Facility Dynamics Engineering

Introduction to Commissioning Control Systems

ASHRAE Oregon Chapter

Presented By:

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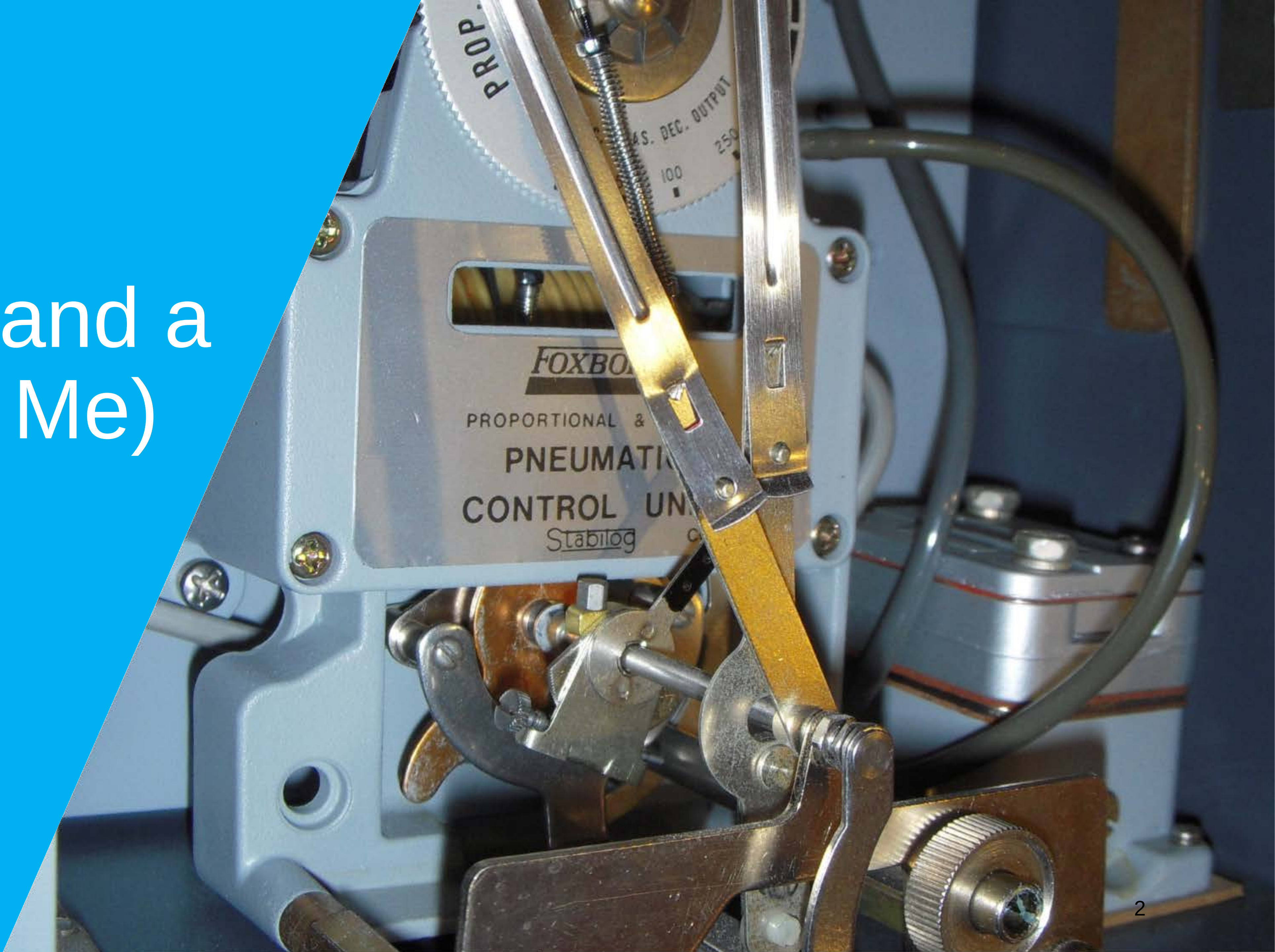
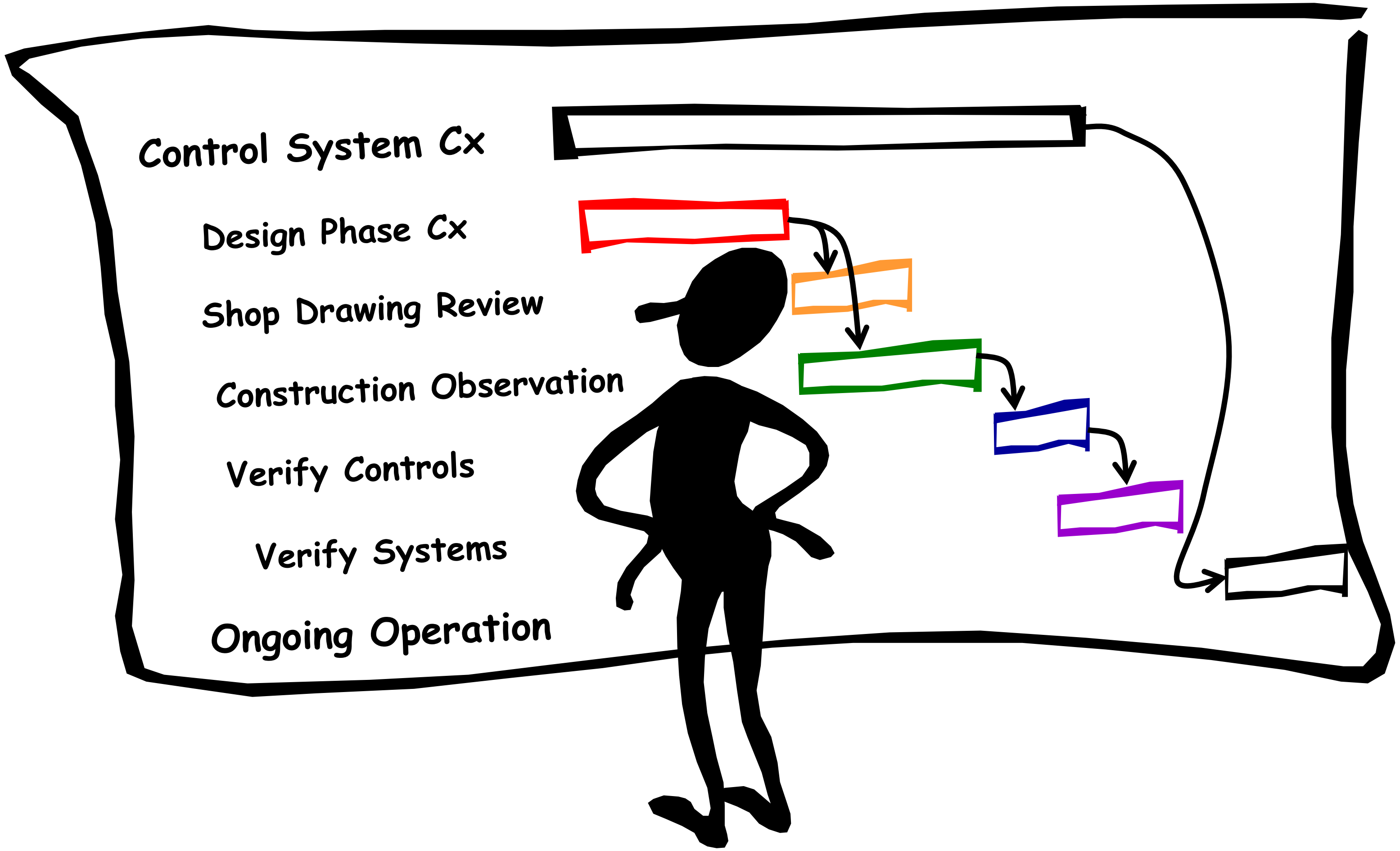
- Senior Engineer
- April 11, 2019

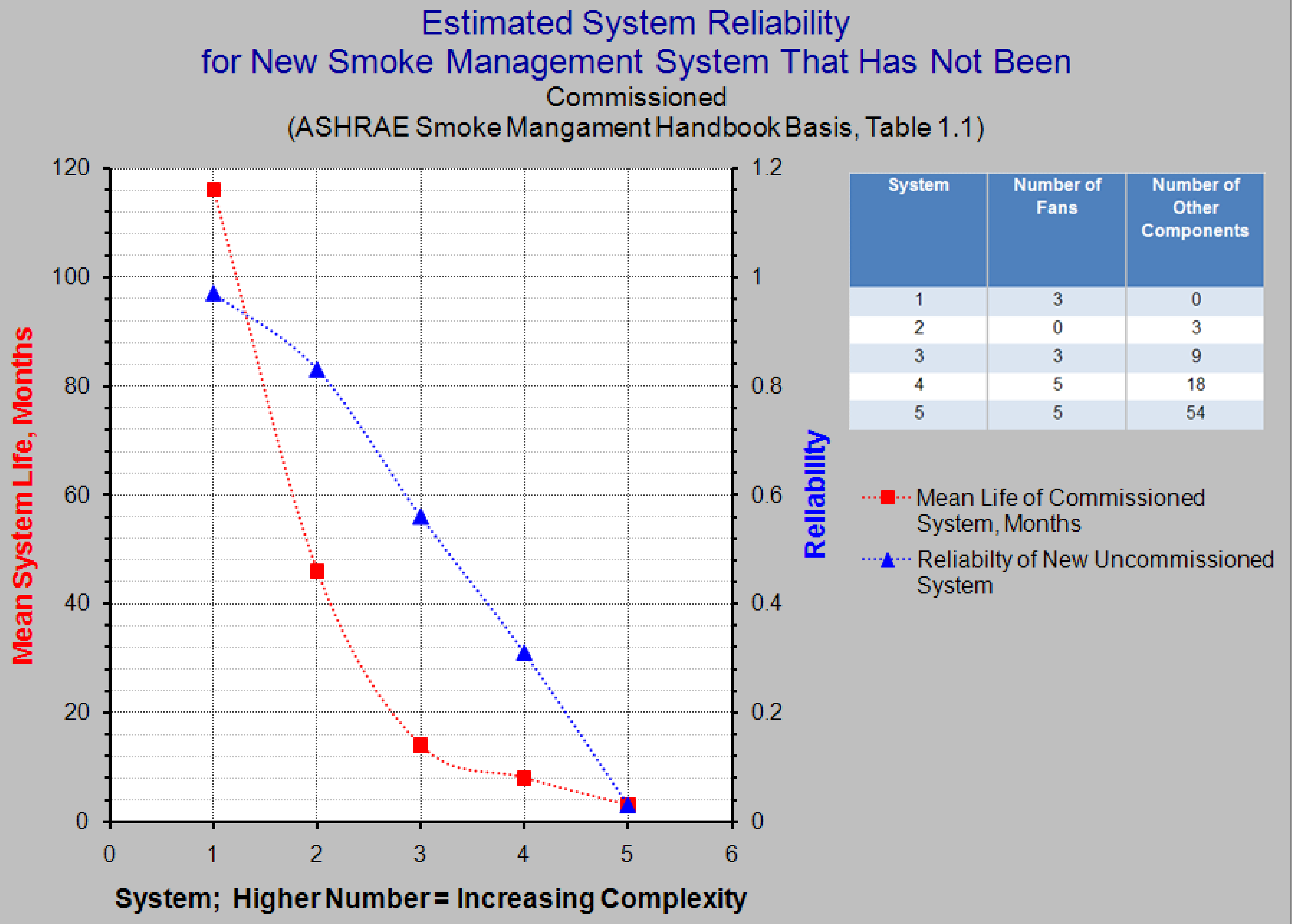
Agenda (and a Bit about Me)



The Path to a Successful Control System

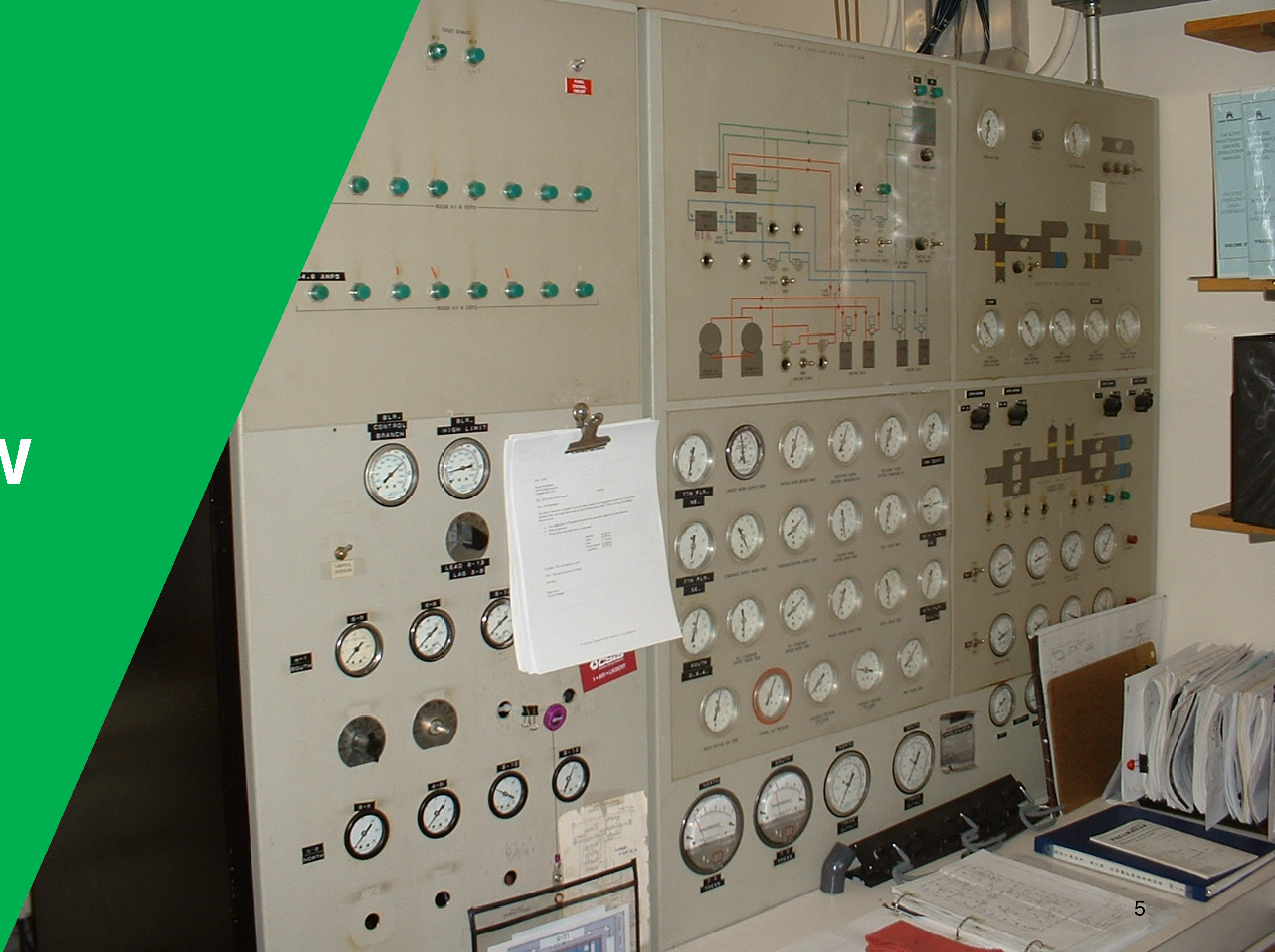


Complexity, Cx, Reliability, and Persistence



System	Number of Fans	Number of Other Components
1	3	0
2	0	3
3	3	9
4	5	18
5	5	54

Control Systems Overview



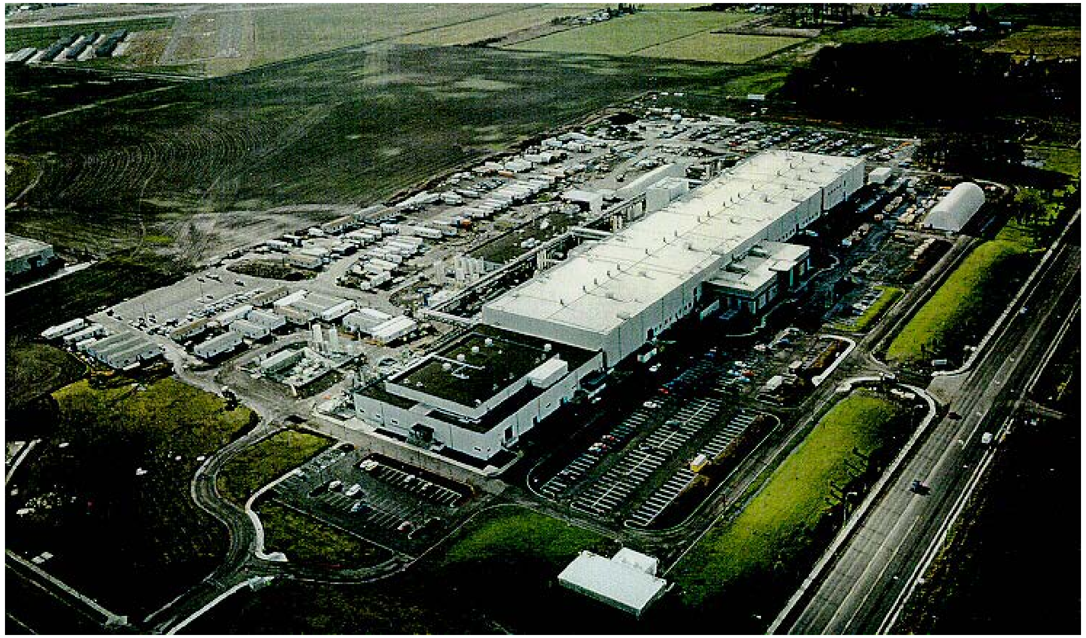
The Fundamental Goal of the Control System

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

The Holistic (Green) Goal of the Control System

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control as efficiently and sustainably as possible

[*Commissioning to Meet Space Qualification Criteria vs. Energy Consumption Optimization Focused Commissioning*](http://www.av8rdas.com/case-studies.html) is an example of how quality can be maintained and energy efficiency improved via an EBCx project (downloadable at http://www.av8rdas.com/case-studies.html)



The “Three R’s”

Repeatable	To make, do, or perform an action again (and again, and again, and again ….)
Reliable	Giving the same result on successive trials
Robust	Sturdy; capable of performing without failure under a wide range of conditions

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Inputs — Measure the process variable

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Inputs	Measure the process variable
Outputs	Adjust the controlled variable

The Fundamental Goal of the Control System

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
Outputs	Adjust the controlled variable
Set Point	Our requirements for the process that is under control, which can be fixed or variable

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Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
Outputs	Adjust the controlled variable
Set Point	Our requirements for the process that is under control, which can be fixed or variable
Control Process	Logic and algorithms that tries to bring the controlled variable into agreement with the set point

A 1914 Central Control System

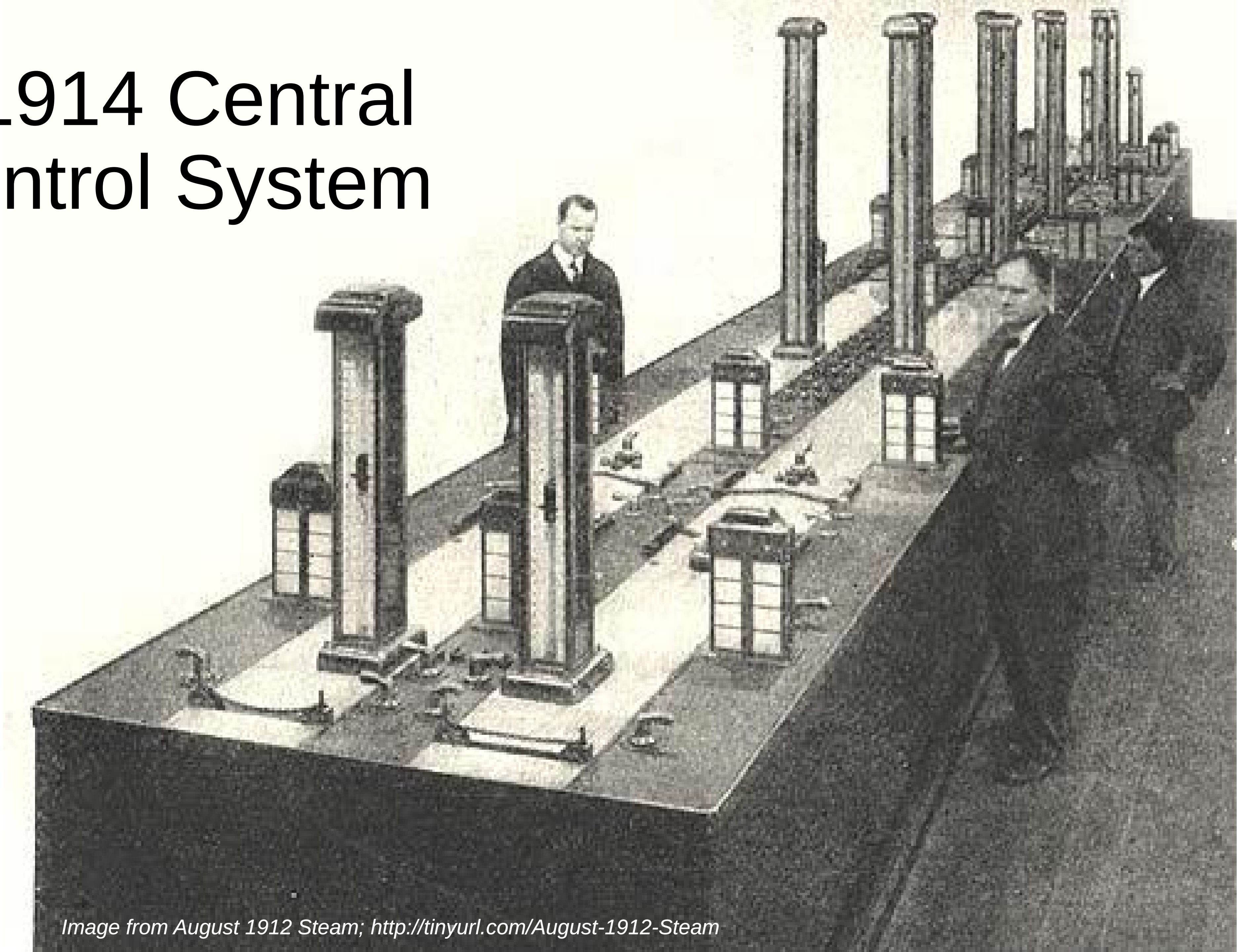


Image from August 1912 Steam; http://tinyurl.com/August-1912-Steam

A 1914 Central Control System

- 2.25 miles of interlocking rod
- 1,100 miles of control wire in the form of 5 to 8 conductor cables
- 732 position indicators and transmitters
- 464 control switches
- 382 indicating lamps
- Accurate to 5/8 inch over a 50 foot span

