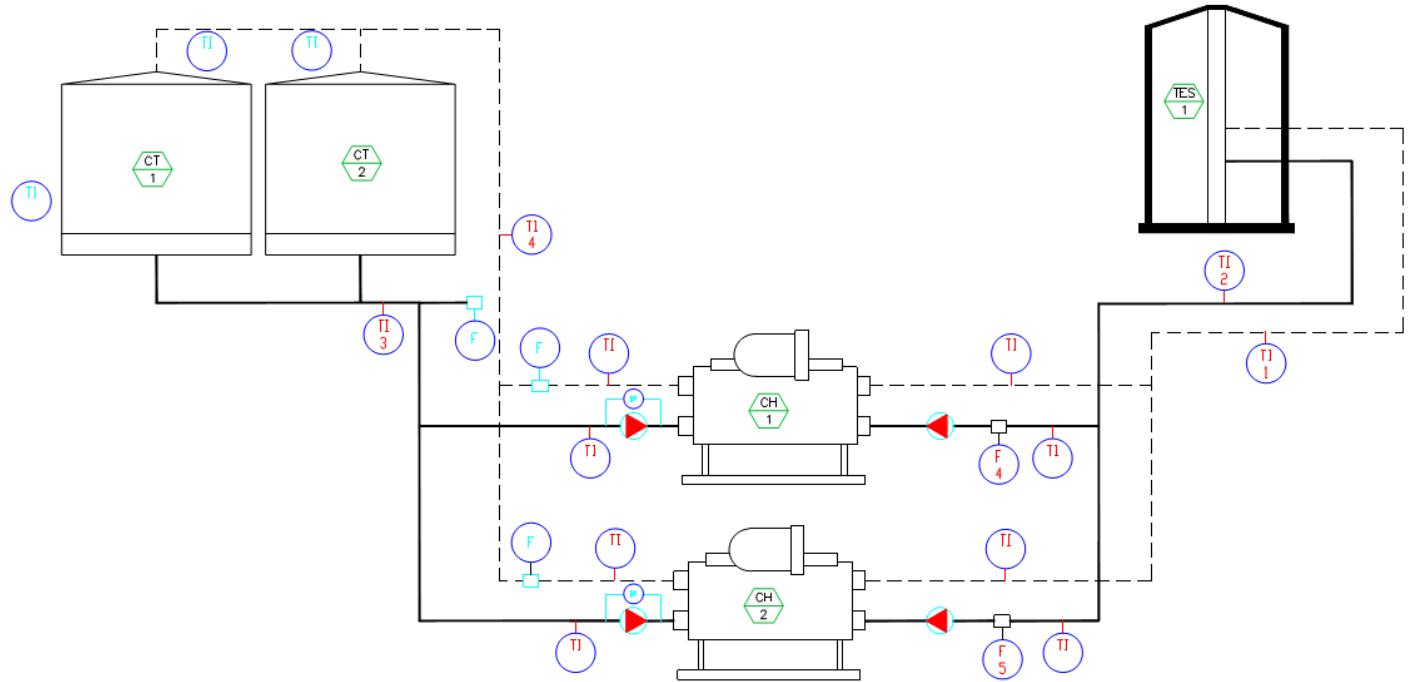
ORIGINAL P&ID

SCALE: NONE

Instrumentation

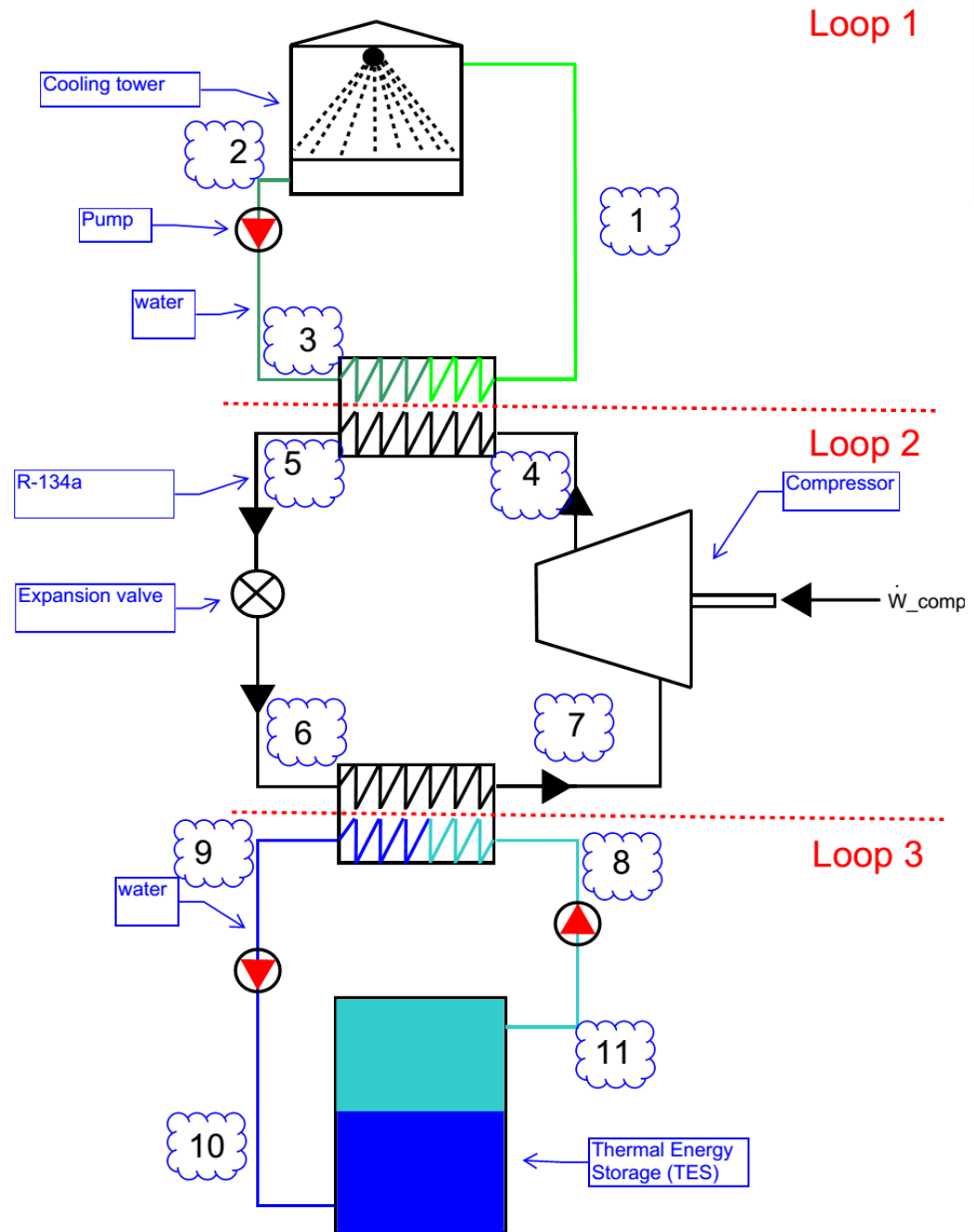
Edited P&ID