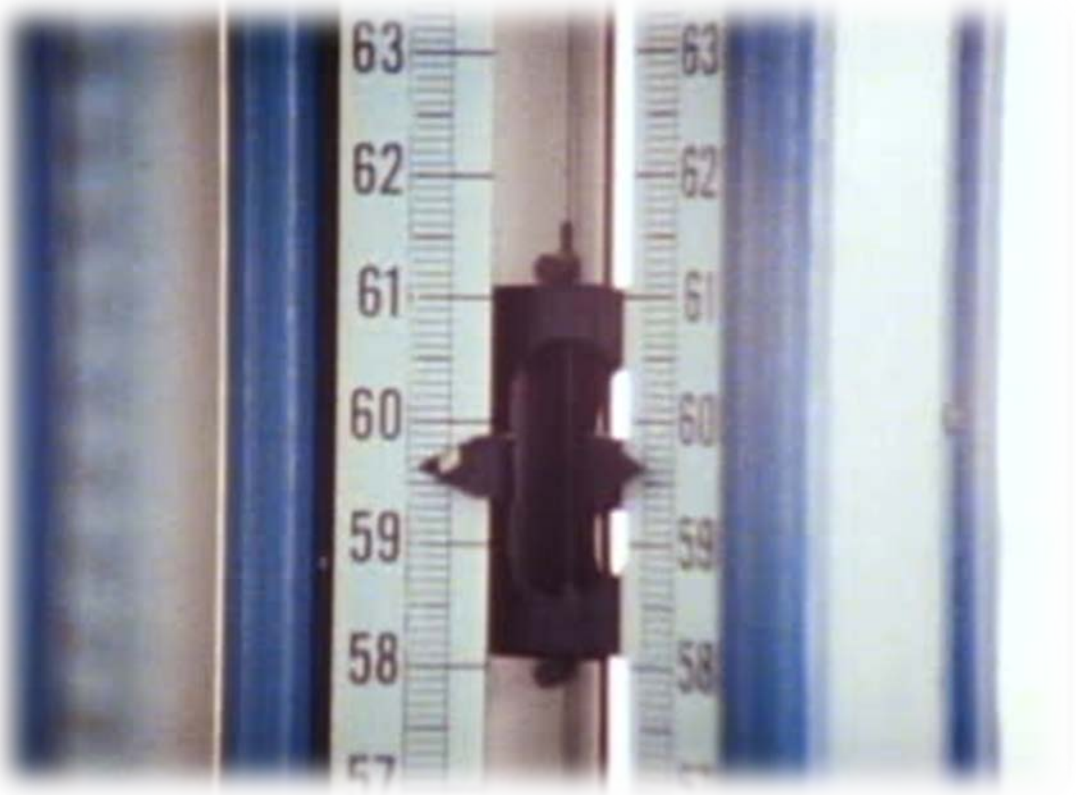


Image courtesy http://ak5.picdn.net/shutterstock/videos/3832016/preview/stock-footage-panama-canal-lock-control-room-close-up-moving-gauge.jpg

Still Doing Its Thing

Image courtesy www.ttnews.comgalleriespanama2014images05-IMG_3730_lg.jpg

The Other End of the Spectrum

Image courtesy http://image.dieselpowermag.com/f/news/9104552+w799+h499+cr1+ar0/0705dp_04_z%2Bnasa_diesel_shuttle_crawler%2Bshuttle.jpg

The Other End of the Spectrum

Main Engine and Controller

- About 50,000 parts
- Rated for multiple flights
- 135 flights with no failures

Image courtesy https://mediaarchive.ksc.nasa.gov/#/Image/45085/L

The Other End of the Spectrum

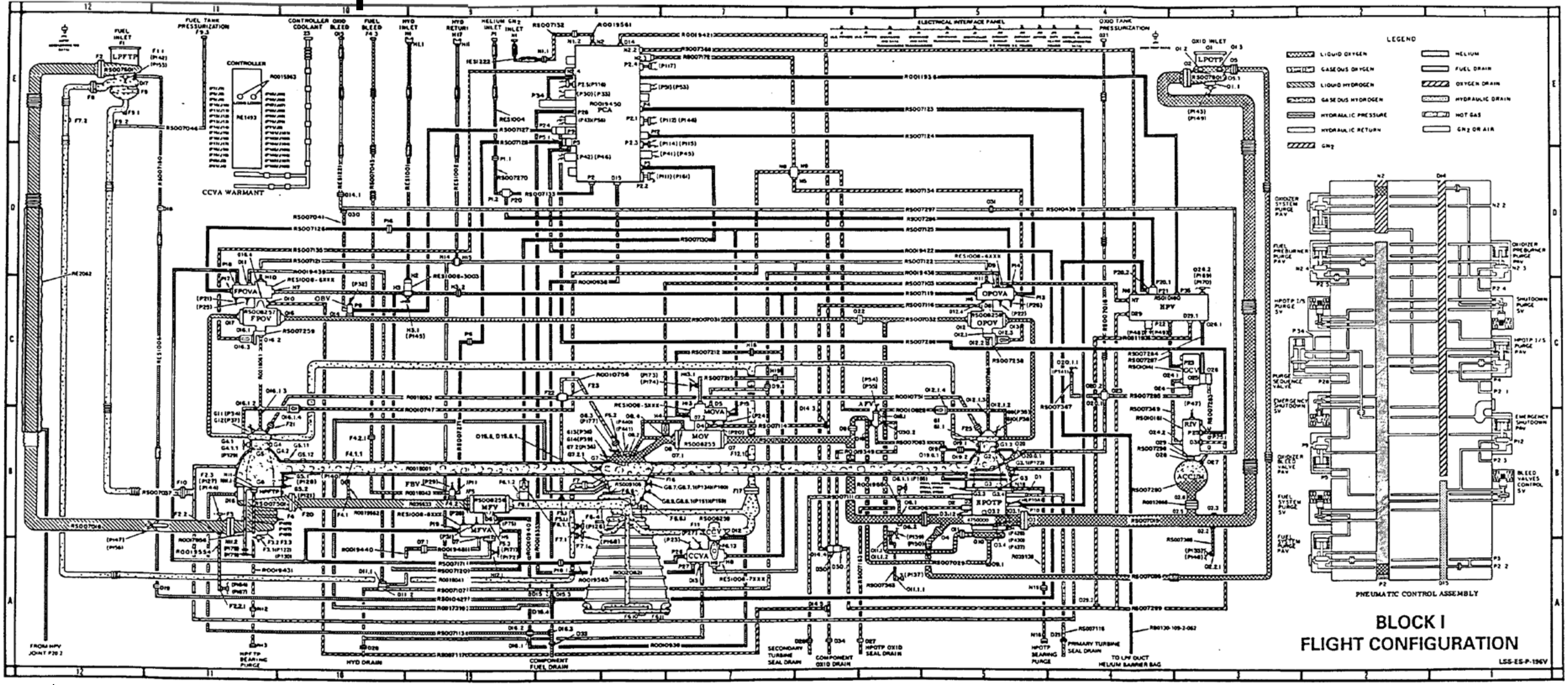
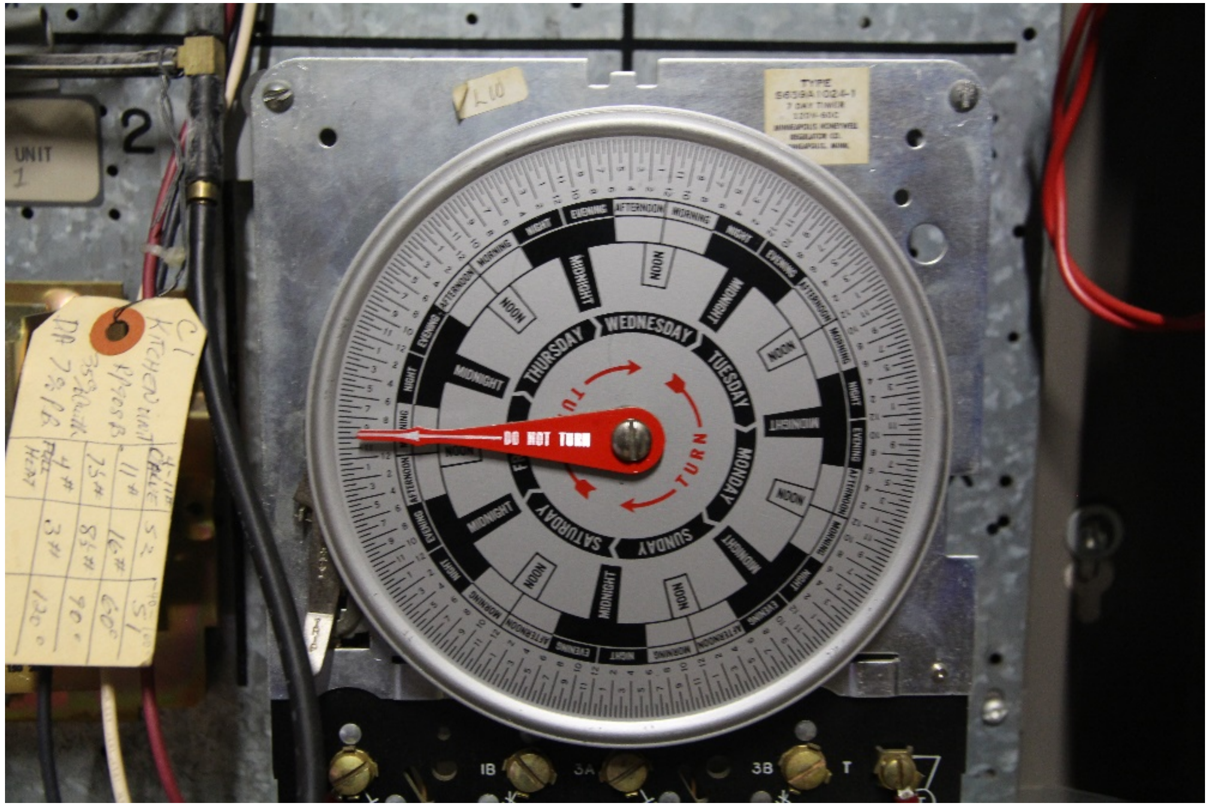


Image courtesy [http://large.stanford.edu/courses/2011/ph240/nguyen1/docs/SSME_PRESENTATION.pdfhttp://large.stanford.edu/courses/2011/ph240/nguyen1/docs/SSME_PRESENTATION.pdf](http://large.stanford.edu/courses/2011/ph240/nguyen1/docs/SSME_PRESENTATION.pdf)

We Are *Not* Doing Rocket Science

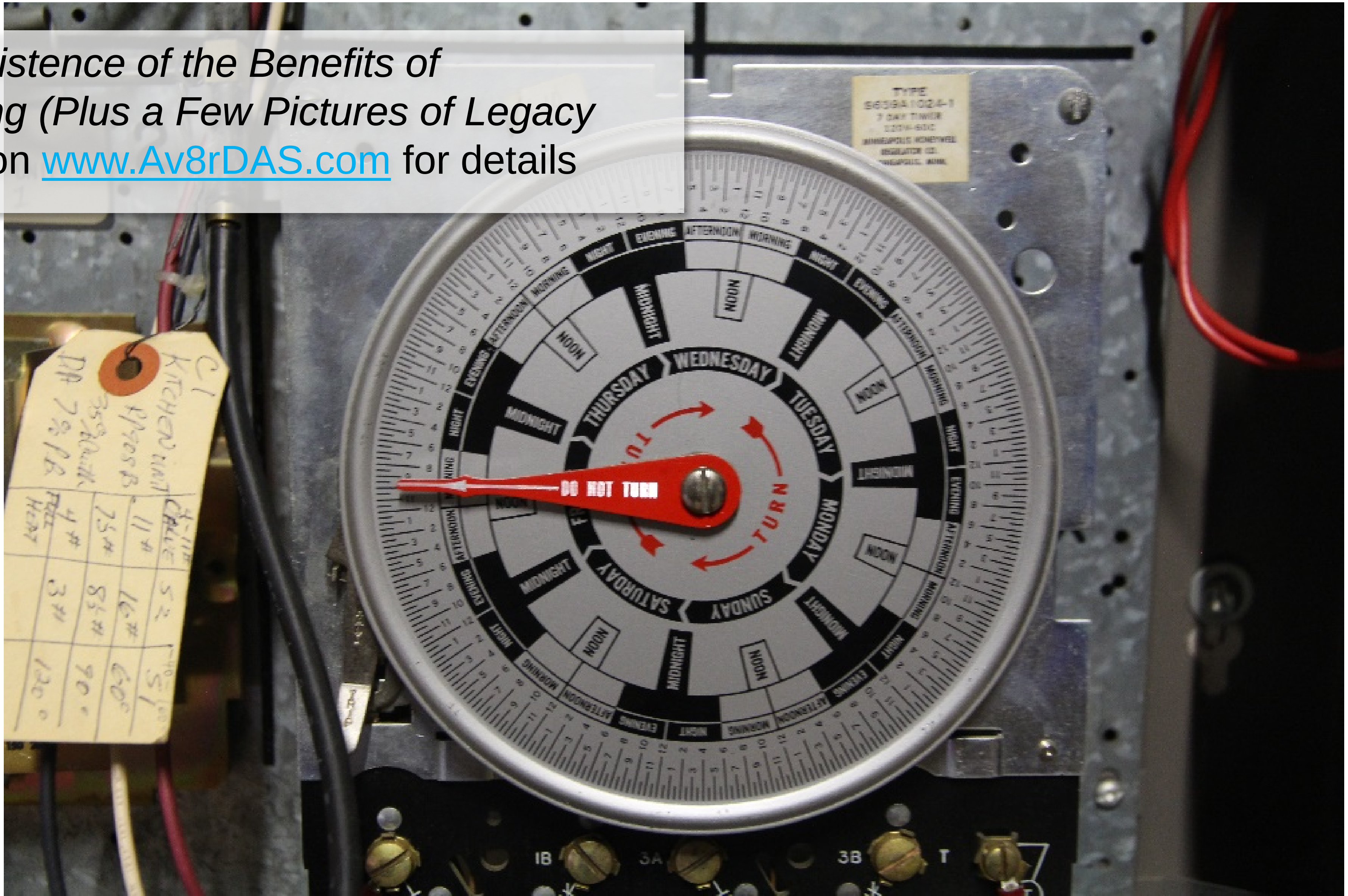
Seems like:

- We should be able to maintain a 57°F discharge temperature by sequencing preheat with the economizer and the chilled water coil
- We should be able to start around 6:00 am and shut down around 7:00 pm

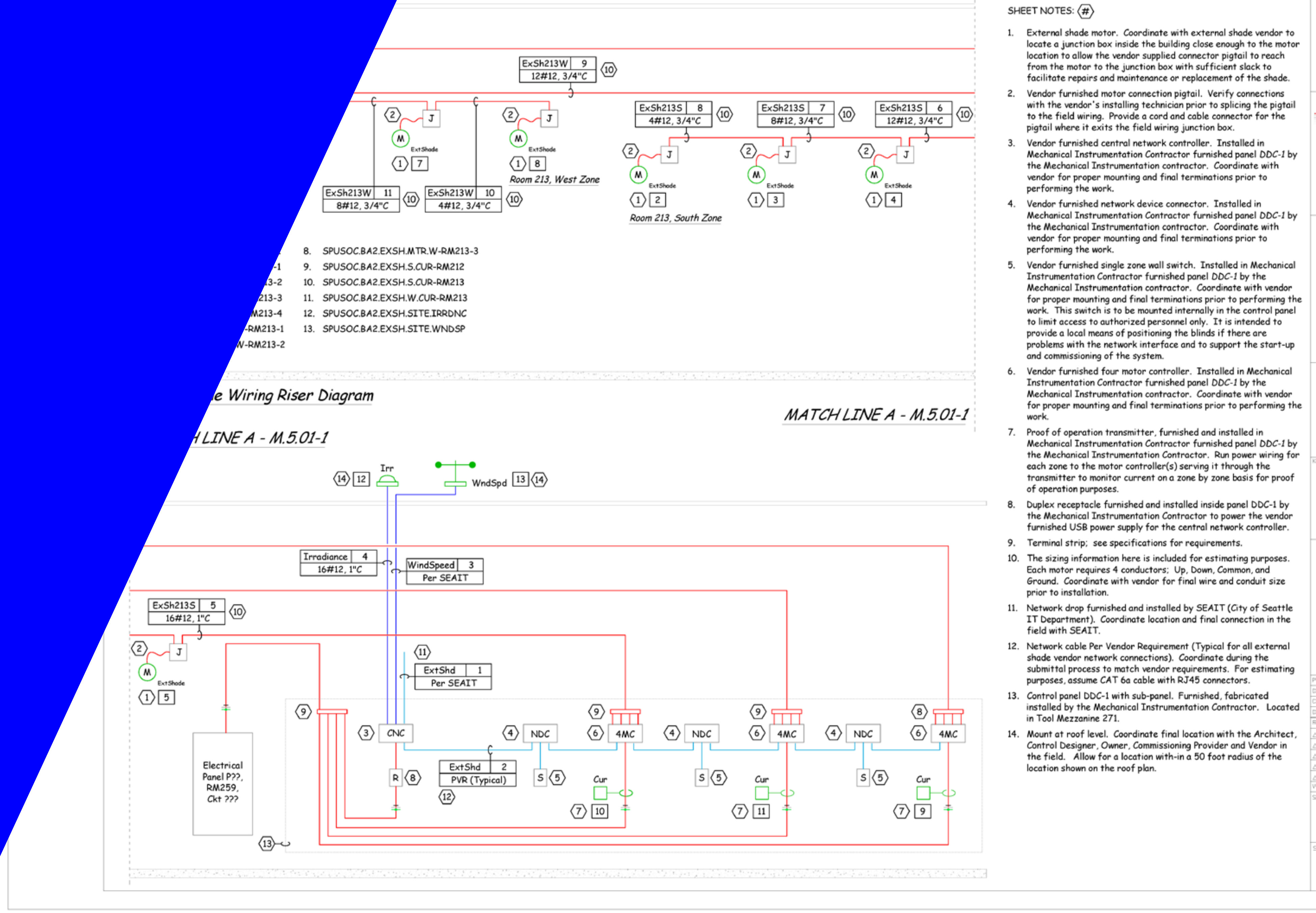


We Are *Not* Doing Rocket Science

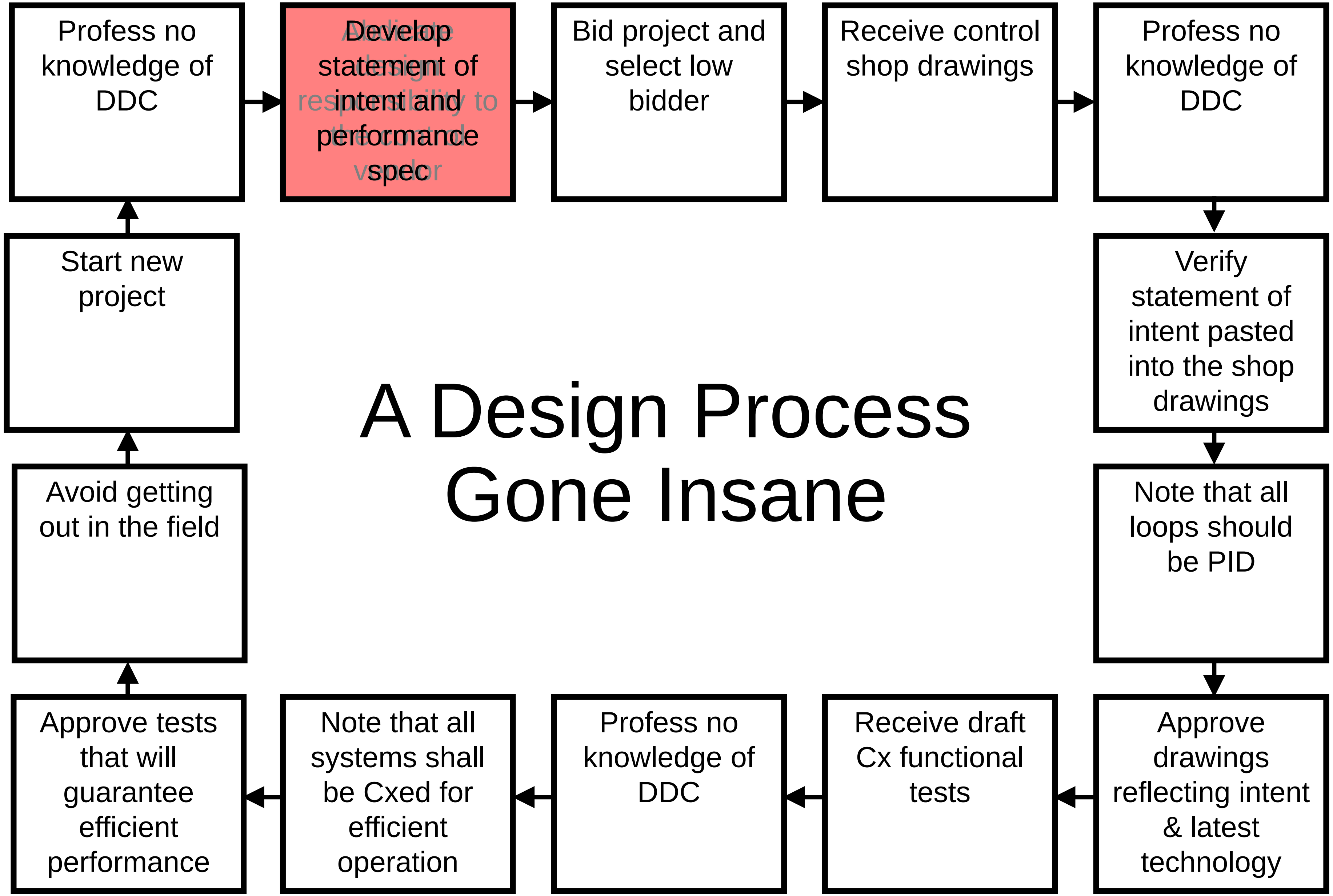
See The Persistence of the Benefits of Commissioning (Plus a Few Pictures of Legacy Instruments) on www.Av8rDAS.com for details



Design Phase



A Design Process Gone Insane



Solving the Problem: Own the Control Design and Commissioning Process

- Not as Hard as You Might Think
  - You *DON'T* need to have:
    - Intimate knowledge of computers
    - Intimate knowledge of networks
    - Intimate knowledge of sensing and actuating technologies
    - Intimate knowledge off differential calculus

Solving the Problem: Own the Control Design and Commissioning Process

- Not as Hard as You Might Think
  - You *DO* need to:
    - Understand your mechanical design and the related design targets
    - Apply sound physical principles in the development of your design
    - Communicate clearly
    - Think logically
    - Address the load profile
    - Recognize that all control systems are not created equal out of the box
    - Enforce your requirements

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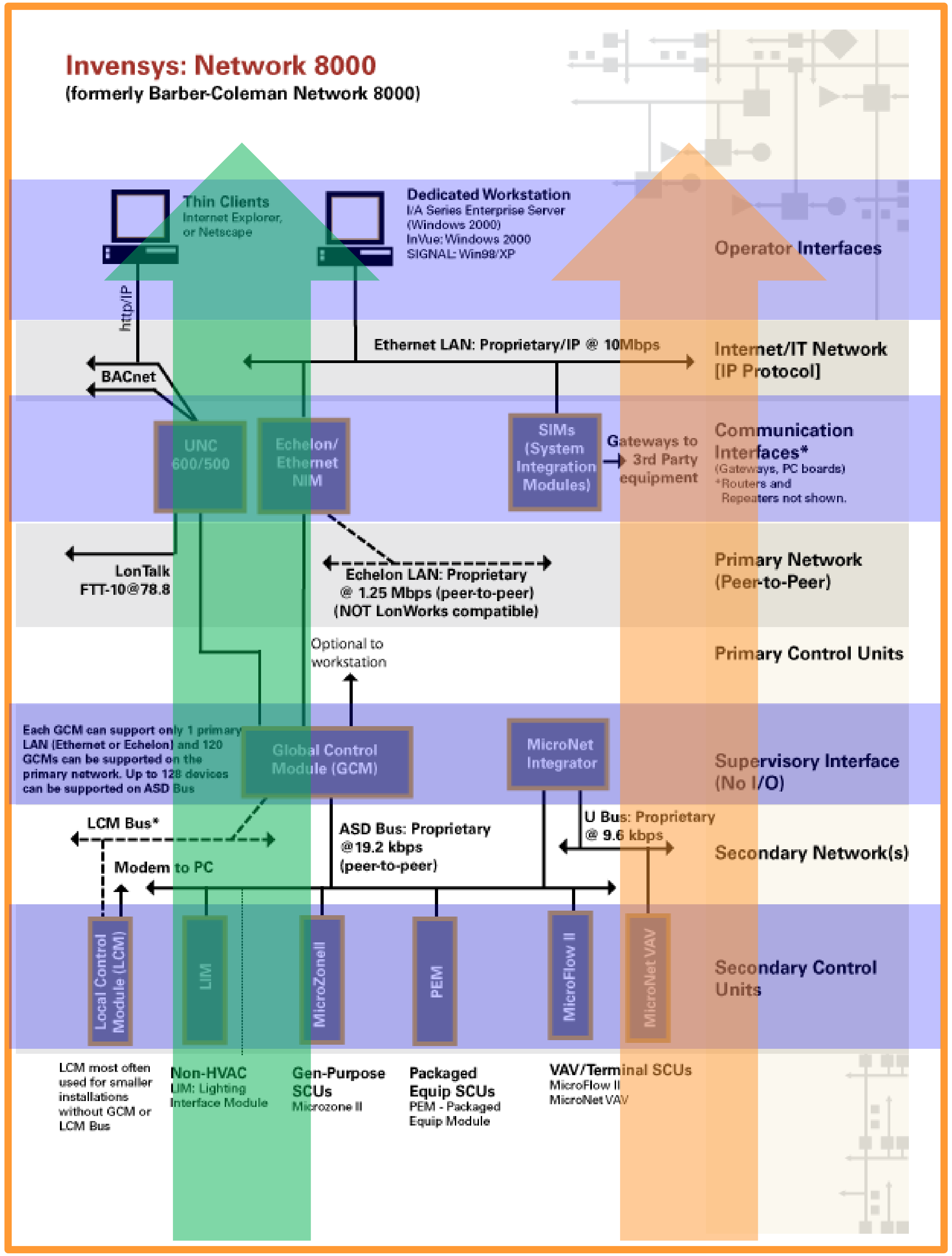
They’re Not All Equal

- Different Network Levels
- Increasing Hardware Capability and Sophistication
- Increasing Network Speed and Protocol Sophistication



Images courtesy www.ddc-online.org

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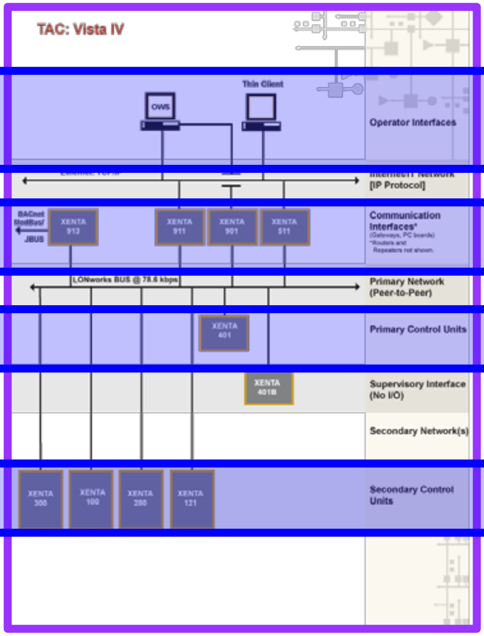
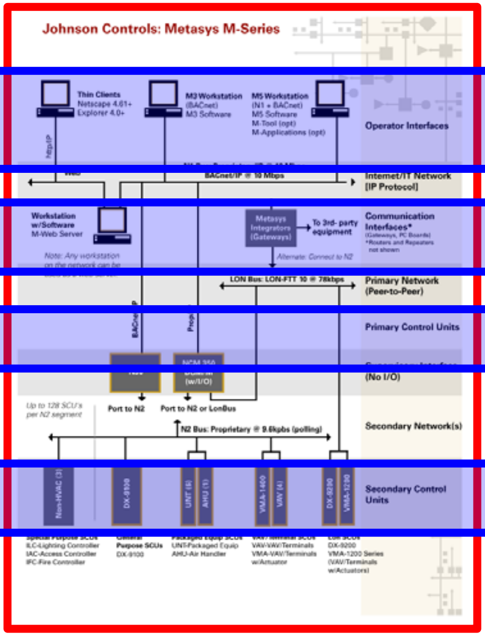
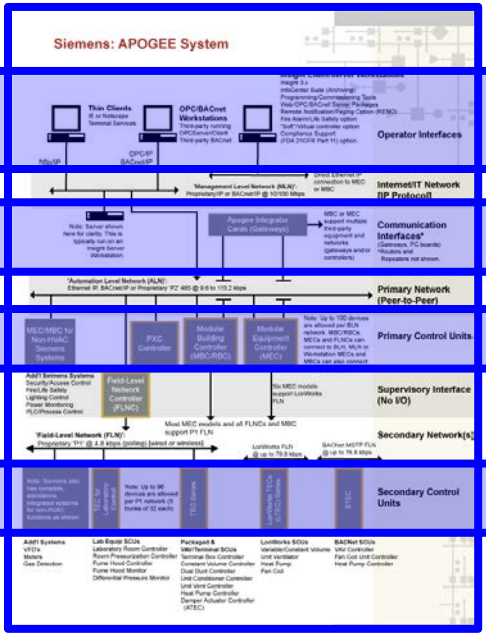
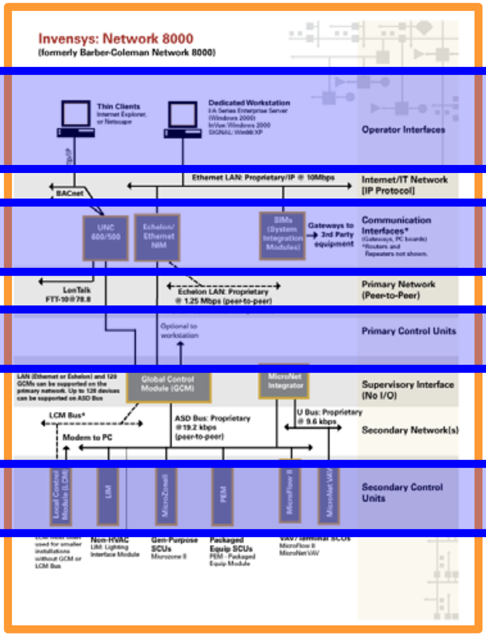
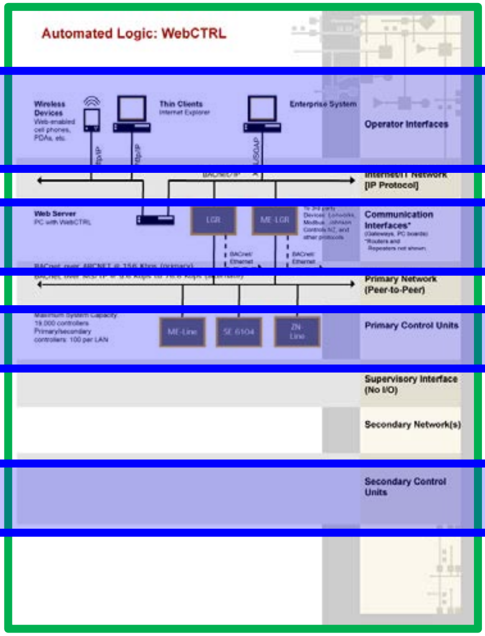








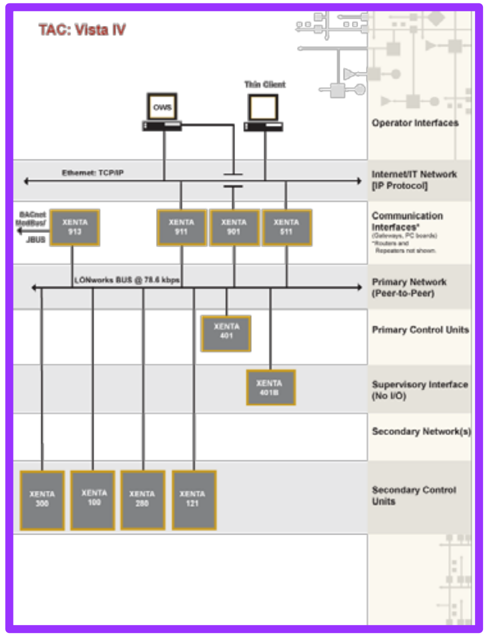


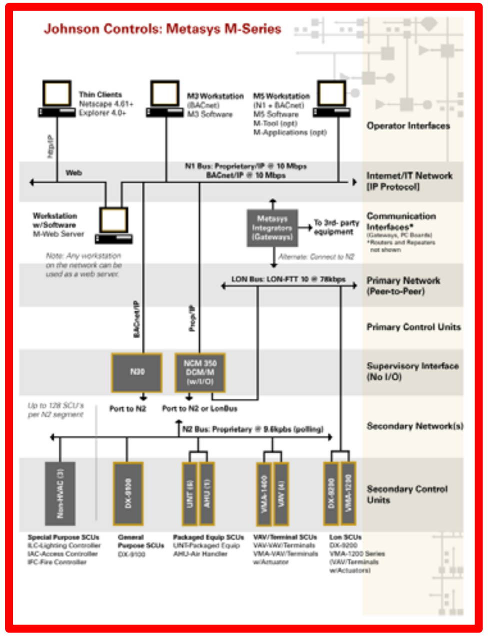
Images courtesy www.ddc-online.org

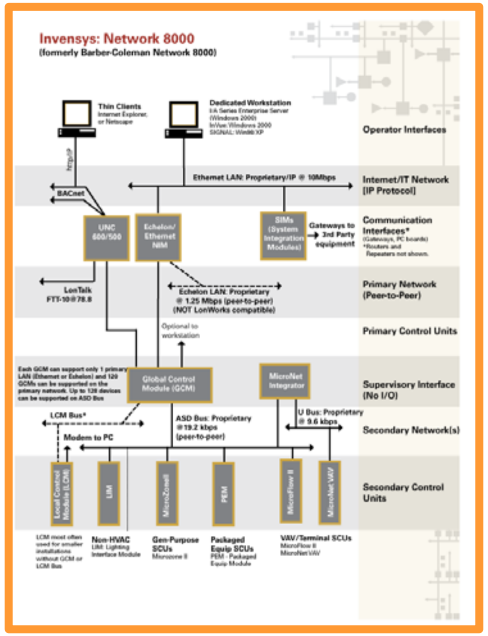
They’re Not All Equal

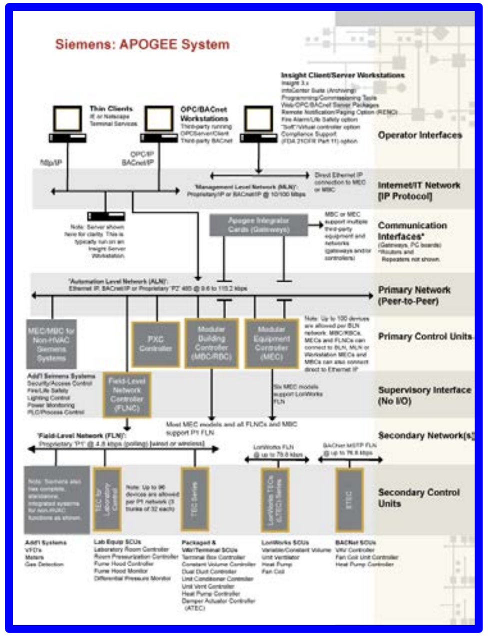
Network Architecture is Critical for Determining:

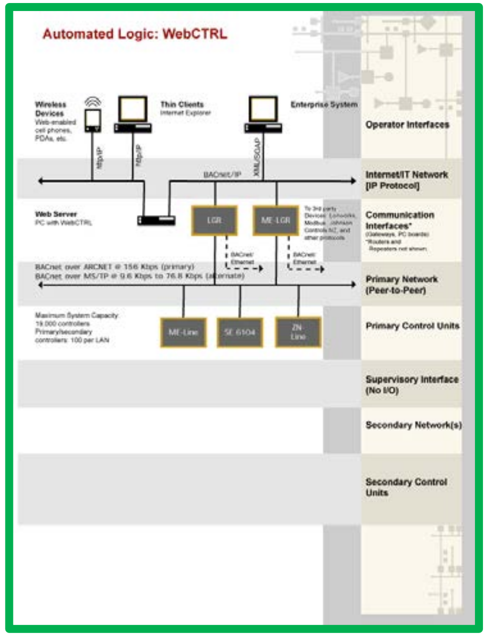
- Network speed
- Data handling capability
- Future flexibility
- Future expansion
- Interoperability







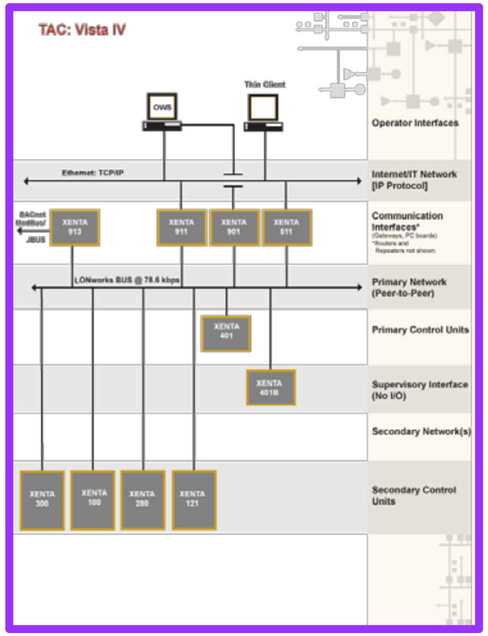


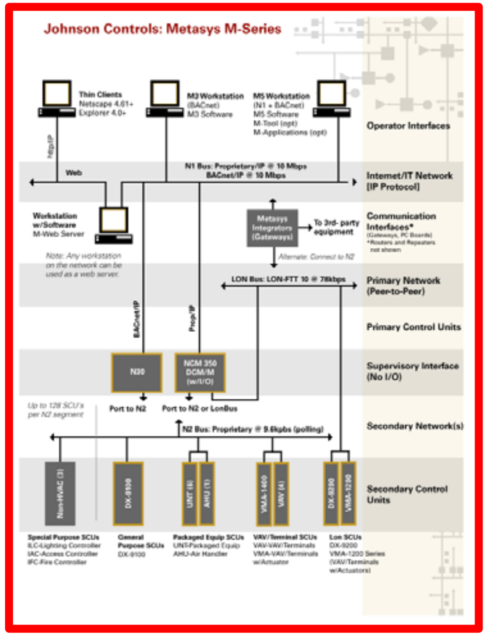


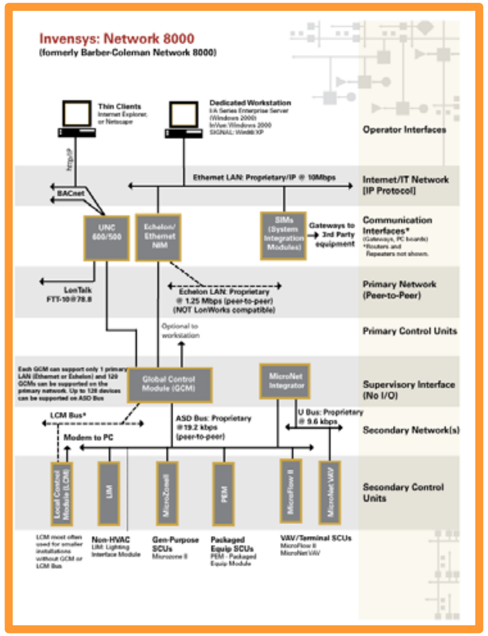
Images courtesy www.ddc-online.org

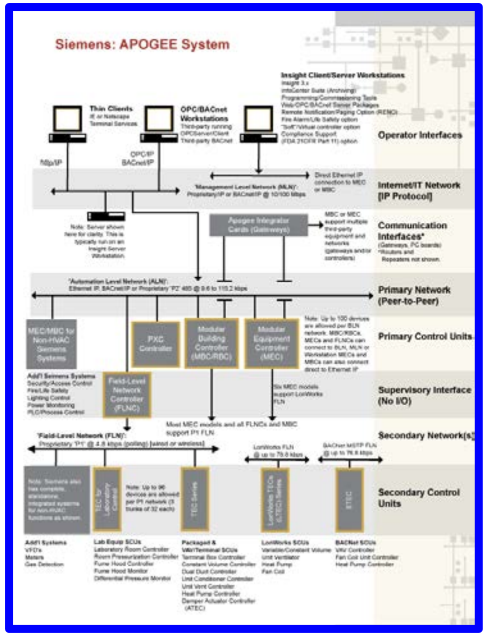
They’re Not All Equal

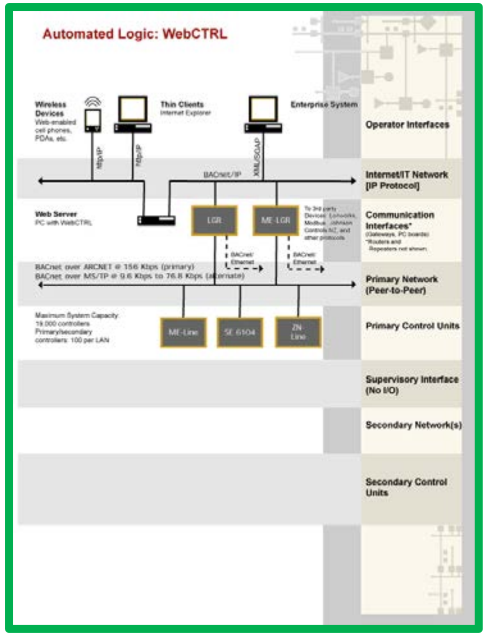
- Hardware Capabilities are Critical to Success









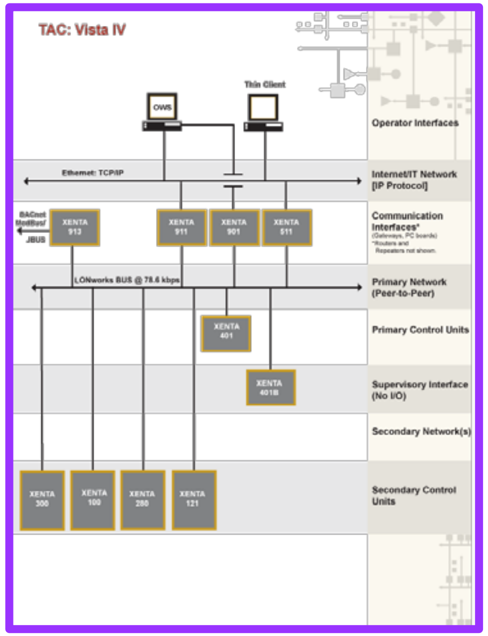


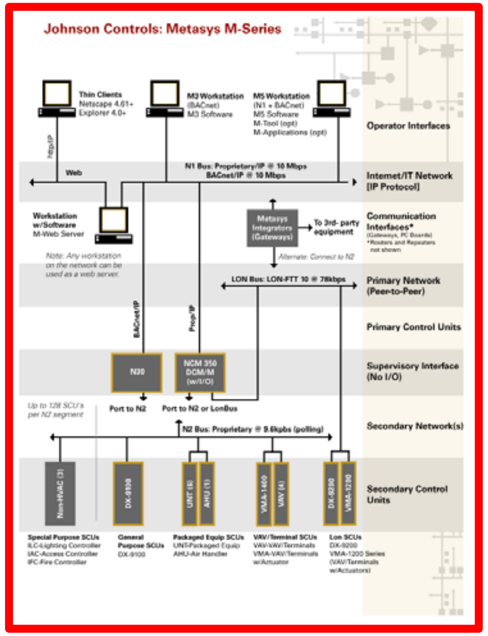
They're Not All Equal

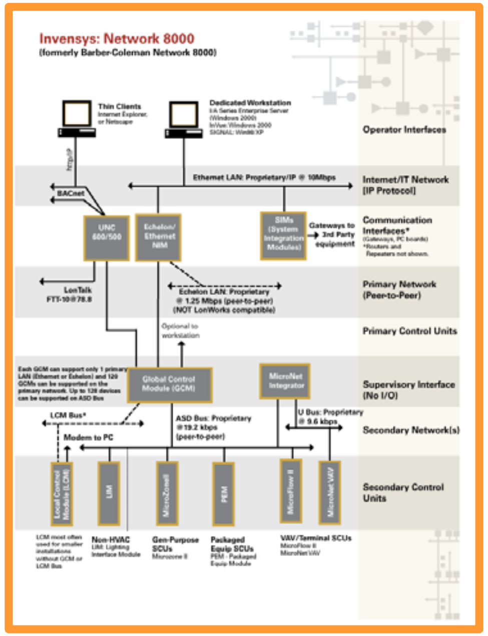
Specifications Can Define Critical Requirements

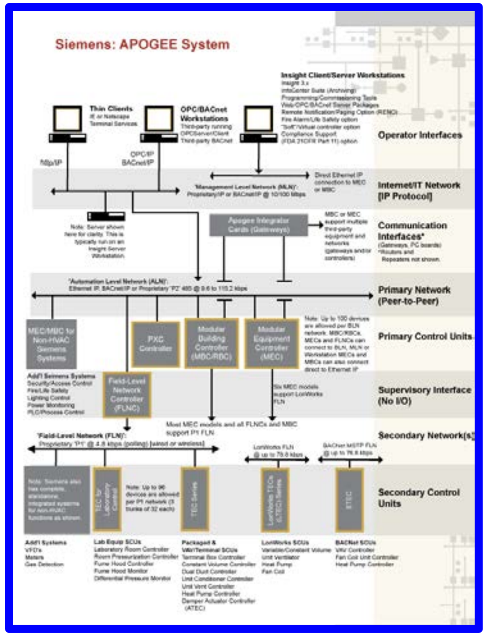
- Software
- Point capacity
- Global strategies
- A to D resolution
- Speed
- Network protocol

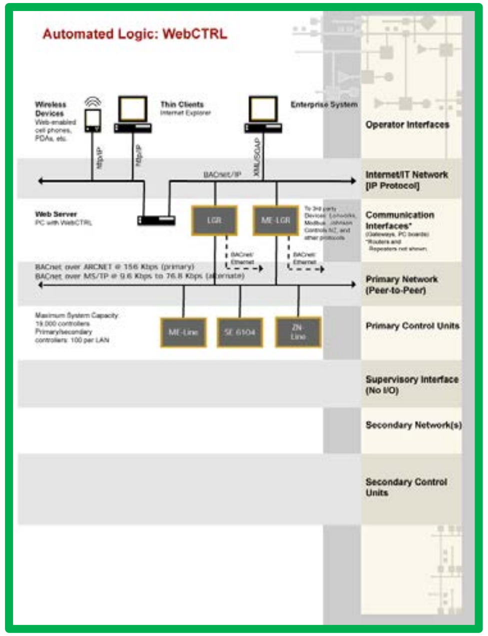
- Memory
- Real time clock
- Buffers
- Fully programmable
- Downloadable
- PC interface





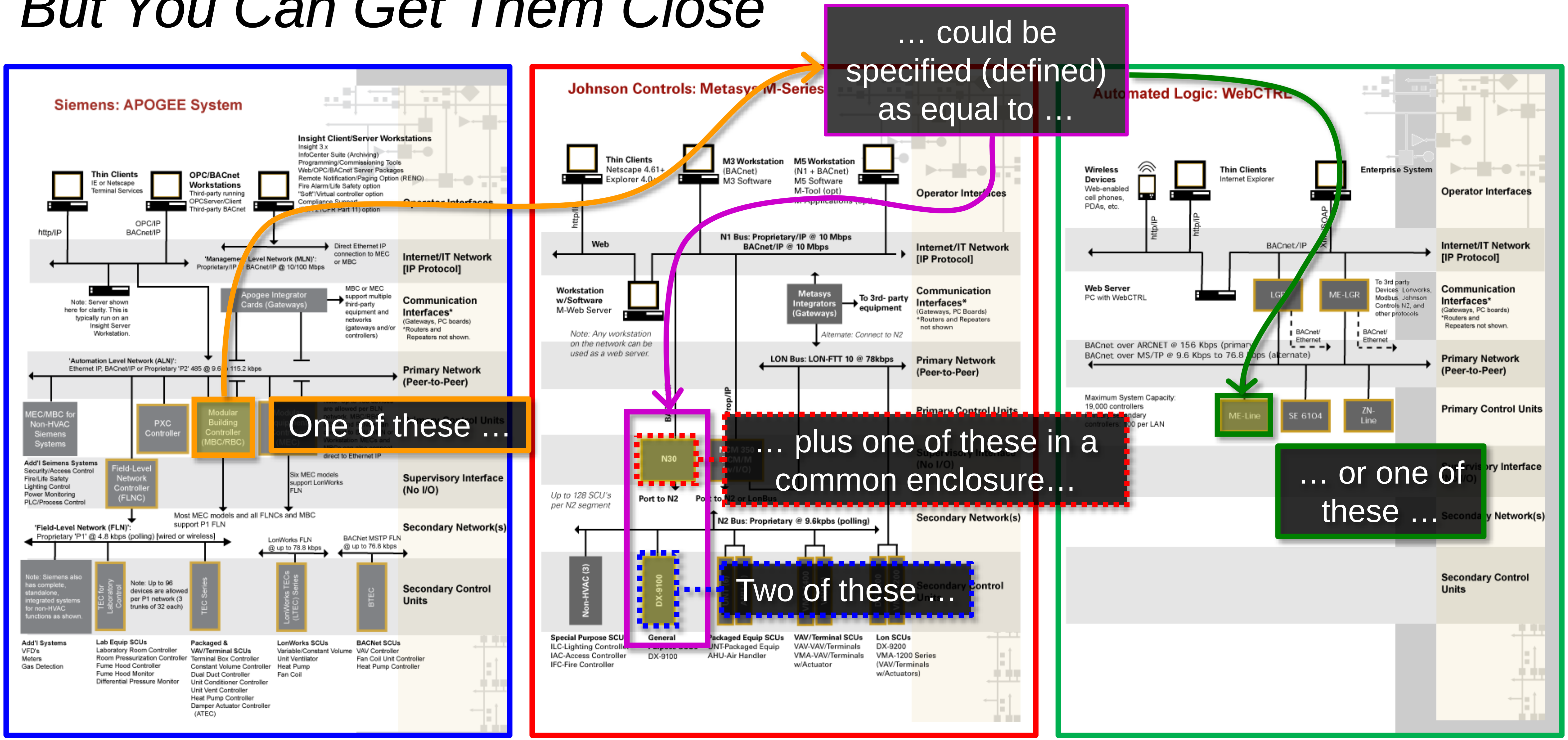






They’re Not All Equal

But You Can Get Them Close



Must Have’s

- Point List

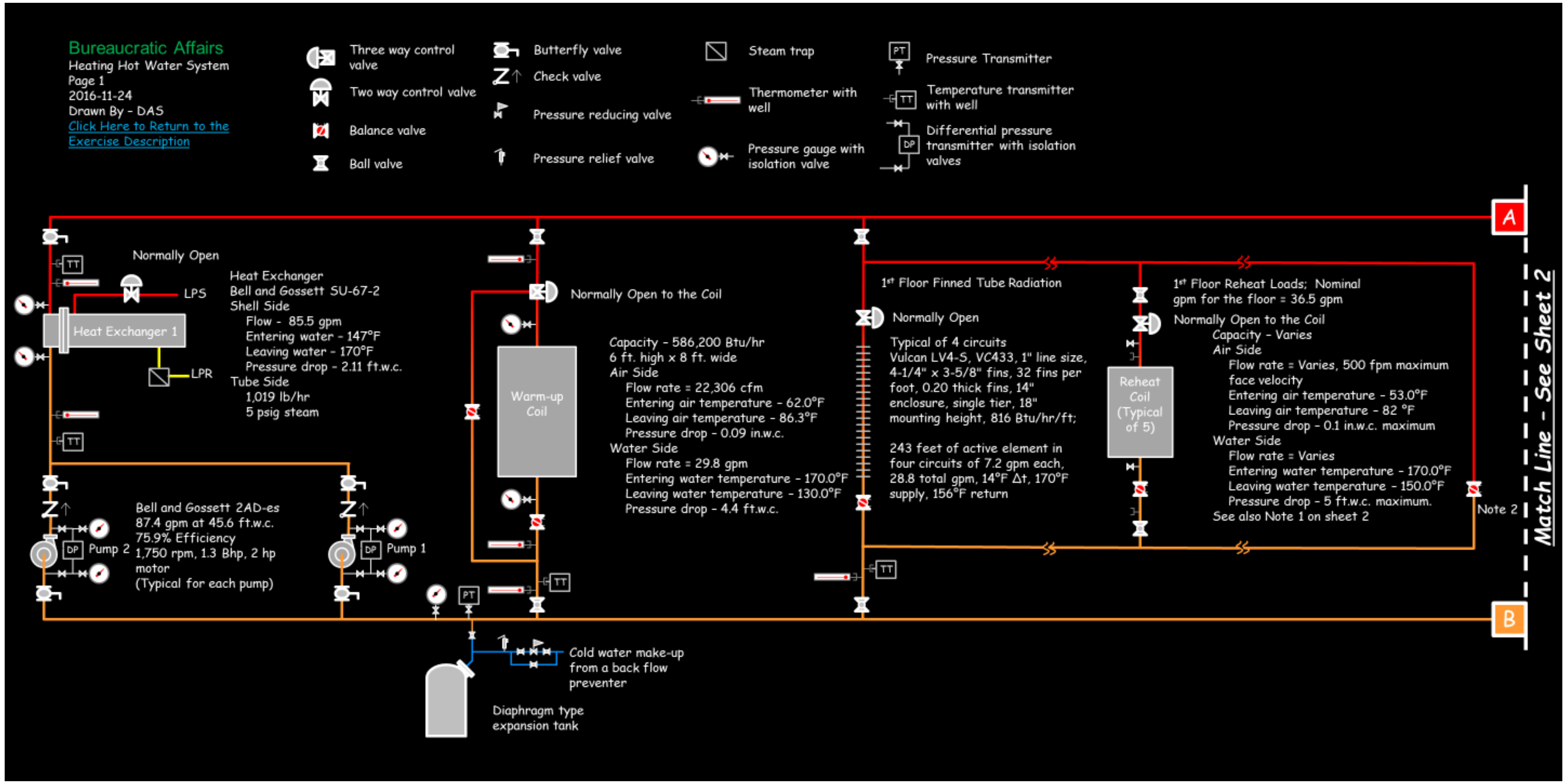
Bureacratic Affairs Building 1st Floor Hot Water System																
Point		Sensor			Features											Notes
Name (Note 6)	Description and Service	Type	Reference Spec Paragraph	Accuracy	Alarms				Trending							
					Limit		Warning		Samples[1]	Commissioning[5]			Operating[5]			
					Hi	Lo	Hi	Lo		Time[2]	Local[3]	Archive	Time[2]	Local[3]	Archive	
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

1. Samples indicates the minimum number of data samples that must be held in the local controller if it is trending the point.
2. Time indicates the required sampling time for the trending function.
3. A check in the local column indicates that the trending only needs to be running in the local controller and the most recent value can write over the last value when the trend buffer fills up.
4. A check in the archive column indicates that the trend data must be archived to the system hard disc when trend buffer fills up so that a continuous trend record is maintained.
5. Commissioning trending requirements only need to be implemented during the start-up and warranty year. After the start-up and warranty process, the control contractor should set the trending parameters to the operating requirements listed if they differ from the commissioning requirements.
6. Point numbers are based on the Owner's point naming convention which is included in the specification. Point names will be verified during the submittal process in the control system integration and coordination meeting.
7. To be determined during the Control System Integration and Coordination Meeting
8. Furnish two wells for installation adjacent to each other by the mechanical contractor. One well is for the sensor and one is for calibration purposes. See the spec and detail.
9. The design intent is that the control loop is a PI loop with derivative added only if tuning in the field indicates that it is necessary to manage the response to a step change or reduce the settling time. Coordinate with the control system designer and Owner proir to adding derviative gain, but provide the point so it is there if needed.

Must Have’s

- Point List
- System Diagram



Must Have's

- Point List
- System Diagram
- Narrative Sequence

Bureaucratic Affairs Building Heat Exchanger Leaving Water Temperature Control

Overview

This sequence applies to the Bureaucratic Affairs Building hot water system steam heat exchanger. The heat exchanger serves finned tube radiation, reheat coils, and a warm-up coil. It is intended to be in operation any time either of the heating hot water pumps are in operation to deliver 170°F water to the loads.

Steam Valve Control

A temperature sensor located in the discharge piping from the heat exchanger serves as an input to a direct acting Proportional plus Integral (PI) control loop. The output of the control loop is used to modulate a normally open steam valve via a 4-20 ma signal that, in turn generates a 3-15 psi pneumatic signal via an electro-pneumatic signal convertor for valve actuation.

The set point of the loop is reset based on outdoor air temperature. The reset schedule set points shall be operator adjustable by an operator with administrator credentials. The initial set points are as follows:

- The hot water supply temperature is 170°F when the outdoor air temperature is 7.4°F. These values represent the design conditions.
- The hot water temperature is 102.5°F when the outdoor air temperature is 55°F. These values target matching the finned tube radiation performance to the perimeter heating load at 55°F outdoors with a 72°F indoor temperature.

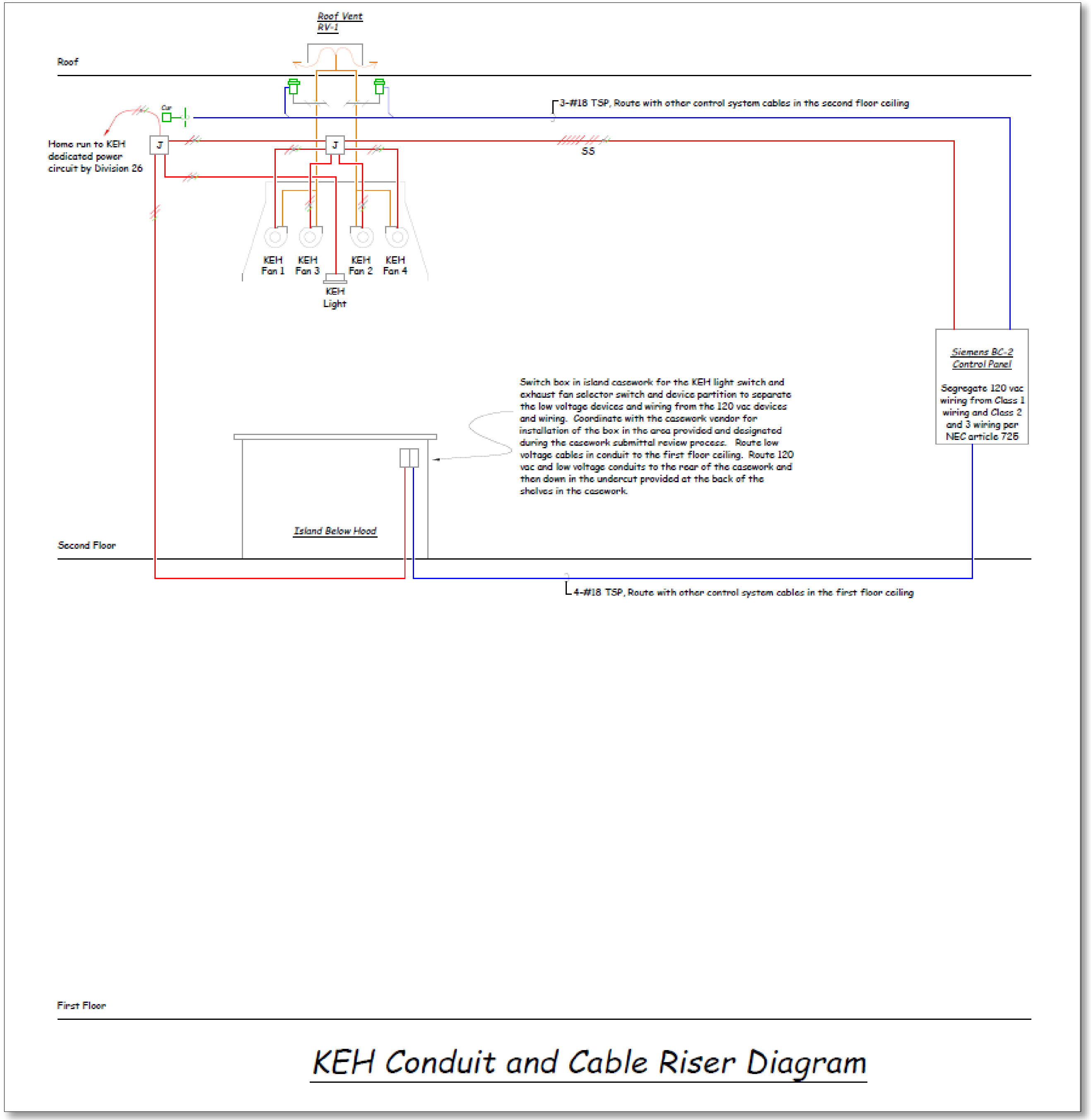
The set point is are limited to a maximum of 170°F and a minimum of 102.5°F, no matter what the output of the reset calculation is.

When the building is unoccupied, the hot water set point shall be maintained at 140°F to provide capacity for the night set back cycle when it is initiated.

As the supply temperature deviates above set point, the output of the control loop modulates from 4 ma towards 20 ma (3 psi towards 15 psi to the actuator), causing the normally open valve to modulate closed. As the supply temperature deviates below set point, the output of the control loop modulates from 20 ma towards 4 ma (15 psi towards 3 psi to the actuator), causing the normally open valve to modulate closed.

Must Have's

- Point List
- System Diagram
- Narrative Sequence
- Details



Must Have's

- Point List
- System Diagram
- Narrative Sequence
- Details
- Specifications

250800 - Integrated Automation - Commissioning

251116 - Integrated Automation - Network Hardware

251413 - Integrated Automation - Remote Control Panels

251516 - Integrated Automation - Software

253500 - Integrated Automation - Instrumentation and Terminal Devices

253513 - Integrated Automation - Actuators and Operators

253516 - Integrated Automation - Sensors and Transmitters

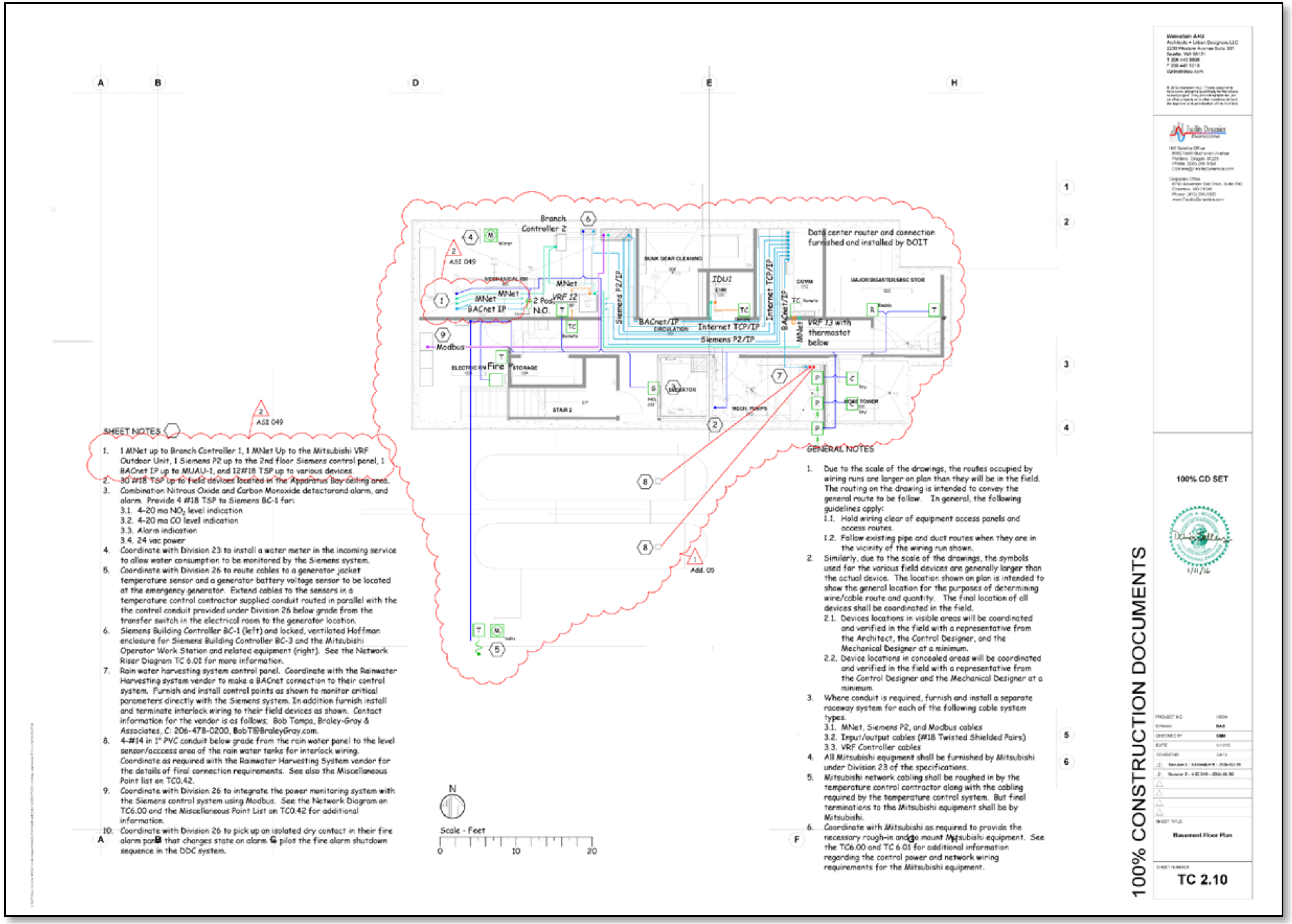
253519 - Integrated Automation - Control Valves

255500 - Integrated Automation - Control of HVAC

255500.13 - Integrated Automation - Control of HVAC-Object Naming Conventions

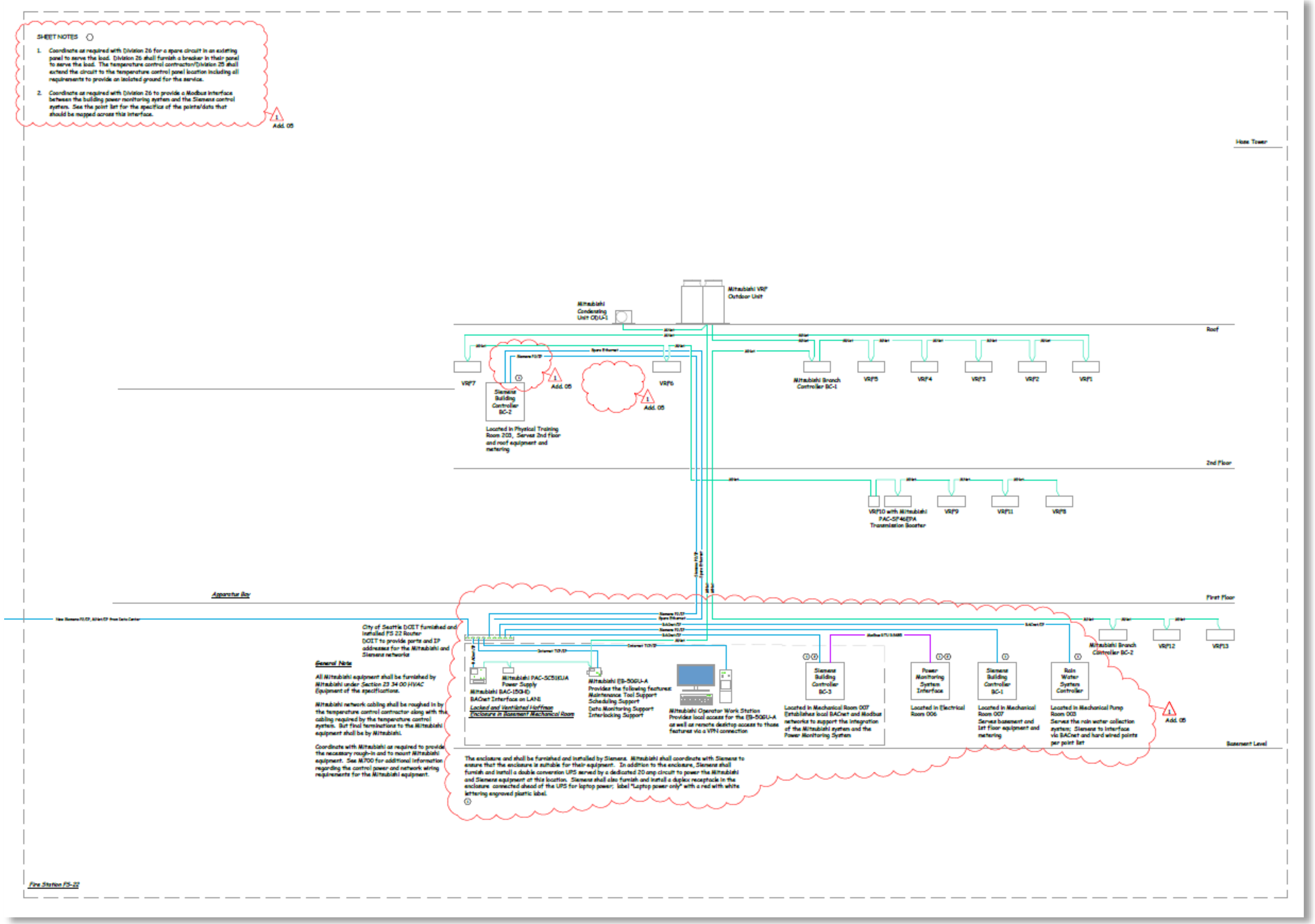
Nice Additions

- Floor Plans



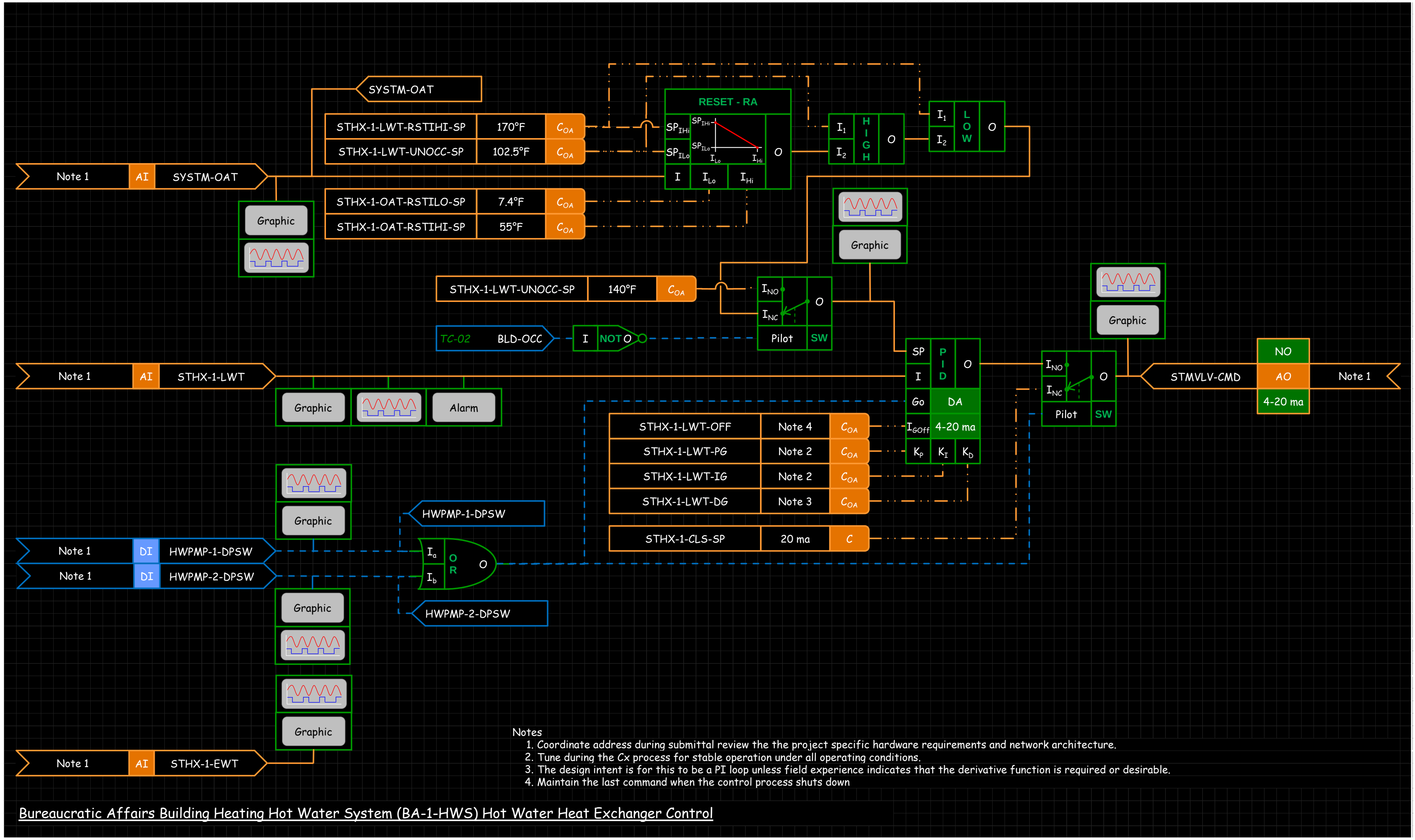
Nice Additions

- Floor Plans
- Network Diagrams



Nice Additions

- Floor Plans
- Network Diagrams
- Logic Diagrams



If Nothing Else, Make a Point List

Point Naming Conventions Establish Consistency

Point
Name (Note 6)
Analog Inputs
STHX-1-LWT
SYSTM-OAT
STHX-1-EWT
Analog Outputs (All analog outputs to include local

Bureacratic Affairs Building 1st Floor Hot Water System

Point		Sensor			Features											Notes
Name (Note 6)	Description and Service	Type	Reference Spec Paragraph	Accuracy	Alarms				Trending							
					Limit		Warning		Samples[1]	Commissioning[5]			Operating[5]			
					Hi	Lo	Hi	Lo		Time[2]	Local[3]	Archive[4]	Time[2]	Local[3]	Archive[4]	
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

1. Samples indicates the minimum number of data samples that must be held in the local controller if it is trending the point.
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6. Point numbers are based on the Owner's point naming convention which is included in the specification. Point names will be verified during the submittal process in the control system integration and coordination meeting.
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8. Furnish two wells for installation adjacent to each other by the mechanical contractor. One well is for the sensor and one is for calibration purposes. See the spec and detail.
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If Nothing Else, Make a Point List

Description Conveys Intent

Description and Service

Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.
System OAT
Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.

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Point Name (Note 6)	Description and Service	Sensor Type	Reference Spec Paragraph	Accuracy	Alarms Limit Hi	Alarms Limit Lo	Alarms Warning Hi	Alarms Warning Lo	Samples[1]	Commissioning[5] Time[2]	Commissioning[5] Local[3]	Commissioning[5] Archive	Operating[5] Time[2]	Operating[5] Local[3]	Operating[5] Archive	Notes
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include loc override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

1. Samples indicates the minimum number of data samples that must be held in the local controller if it is trending the point.
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If Nothing Else, Make a Point List

Sensor Type Establishes Performance Level Required

Sensor
Type
1,000 Ω Pt RTD with close coupled transmitter and thermometer well
Single point 1,000 Ω Pt RTD with close coupled transmitter
1,000 Ω Pt RTD with close coupled transmitter and thermometer well

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Point		Sensor			Features											Notes
Name (Note 6)	Description and Service	Type	Reference Spec Paragraph	Accuracy	Alarms				Trending							
					Limit		Warning		Samples[1]	Commissioning[5]			Operating[5]			
					Hi	Lo	Hi	Lo		Time[2]	Local[3]	Archive[4]	Time[2]	Local[3]	Archive[4]	
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

1. Samples indicates the minimum number of data samples that must be held in the local controller if it is trending the point.
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If Nothing Else, Make a Point List

Specification Reference and Accuracy Reinforce Performance Requirements

Reference Spec Paragraph	Accuracy
25 35 00	0.75% of span for sensor + transmitter
25 35 00	0.75% of span for sensor + transmitter
25 35 00	0.75% of span for sensor + transmitter

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Point		Sensor			Features											Notes
Name (Note 6)	Description and Service	Type	Reference Spec Paragraph	Accuracy	Alarms				Trending							
					Limit		Warning		Samples[1]	Commissioning[5]			Operating[5]			
					Hi	Lo	Hi	Lo		Time[2]	Local[3]	Archive[4]	Time[2]	Local[3]	Archive[4]	
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
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HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
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Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
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STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

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If Nothing Else, Make a Point List

Alarm Requirements Tailor the System to the Operator's Needs and Your Design Concerns

Alarms			
Limit		Warning	
Hi	Lo	Hi	Lo
Note 7			
None			
Note 7			

Bureacratic Affairs Building 1st Floor Hot Water System

Point		Sensor			Features											Notes
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HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

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If Nothing Else, Make a Point List

Trending Requirements Drive System Architecture and Memory and Support LEED

Trending						
Samples[1]	Commissioning[5]			Operating[5]		
	Time[2]	Local[3]	Archive	Time[2]	Local[3]	Archive
60	1 min.	X	X	1 min.	X	X
12	5 min.	X	X	5 min.	X	X
60	1 min.	X	X	1 min.	X	X

Bureacratic Affairs Building 1st Floor Hot Water System

Point		Sensor			Features											Notes
Name (Note 6)	Description and Service	Type	Reference Spec Paragraph	Accuracy	Alarms				Trending							
					Limit		Warning		Samples[1]	Commissioning[5]			Operating[5]			
					Hi	Lo	Hi	Lo		Time[2]	Local[3]	Archive	Time[2]	Local[3]	Archive	
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

Notes:

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Notes

Note 8

Note 8

If Nothing Else, Make a Point List

Point Specific Notes Provide Additional Clarification if Needed

Bureacratic Affairs Building 1st Floor Hot Water System

Point Name (Note 6)	Description and Service	Sensor Type	Reference Spec Paragraph	Accuracy	Alarms Limit Hi	Alarms Limit Lo	Alarms Warning Hi	Alarms Warning Lo	Samples[1]	Commissioning[5] Time[2]	Commissioning[5] Local[3]	Commissioning[5] Archive[4]	Operating[5] Time[2]	Operating[5] Local[3]	Operating[5] Archive[4]	Notes
Analog Inputs																
STHX-1-LWT	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
SYSTM-OAT	System OAT	Single point 1,000 Ω Pt RTD with close coupled transmitter	25 35 00	0.75% of span for sensor + transmitter	None				12	5 min.	X	X	5 min.	X	X	
STHX-1-EWT	Shell and Tube Heat Exchanger -1 Ent. Wtr. Temp.	1,000 Ω Pt RTD with close coupled transmitter and thermometer well	25 35 00	0.75% of span for sensor + transmitter	Note 7				60	1 min.	X	X	1 min.	X	X	Note 8
Analog Outputs (All analog outputs to include local override capability and status indication at the controller)																
STHX-1-STMVLV-CMD	Shell and Tube Heat Exchanger -1 Steam Valve Command	4-20 ma actuator	25 35 13	N/A	N/A	N/A	N/A	N/A	60	1 min.	X	X	1 min.	X	X	
Digital Inputs																
HWPMP-1-DPSW	Hot Water Pump -1 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
HWPMP-2-DPSW	Hot Water Pump -2 Differential Pressure Switch	Penn model P74FA-5 differential pressure switch	25 35 16 2.04	N/A	Note 7				10	COV	X	X	COV	X	X	
Virtual Points																
STHX-1-LWT-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-PG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Proportional Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-IG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Integral Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-DG	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Derivative Gain	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-OFF	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Loop Off Value	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	Note 9
STHX-1-OAT-RSTILO-SP	Shell and Tube Heat Exchanger -1 OAT Reset Lo Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-OAT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 OAT Reset Hi Lmt. Set Pnt.	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTILO-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Lo Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-RSTIHI-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Reset Hi Lmt. Set	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-LWT-UNOCC-SP	Shell and Tube Heat Exchanger -1 Lvg. Wtr. Temp. Unoccupied Set Pn	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	
STHX-1-CLS-SP	Shell and Tube Heat Exchanger -1 Close Set Pnt	N/A	25 35 00	N/A	Note 7				10	COV	X	X	COV	X	X	

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A Point List Tool

The Control Design Guide

- *Design process recommendations*
- *Sensor selection and application guidelines*
- *Point list tool*

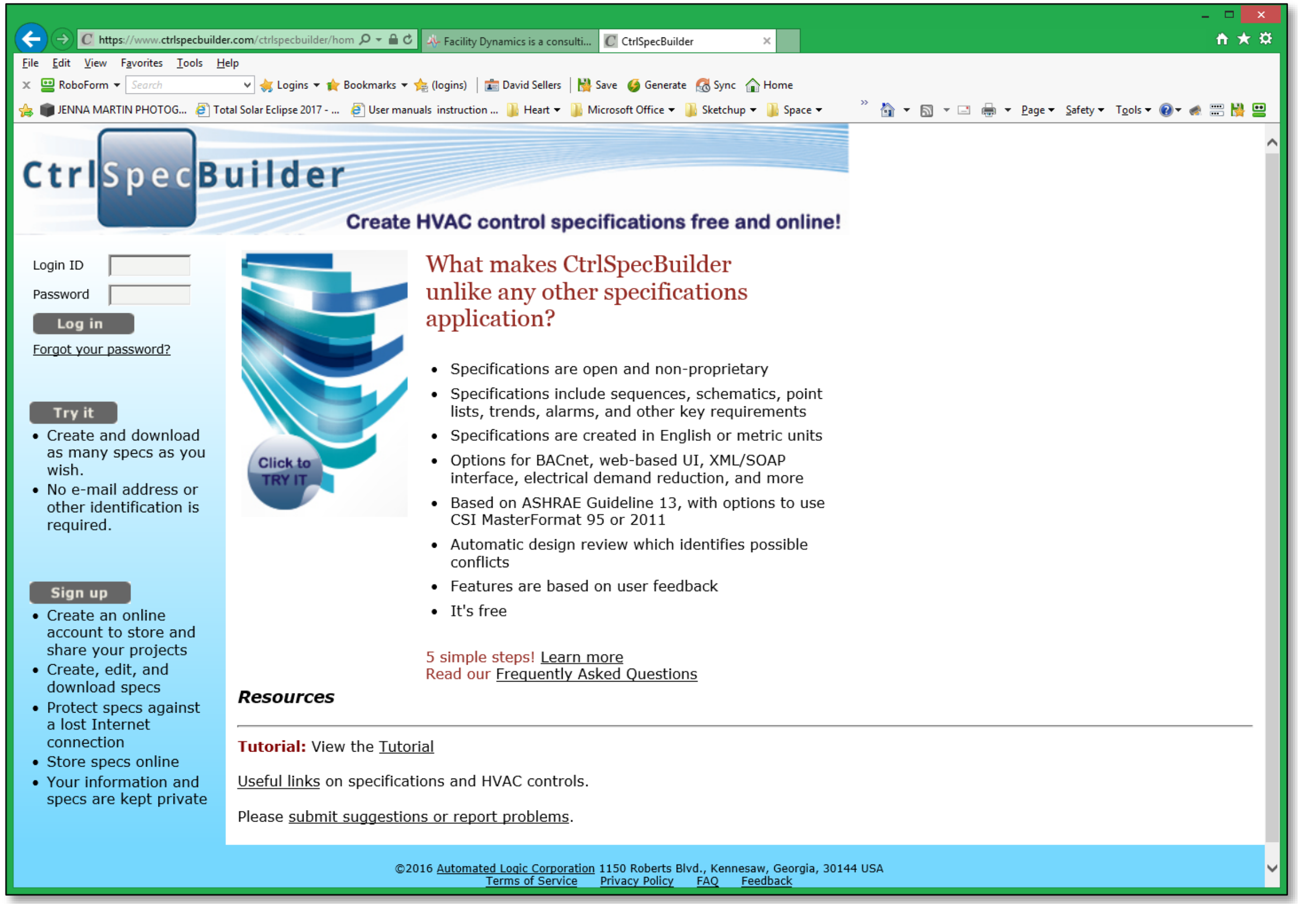
http://www.ftguide.org/csdg/CSDG.htm

(Note this runs best in a version of Internet Explorer with compatibility mode turned on)

A Specification Resource

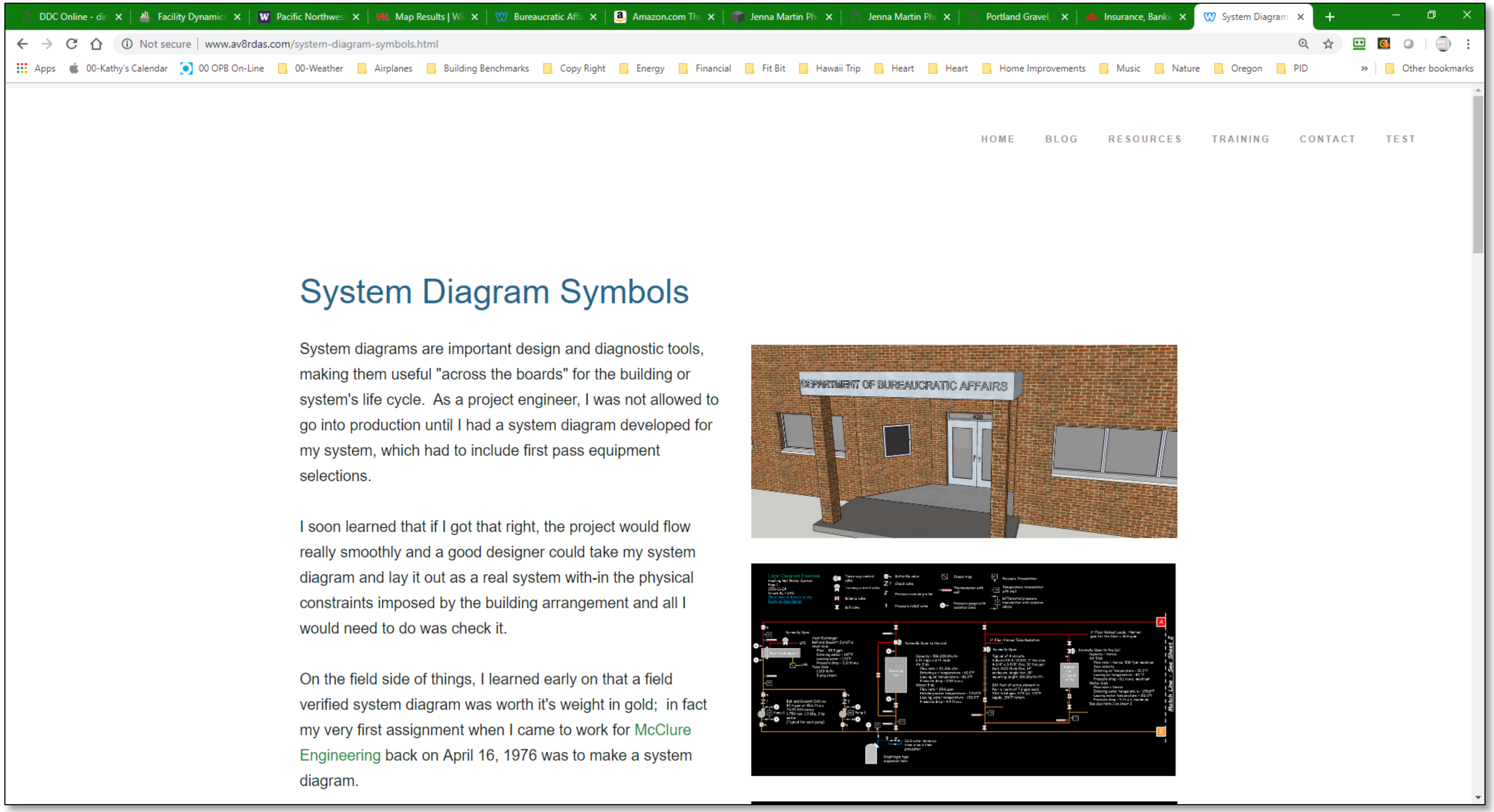
Control Spec Builder

- *Generic spec development in Word format*
- *Point list tool*
- *System diagram tool*
- *Sequence of operation tool*



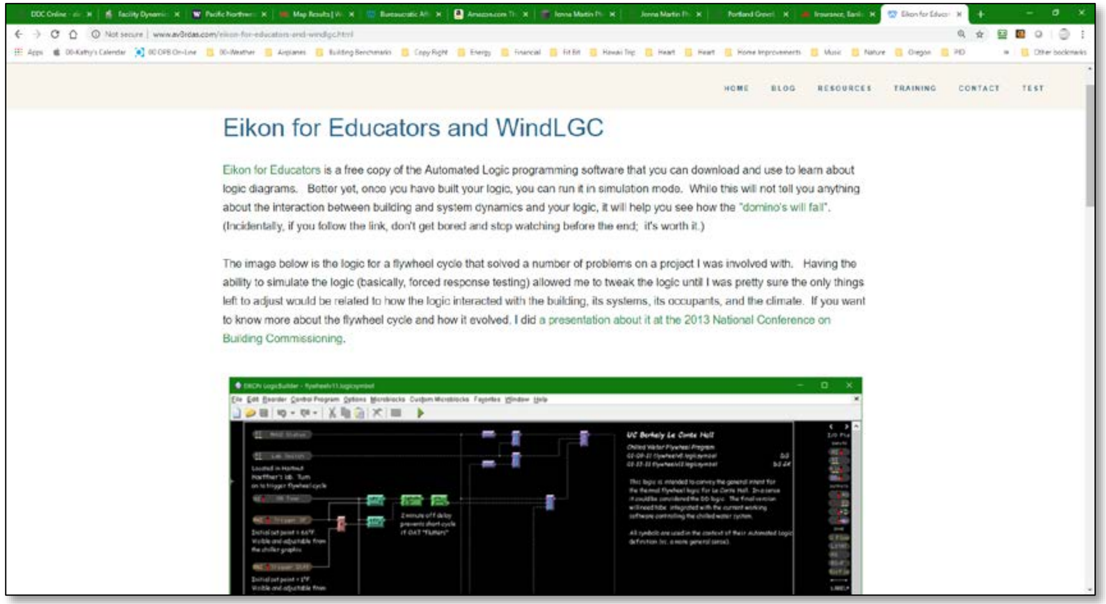
https://www.ctrlspecbuilder.com/

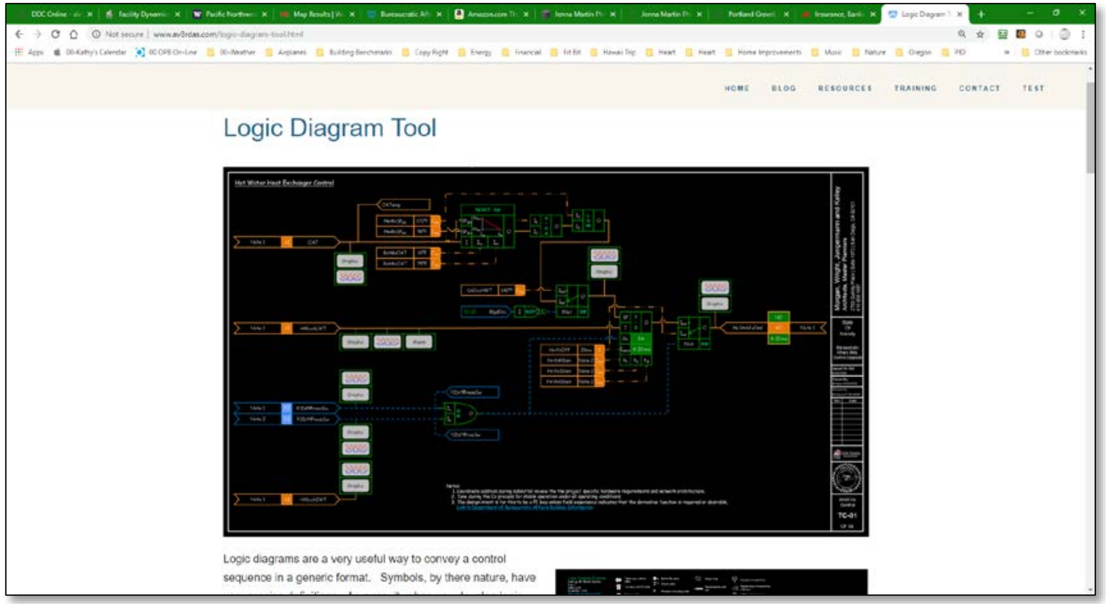
A System Diagram Tool



http://www.av8rdas.com/system-diagram-symbols.html/

Logic Diagram Tools

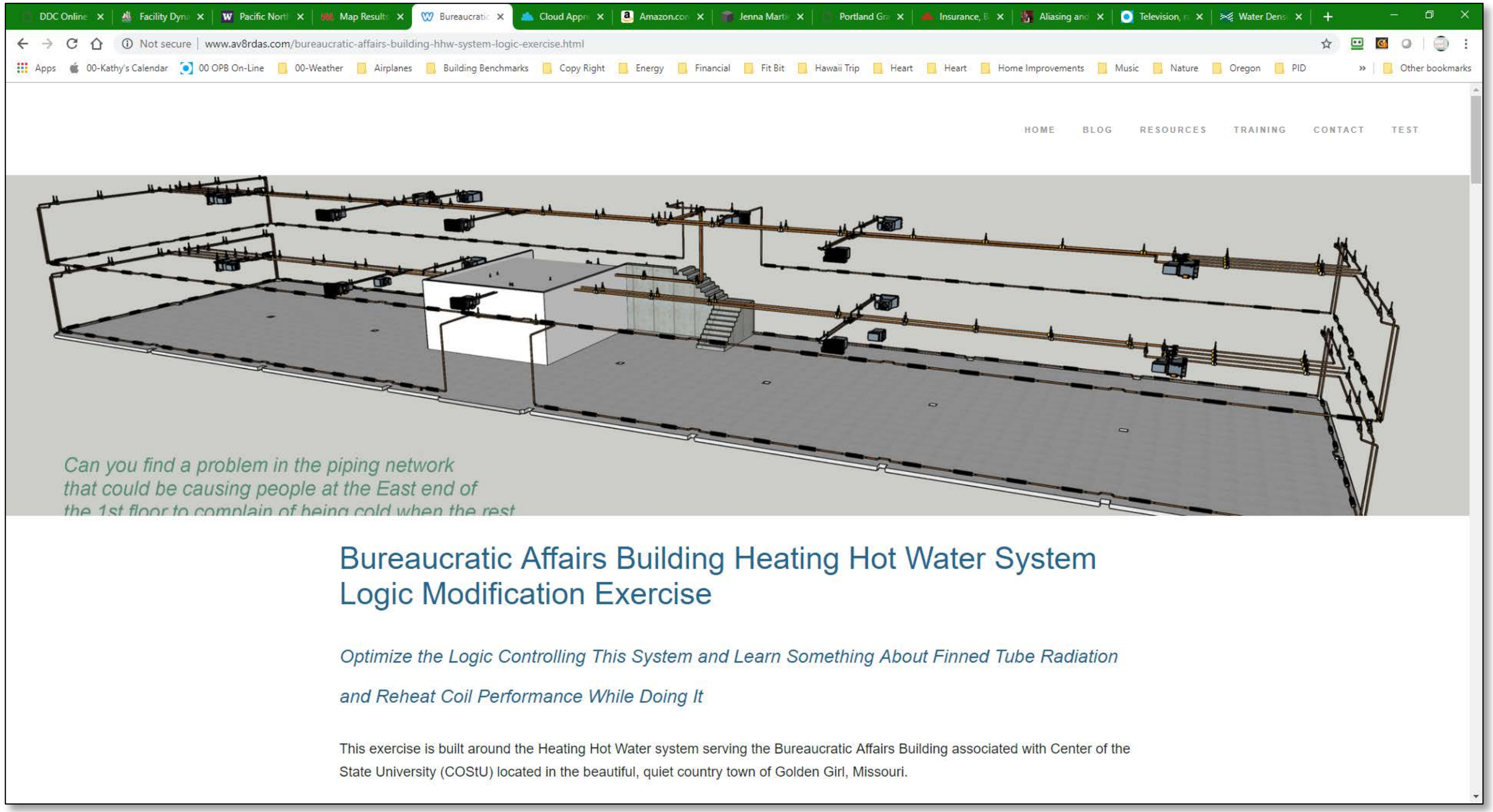




http://www.av8rdas.com/eikon-for-educators-and-windlgc.html

http://www.av8rdas.com/logic-diagram-tool.html

A Logic Diagram Exercise



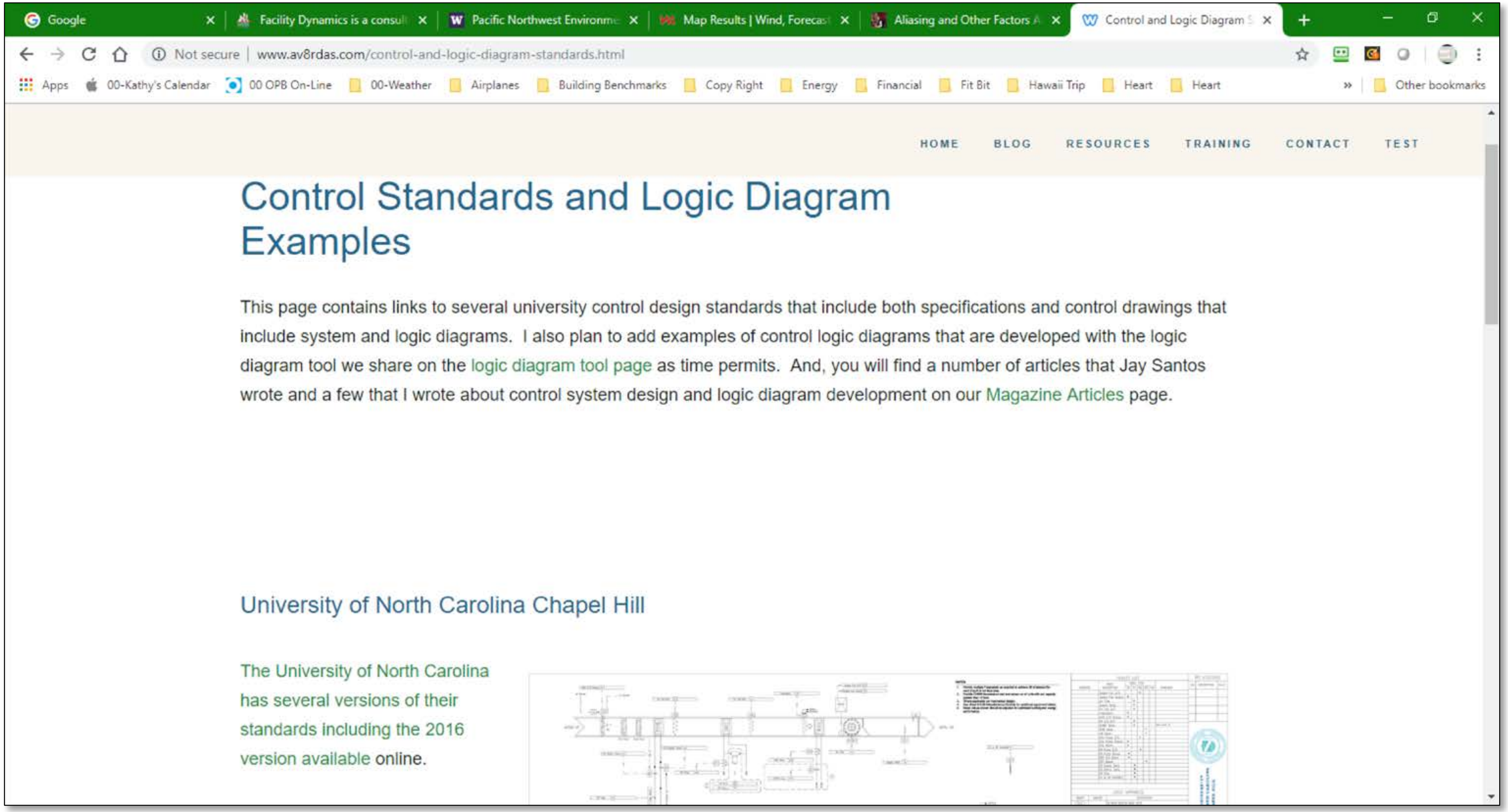
Blog Post Describing the Exercise

https://av8rdas.wordpress.com/2019/02/18/a-control-logic-exercise-and-a-way-to-get-comfortable-with-navigating-sketchup-models/

Exercise Set-up and Materials

http://www.av8rdas.com/bureaucratic-affairs-building-hhw-system-logic-exercise.html

Examples of Standards Applying These Principles http://www.av8rdas.com/control-and-logic-diagram-standards.html



Submittal Review

Washington
2602 S 38th St, PMB 461
Tacoma, WA 98409
Phone (253) 272-0235
Fax (253) 276-0088
WA #PARTECI972J1

ceptions taken. But since they were
isions are required or items which were simply
have no problem if Siemens wants to begin
s Noted" or "Exceptions Noted" contingent, of
t.

vise and Resubmit", items that were "Rejected", and
the items that we would like to see submittals on but

comment I made to make it easier to find them. Note
for a particular product so please review all pages
e bookmarks to move around.

gs,

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ection.

or battery.

rk and I/O
and cable

are coordinated
pick up a

team members (see
ATED AUTOMATION
aph 1.07).

- [ ] No Exceptions Noted
- [ ] Exceptions Noted (Do Not Resubmit)
- [x] Revise and Resubmit (See Notes)
- [ ] Rejected
- [ ] Not Required -Returned Without Action

Corrections or comments made to the shop drawings during this review do not relieve contractor from compliance with requirements of the drawings and specifications. This check is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The contractor is responsible for: confirming and correlating all quantities and dimensions; selecting fabrication process and techniques of construction; coordinating its work with that of all other trades; and performing its work in a safe and satisfactory manner.

Facility Dynamics
ENGINEERING

AE

Submittal Sheet
Document No. 154-072
April 18, 2011

OpenAir™ GQD Series, Spring Return, 20 lb-in (2 Nm), Rotary Electronic Damper Actuators

Product Number*	Torque	Voltage		Control Signals			Plenum Cabling	Appliance Cable	Auxiliary Switch
	20 lb-in	24 Vac/dc	120 Vac	2-Position	Floating	Modulating 2 to 10 Vdc/ 10 to 2 Vdc			
GQD121.1P	●	●	—	●	—	—	●	—	—
GQD126.1P	●	●		●	—	—	●	—	●
GQD131.1P	●	●	—	—	●	—	●	—	—
GQD136.1P	●	●	—	—	●	—	●	—	●
GQD151.1P	●	●	—	—	—	●	●	—	—
GQD156.1P	●	●	—	—	—	●	●	—	●
GQD221.1U	●	—	●	●	—	—	—	●	—
GQD226.1U	●	—	●	●	—	—	—	●	●

* Add /B to part number to order a bulk pack of 10.

Description

The OpenAir GQD Series direct-coupled, spring return rotary electronic damper actuators are 24 Vac/dc rated and available in 2-position, floating, and modulating (2 to 10 Vdc) control. The small footprint and torque make this actuator ideal for small HVAC dampers, economizers, or residential zone dampers requiring fail-safe operation.

c UL us LISTED CE

Technical Data

Torque		20 lb-in (2 Nm)	
Runtime for 90°		30 seconds	
Spring Return		15 seconds typical	
Nominal angle of rotation		90° typical	
Power consumption:		Running	Holding
24 Vac ±20%/ 24 Vdc ±15%			
	GQD12x	6.5 VA (4.5W)	4 VA (2.5W)
	GQD13x	4 VA (2.5W)	3 VA (1.5W)
	GQD15x	4.5 VA (3W)	3.5 VA (2W)
120 Vac ±15%			
	GQD22x	10 VA	7 VA
Damper shaft size		3/8-inch to 1/2-inch diameter (8 mm to 13 mm) 1/4-inch to 7/16-inch square (6 mm to 11 mm)	
Damper shaft size, minimum		3/4-inch (20 mm) minimum length	
Agency listings		UL listed to UL873 cUL listed; CE certified	
120 Vac		EMC and Low Voltage Directives	
Ambient temperature			
Operating		–25°F to 130°F (–32°C to 55°C)	
Storage/transport		–40°F to 158°F (–40°C to 70°C)	
Ambient humidity (non-condensing)		95% rh (non-condensing)	
Pre-cabled connection		18 AWG (0.75mm^2), 3 ft (0.9m) long	
Enclosure		NEMA 1	
Housing material		Plenum rated rugged plastic	
Dimensions:		4-23/32" × 2-22/32" × 2-15/32" (120 mm × 69 mm × 63 mm)	
GQD221.1U (only)		5-1/2" × 2-22/32" × 2-15/32" (138.5 mm × 69 mm × 63 mm)	
GQDxx6 w/conduit adapter		6-3/16" × 2-22/32" × 2-15/32" (156.7 mm ×69 mm ×63 mm	
Weight		1.06 lbs (0.48 kg)	

Features

- Bi-directional, fail-safe spring return
- Pre-cabled
- Plenum rated models available
- Optional built-in auxiliary switches with fixed switch points at 5° and 85° rotation
- Fast run time
- Signal inversion capability on modulating type (2 to 10 Vdc or 10 to 2 Vdc)
- Small footprint for installation flexibility
- UL and cUL listed; CE certified
- These devices were approved for installation in plenum areas by Underwriters Laboratories, Inc. per UL 1995.
- Low voltage models are 24 Vac/dc compatible
- 120 Vac, 1/2" NPT conduit, model available
- Fixed Dual End Switches
  24 Vdc, 24 Vac to 250 Vac
  6A resistive
  2FLA/12 LRA
  SPST
  Fixed 5° and 85°

Revise and Resubmit

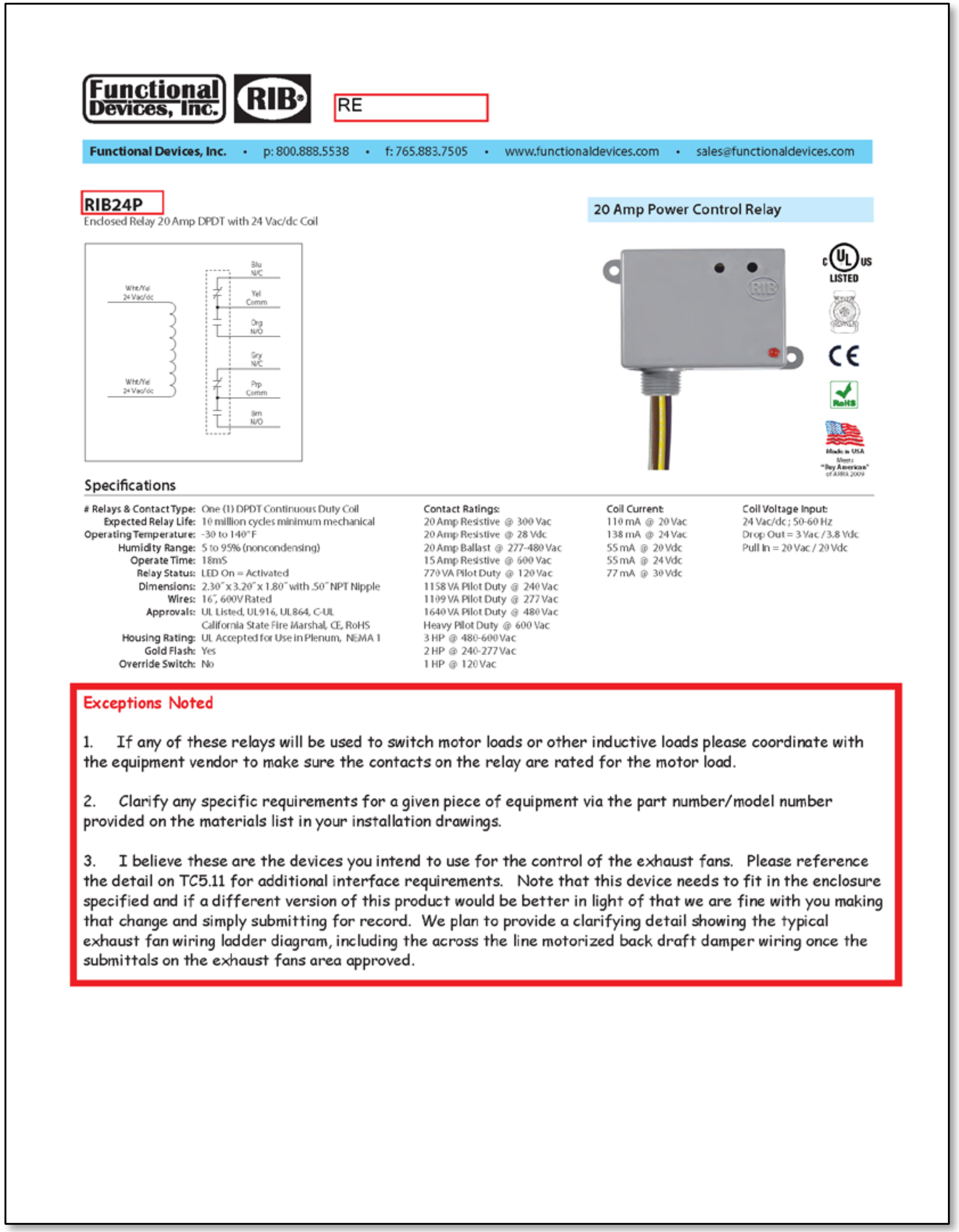
1. Provide a damper schedule per the requirements of SECTION 25 55 00 INTEGRATED AUTOMATION CONTROL OF HVAC Paragraph 1.11.E.10.

2. For each damper where the actuator is applied, verify the actuator torque meets damper requirements for operating over the entire stroke and for the force applied at each end of the stroke to meet leakage requirements, including the impact of any linkage system on the force available to the damper drive shaft.
3. Verify specified 60,000 full cycle life minimum. The product is rejected if it does not meet this requirement.
4. Technically, all of the actuators are specified with manual over-ride capability But we may be able to waive that for some. Please clarify in the damper schedule where that feature will be provided and where not so we can run it by Fac Ops.

Submittal Review

Hardware Submittal

- Can be assembled fairly quickly
- Gets long lead items on order
- Supports the installation and software submittal



Functional Devices, Inc. RIB RE

Functional Devices, Inc. • p: 800.888.5538 • f: 765.883.7505 • www.functionaldevices.com • sales@functionaldevices.com

RIB24P

Enclosed Relay 20 Amp DPDT with 24 Vac/dc Coil

20 Amp Power Control Relay

LISTED

Made in USA

Meets "Buy American" of ARRA 2009

Specifications

# Relays & Contact Type:	One (1) DPDT Continuous Duty Coil
Expected Relay Life:	10 million cycles minimum mechanical
Operating Temperature:	-30 to 140° F
Humidity Range:	5 to 95% (noncondensing)
Operate Time:	18mS
Relay Status:	LED On = Activated
Dimensions:	2.30" x 3.20" x 1.80" with .50" NPT Nipple
Wires:	16", 600V Rated
Approvals:	UL Listed, UL916, UL864, C-UL California State Fire Marshal, CE, RoHS
Housing Rating:	UL Accepted for Use in Plenum, NEMA 1
Gold Flash:	Yes
Override Switch:	No

Contact Ratings:
20 Amp Resistive @ 300 Vac
20 Amp Resistive @ 28 Vdc
20 Amp Ballast @ 277-480 Vac
15 Amp Resistive @ 600 Vac
770 VA Pilot Duty @ 120 Vac
1158 VA Pilot Duty @ 240 Vac
1109 VA Pilot Duty @ 277 Vac
1640 VA Pilot Duty @ 480 Vac
Heavy Pilot Duty @ 600 Vac
3 HP @ 480-600 Vac
2 HP @ 240-277 Vac
1 HP @ 120 Vac

Coil Current:
110 mA @ 20 Vac
138 mA @ 24 Vac
55 mA @ 20 Vdc
55 mA @ 24 Vdc
77 mA @ 30 Vdc

Coil Voltage Input:
24 Vac/dc ; 50-60 Hz
Drop Out = 3 Vac / 3.8 Vdc
Pull In = 20 Vac / 20 Vdc

Exceptions Noted

1. If any of these relays will be used to switch motor loads or other inductive loads please coordinate with the equipment vendor to make sure the contacts on the relay are rated for the motor load.

2. Clarify any specific requirements for a given piece of equipment via the part number/model number provided on the materials list in your installation drawings.

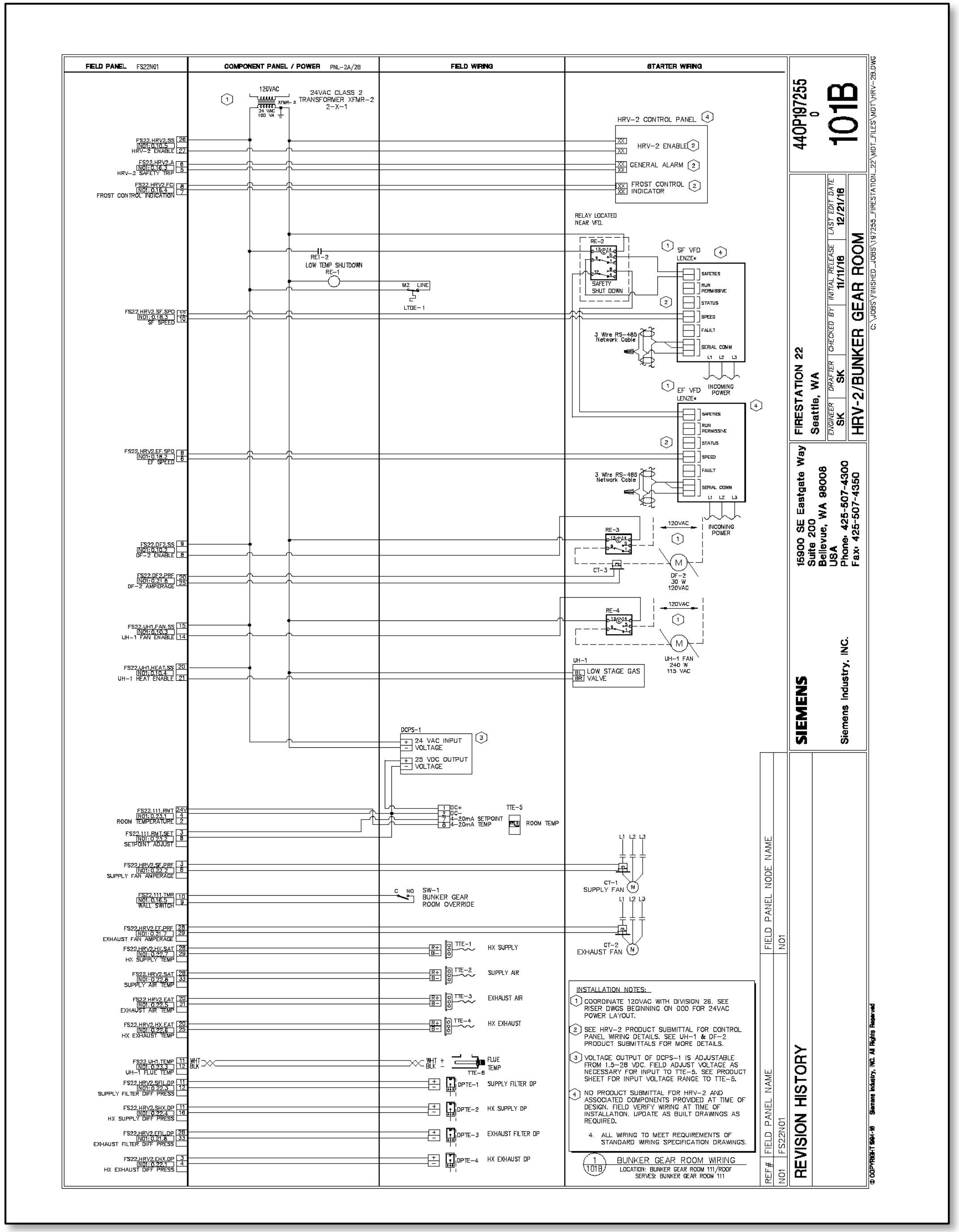
3. I believe these are the devices you intend to use for the control of the exhaust fans. Please reference the detail on TC5.11 for additional interface requirements. Note that this device needs to fit in the enclosure specified and if a different version of this product would be better in light of that we are fine with you making that change and simply submitting for record. We plan to provide a clarifying detail showing the typical exhaust fan wiring ladder diagram, including the across the line motorized back draft damper wiring once the submittals on the exhaust fans area approved.

Submittal Review

Installation and Software Submittal

- Long lead time
- Supported by the hardware submittal
- Changes identified during review and approval will likely be low-cost or no-cost …

… but once approved, that will change



Submittal Review

Installation and Software Submittal

- Consider a controls system installation and coordination meeting
- See *The Controls Integration Meeting* by Karl Stum and Norm Nelson
- https://av8rdas.wordpress.com/2008/10/05/the-controls-integration-and-coordination-meeting/

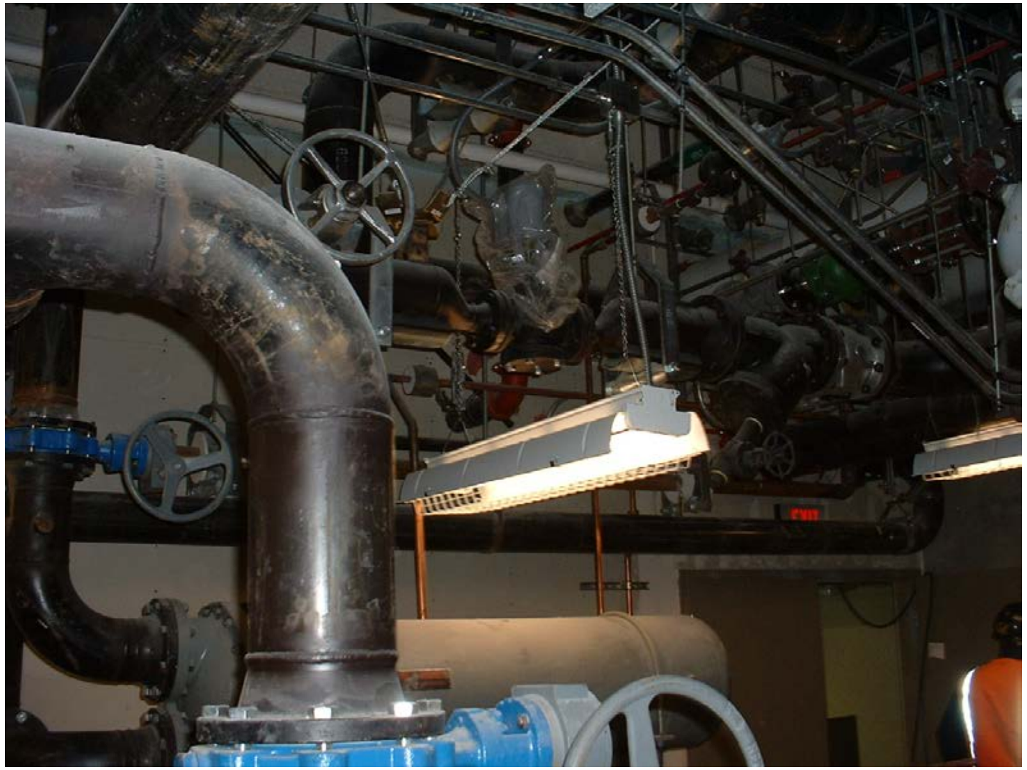
Construction Observation

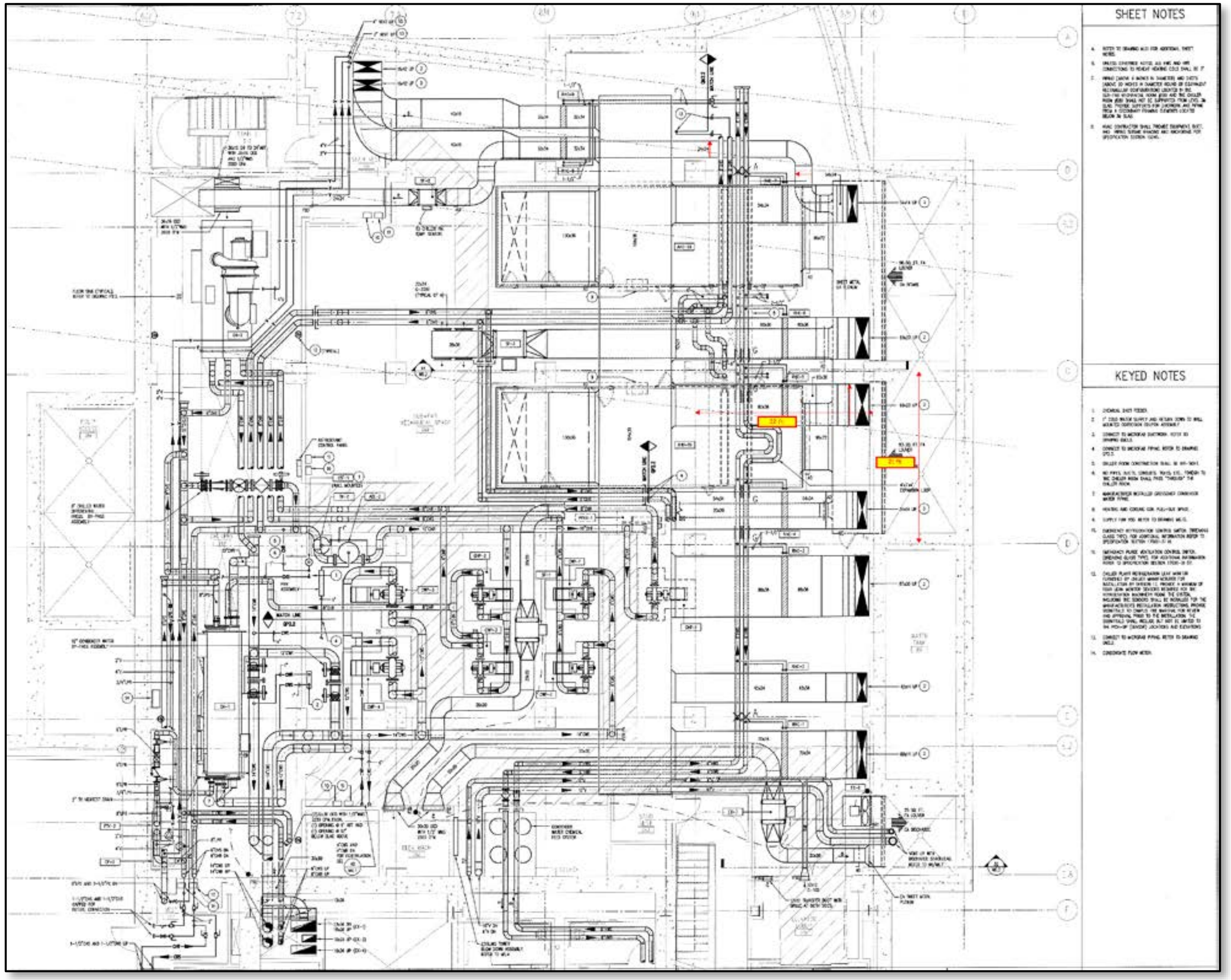
Sometimes Things Are Just Not Right

Sometimes Things Are Just Not Right

Developing a System Diagram

- A good way to learn the system prior to going on site

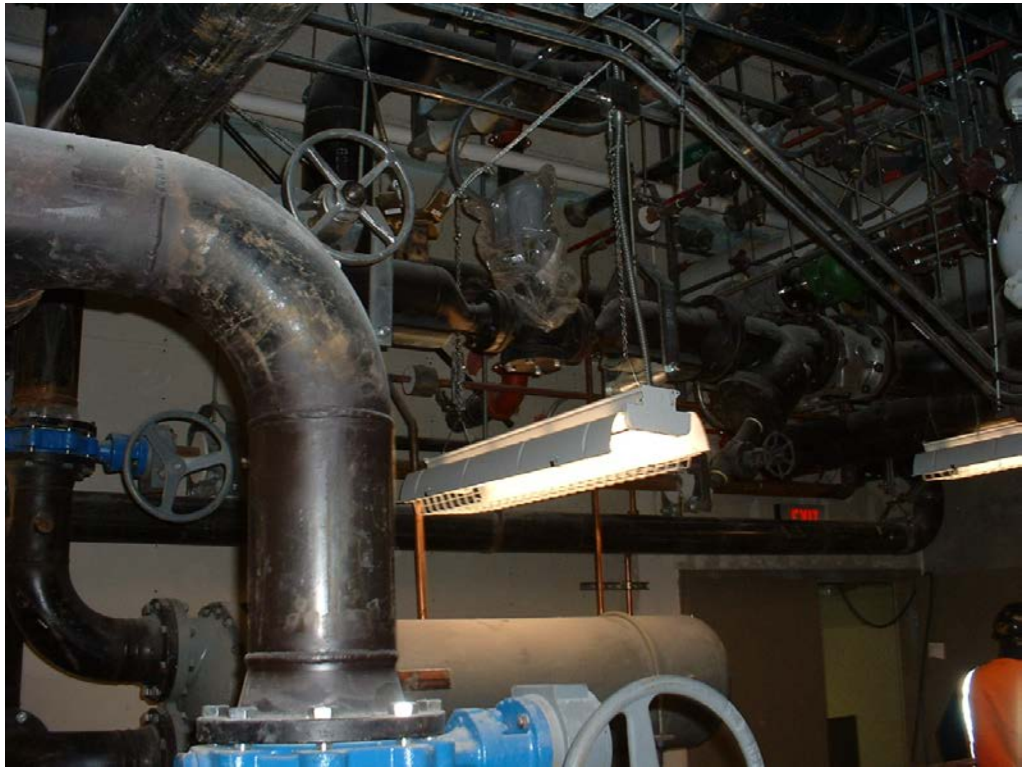


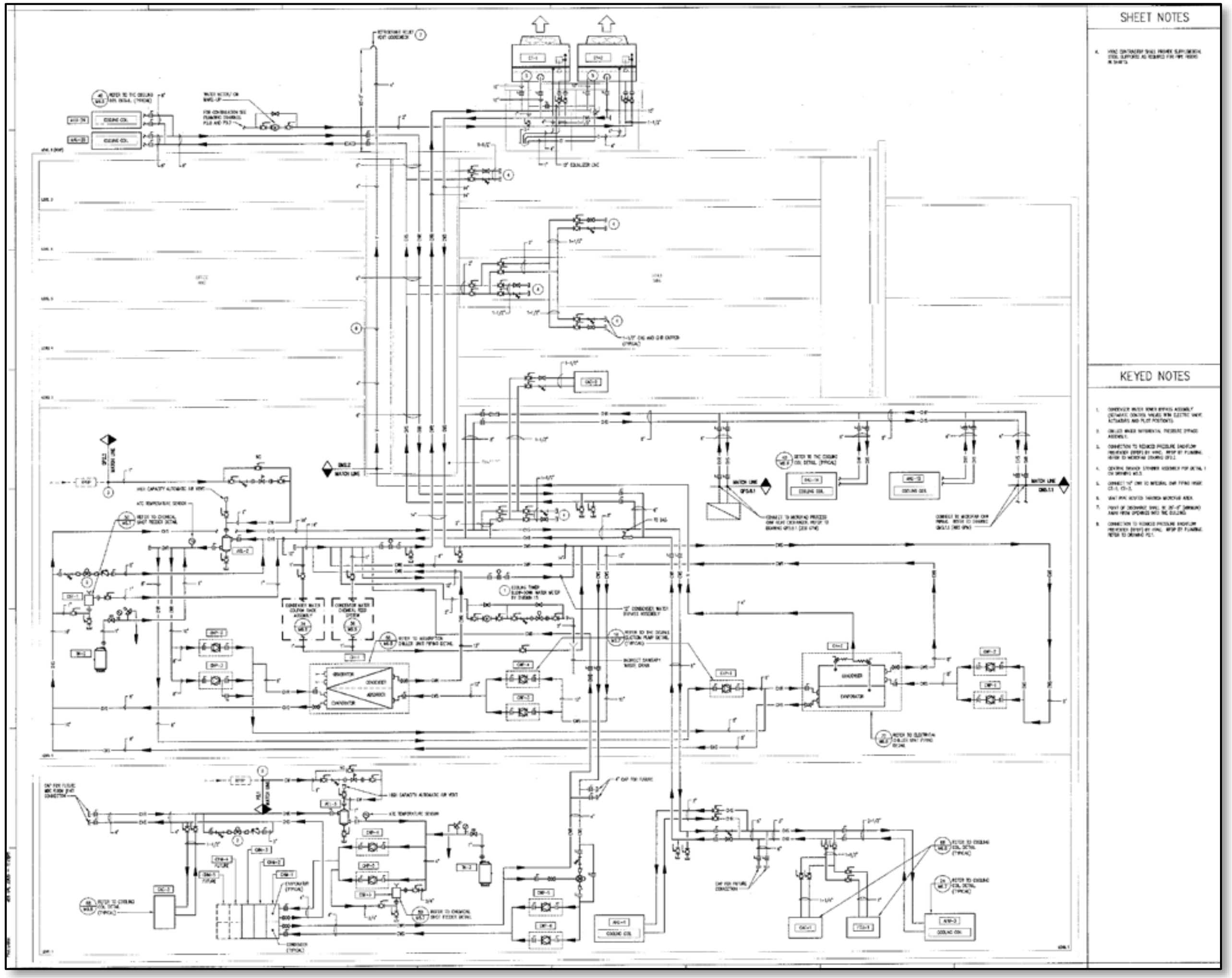


The Piping Plan

Developing a System Diagram

- A good way to learn the system prior to going on site

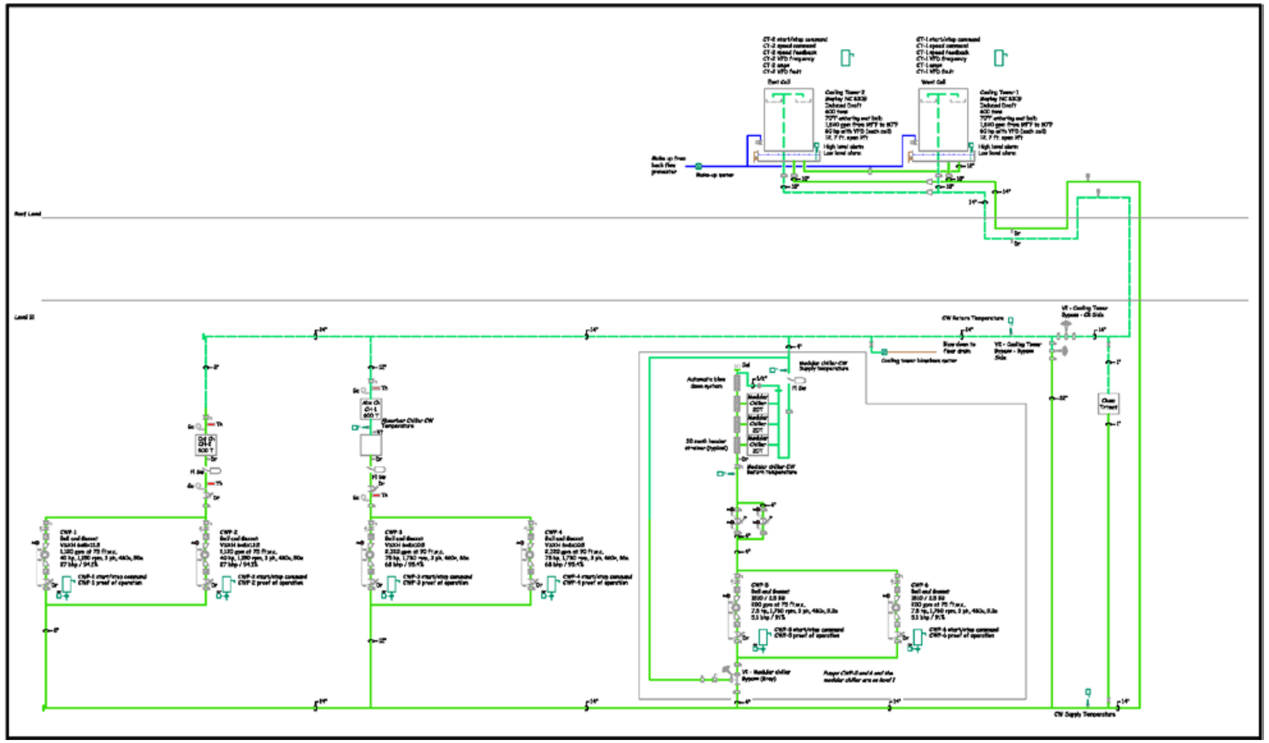




The “System Diagram” from the Drawing Set

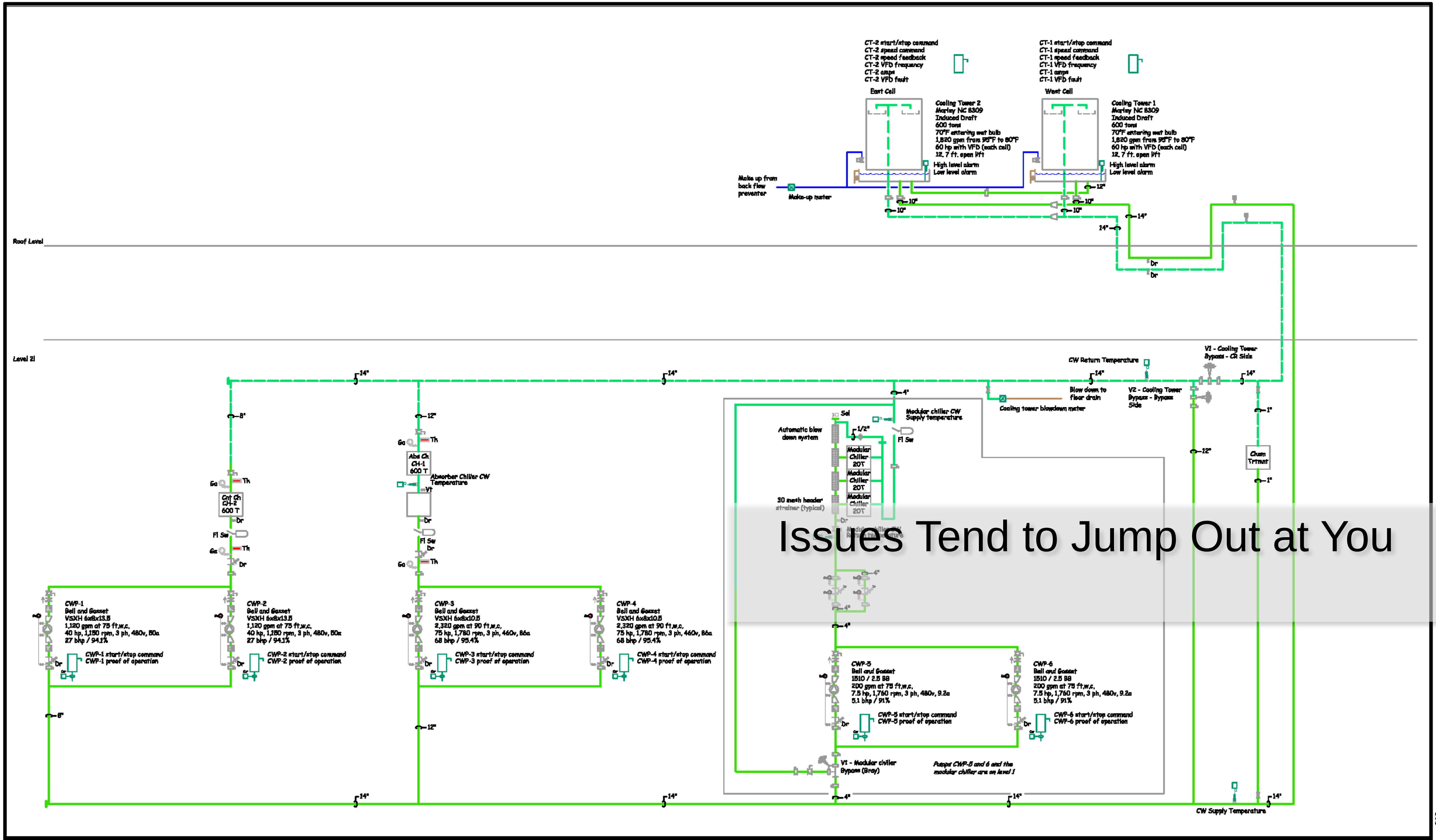
Developing a System Diagram

- A good way to learn the system prior to going on site
- Focusing on one system can be helpful
- “Untangling” can be helpful