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



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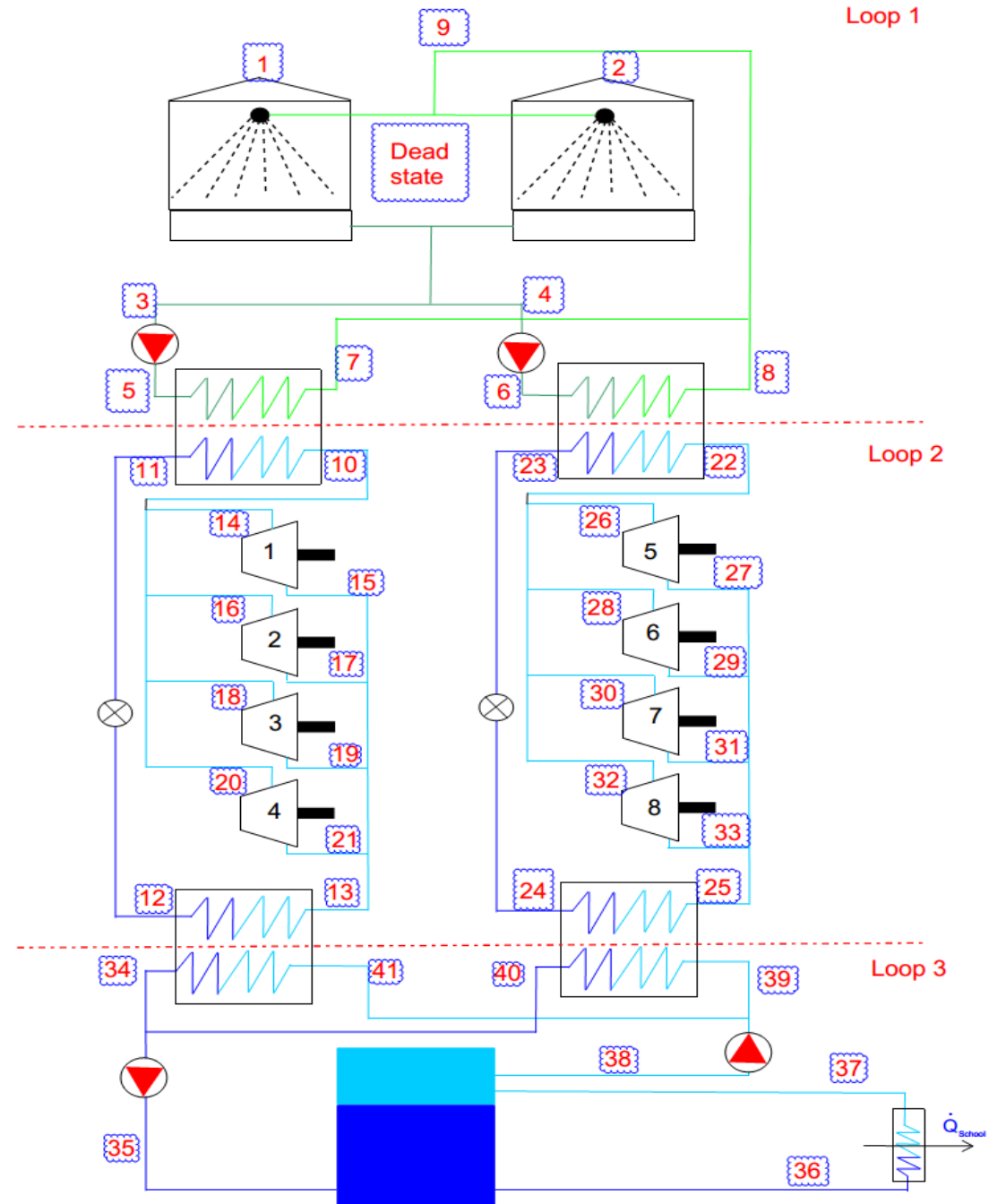
- ▶ Contents
 - ▶ One Chiller
 - ▶ One Compressor
 - ▶ One Cooling Tower
- ▶ Three Thermodynamic Loops
- ▶ First Law
- ▶ Steady State Analysis



Math Model: Expansion

Realistic Thermodynamic Model

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



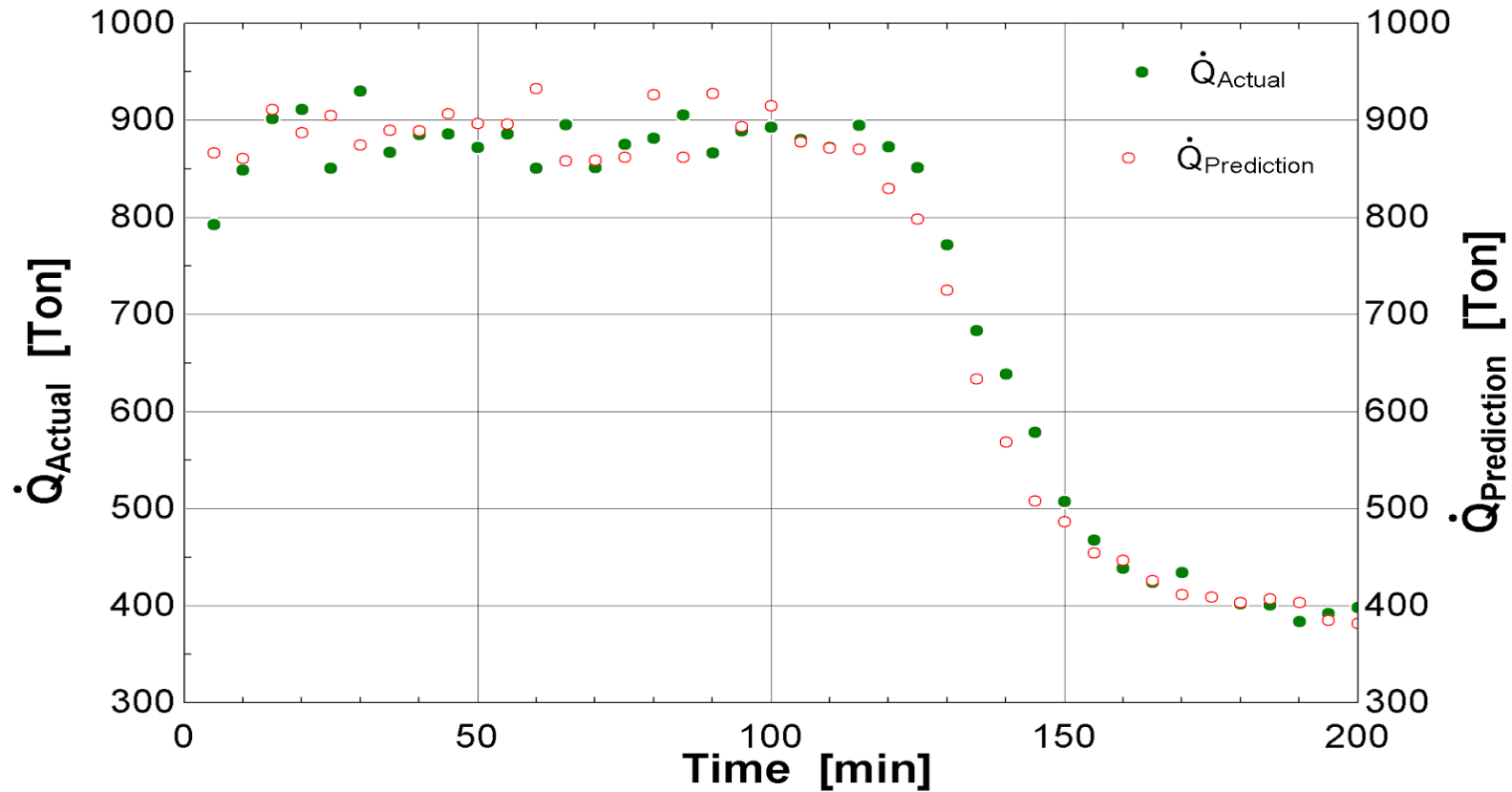
U of I SCADA Data

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	""
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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



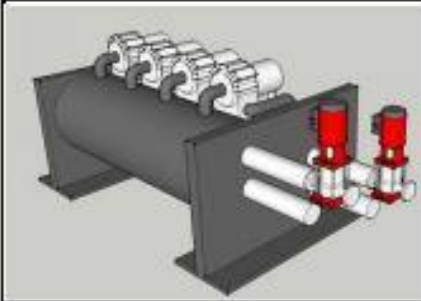
Performance Calculator Snapshot

Chiller 1 & 2 Full

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

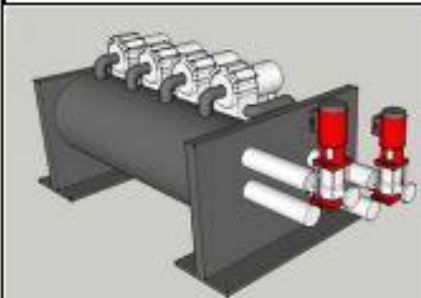
Avista	0.08	[\$/kW-hr]
Hours operation	24	[Hours]