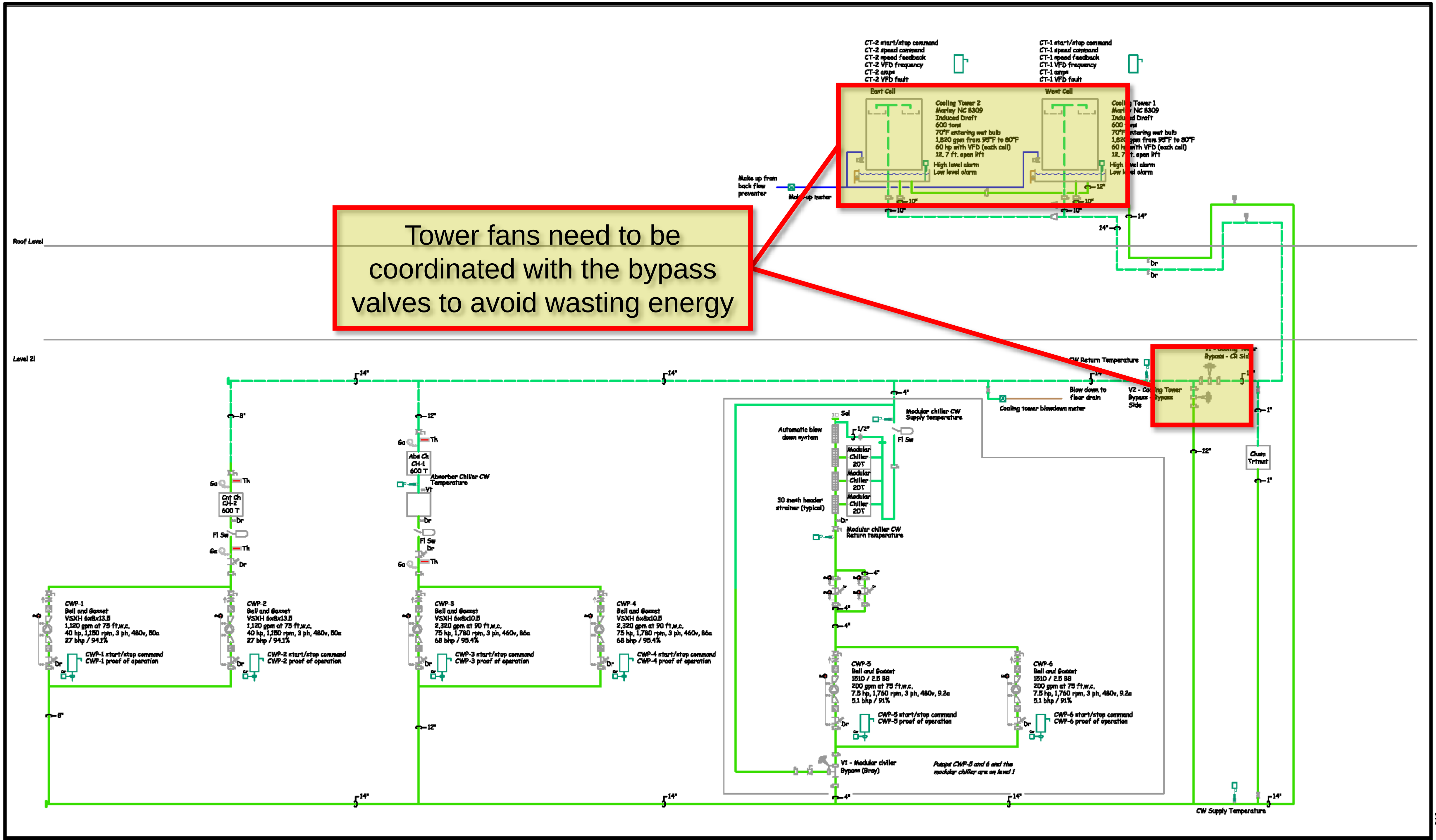


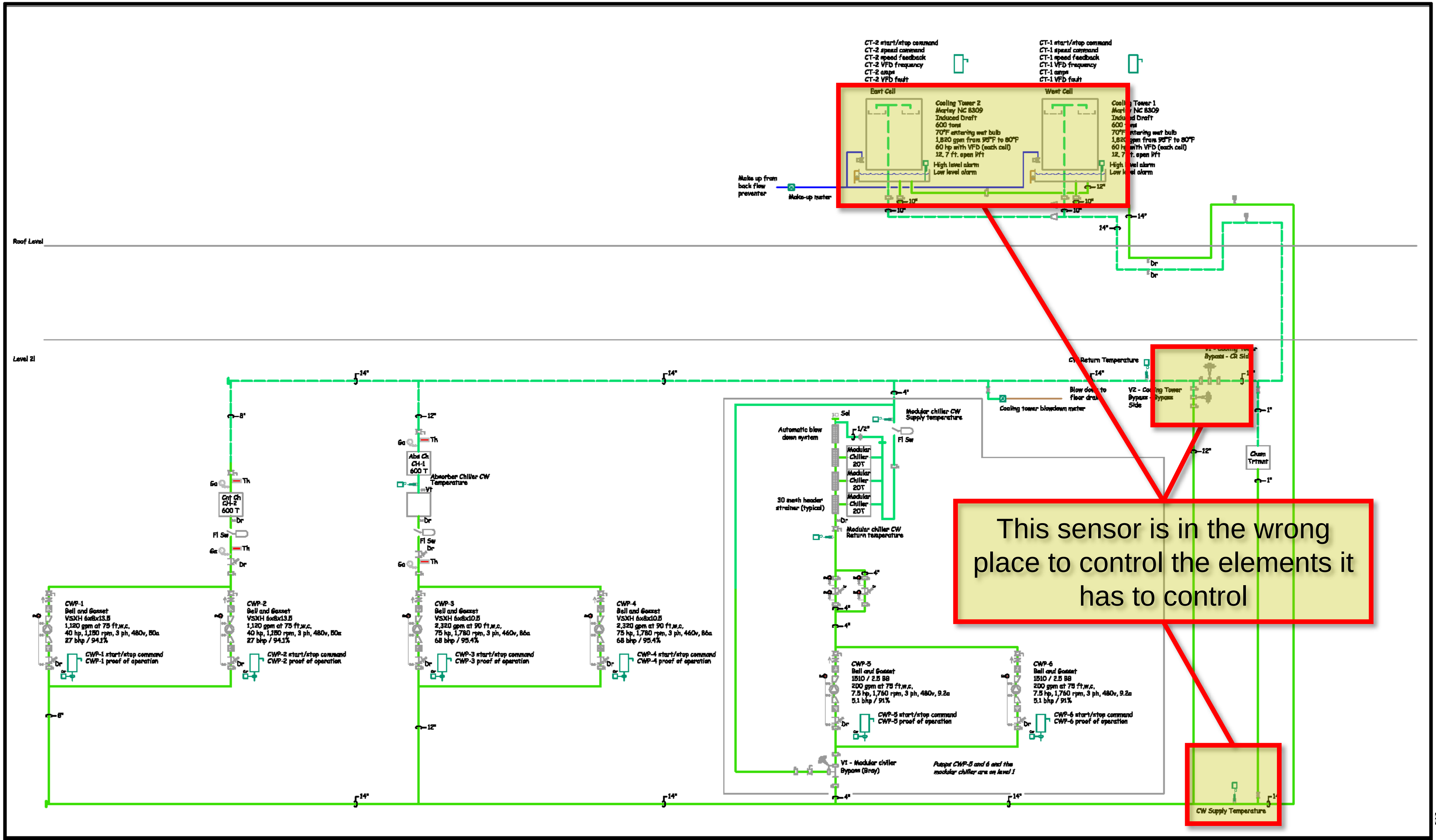
My “System Diagram” for the Condenser Water System

Issues Tend to Jump Out at You

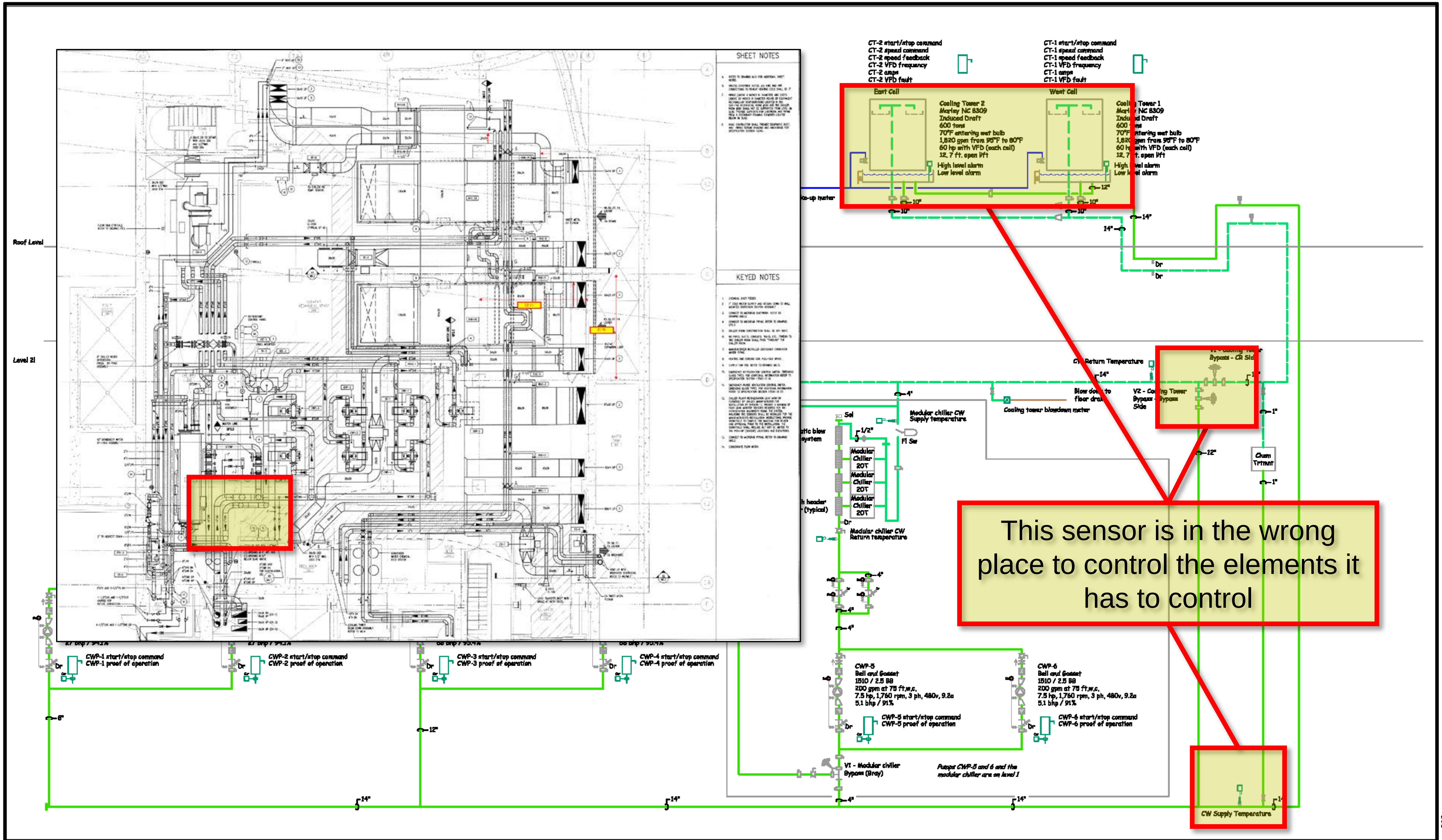


Tower fans need to be coordinated with the bypass valves to avoid wasting energy





This sensor is in the wrong place to control the elements it has to control
CT-2 start/stop command
CT-2 speed command
CT-2 speed feedback
CT-2 VFD frequency
CT-2 amps
CT-2 VFD fault
CT-1 start/stop command
CT-1 speed command
CT-1 speed feedback
CT-1 VFD frequency
CT-1 amps
CT-1 VFD fault
East Cell
West Cell
Cooling Tower 2
Marley NC 8309
Induced Draft
600 tons
70°F entering wet bulb
1,820 gpm from 95°F to 80°F
60 hp with VFD (each cell)
12.7 ft. open lift
High level alarm
Low level alarm
Cooling Tower 1
Make up from back flow preventer
Make-up meter
Roof Level
Level 2I
CW Return Temperature
Blow down to floor drain
Cooling tower blowdown meter
V2 - Cooling Tower Bypass - Bypass Side
Modular chiller CW Supply temperature
Automatic blow down system
Modular Chiller 20T
30 mesh header strainer (typical)
Modular chiller CW Return temperature
Abs Ch CH-1 600 T
Absorber Chiller CW Temperature
Cnt Ch CH-2 600 T
Chem Trtmnt
CWP-1
Bell and Gossett
VSXH 6x8x13.5
1,120 gpm at 75 ft.w.c.
40 hp, 1,180 rpm, 3 ph, 480v, 50a
27 bhp / 94.1%
CWP-1 start/stop command
CWP-1 proof of operation
CWP-2
Bell and Gossett
VSXH 6x8x13.5
1,120 gpm at 75 ft.w.c.
40 hp, 1,180 rpm, 3 ph, 480v, 50a
27 bhp / 94.1%
CWP-2 start/stop command
CWP-2 proof of operation
CWP-3
Bell and Gossett
VSXH 6x8x10.5
2,320 gpm at 90 ft.w.c.
75 hp, 1,780 rpm, 3 ph, 460v, 86a
68 bhp / 95.4%
CWP-3 start/stop command
CWP-3 proof of operation
CWP-4
Bell and Gossett
VSXH 6x8x10.5
2,320 gpm at 90 ft.w.c.
75 hp, 1,780 rpm, 3 ph, 460v, 86a
68 bhp / 95.4%
CWP-4 start/stop command
CWP-4 proof of operation
CWP-5
Bell and Gossett
1510 / 2.5 BB
200 gpm at 75 ft.w.c.
7.5 hp, 1,760 rpm, 3 ph, 480v, 9.2a
5.1 bhp / 91%
CWP-5 start/stop command
CWP-5 proof of operation
CWP-6
Bell and Gossett
1510 / 2.5 BB
200 gpm at 75 ft.w.c.
7.5 hp, 1,760 rpm, 3 ph, 480v, 9.2a
5.1 bhp / 91%
CWP-6 start/stop command
CWP-6 proof of operation
V1 - Modular chiller Bypass (Gray)
Pumps CWP-5 and 6 and the modular chiller are on level 1
CW Supply Temperature



CT-2 start/stop command
CT-2 speed command
CT-2 speed feedback
CT-2 VFD frequency
CT-2 amps
CT-2 VFD fault
CT-1 start/stop command
CT-1 speed command
CT-1 speed feedback
CT-1 VFD frequency
CT-1 amps
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East Cell
West Cell
Cooling Tower 2
Marley NC 8309
Induced Draft
600 tons
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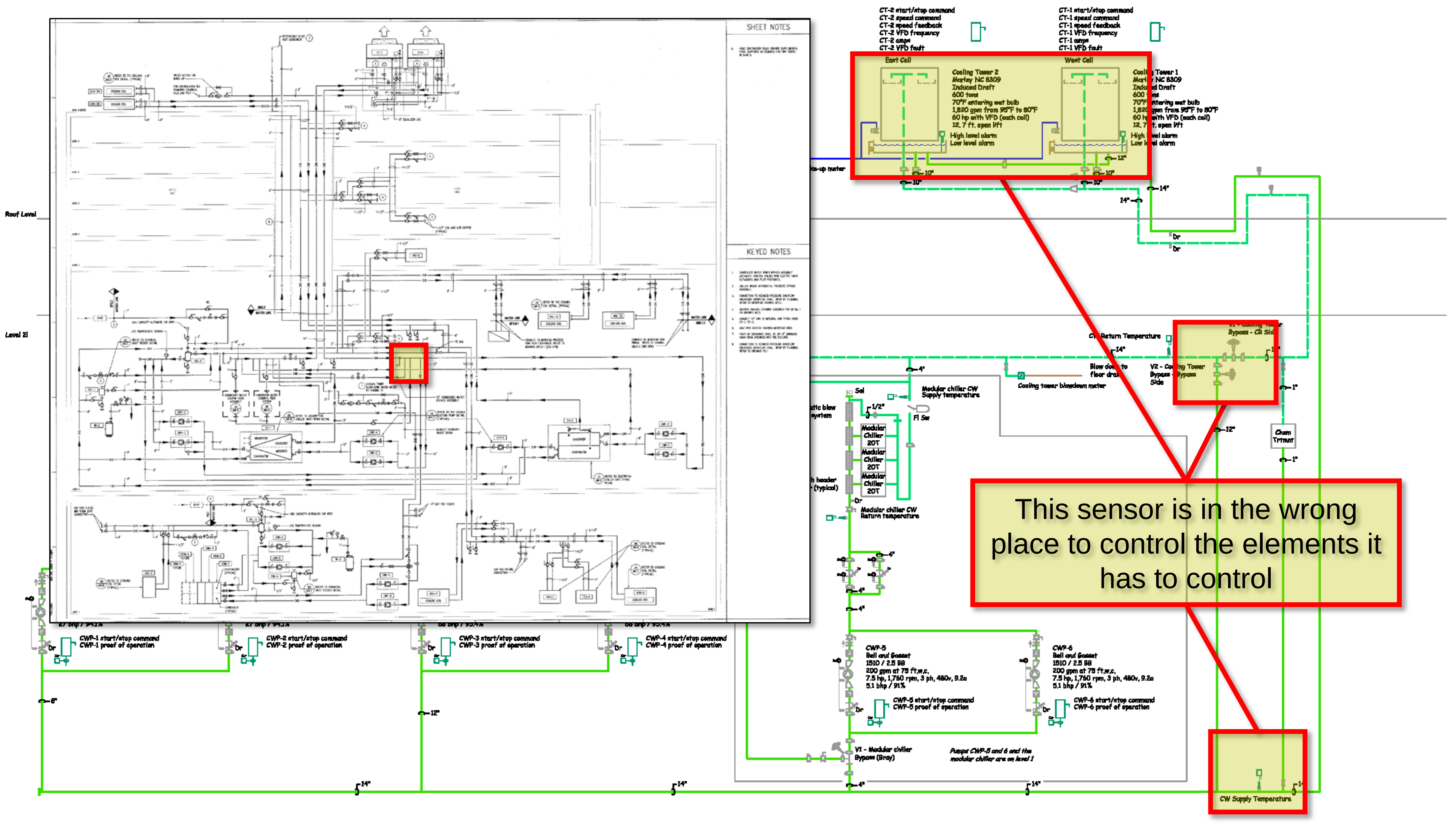
60 hp with VFD (each cell)
12.7 ft. open lift
High level alarm
Low level alarm
Roof Level
Level 2I
SHEET NOTES
KEYED NOTES
CW Return Temperature
Blow down to floor drain
V2 - Cooling Tower Bypass - Bypass Side
Cooling tower blowdown meter
Modular chiller CW Supply temperature
Fl Sw
Modular Chiller 20T
Modular Chiller 20T
Modular Chiller 20T
Modular chiller CW Return temperature
Chem Trtmnt
This sensor is in the wrong place to control the elements it has to control
CWP-1 start/stop command
CWP-1 proof of operation
CWP-2 start/stop command
CWP-2 proof of operation
CWP-3 start/stop command
CWP-3 proof of operation
CWP-4 start/stop command
CWP-4 proof of operation
CWP-5
Bell and Gossett
1510 / 2.5 BB
200 gpm at 75 ft.w.c.
7.5 hp, 1,760 rpm, 3 ph, 480v, 9.2a
5.1 bhp / 91%
CWP-5 start/stop command
CWP-5 proof of operation
CWP-6
Bell and Gossett
1510 / 2.5 BB
200 gpm at 75 ft.w.c.
7.5 hp, 1,760 rpm, 3 ph, 480v, 9.2a
5.1 bhp / 91%
CWP-6 start/stop command
CWP-6 proof of operation
V1 - Modular chiller Bypass (Gray)
Pumps CWP-5 and 6 and the modular chiller are on level 1
CW Supply Temperature



This sensor is in the wrong place to control the elements it has to control
CT-2 start/stop command
CT-2 speed command
CT-2 speed feedback
CT-2 VFD frequency
CT-2 amps
CT-2 VFD fault
CT-1 start/stop command
CT-1 speed command
CT-1 speed feedback
CT-1 VFD frequency
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Low level alarm
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SHEET NOTES
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Cooling tower blowdown meter
Modular chiller CW Supply temperature
Modular Chiller 20T
Modular chiller CW Return temperature
CWP-1 start/stop command
CWP-1 proof of operation
CWP-2 start/stop command
CWP-2 proof of operation
CWP-3 start/stop command
CWP-3 proof of operation
CWP-4 start/stop command
CWP-4 proof of operation
CWP-5
Bell and Gossett
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200 gpm at 75 