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]			
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]			
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

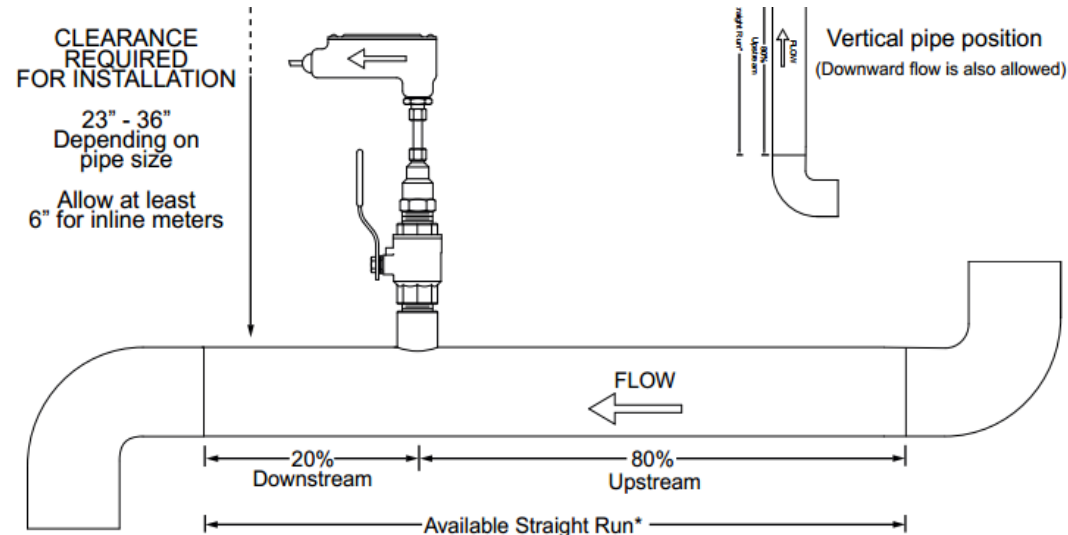


Recommendations

Flow Meter & VFD Controller

Possible Causes

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



*See following pages for model specific straight run requirements.

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

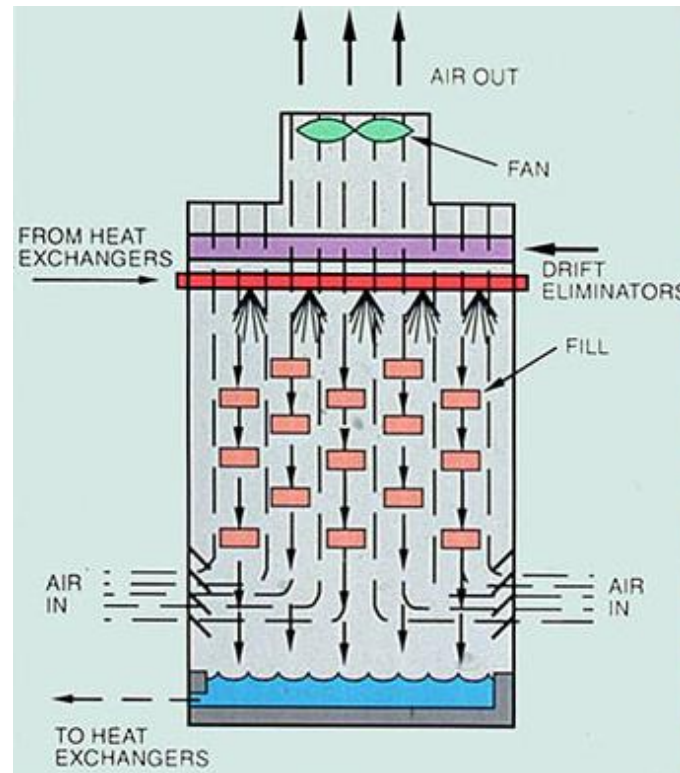
R134a Fouling Factors
Gases & vapors: 0.002
Liquids: 0.001



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!

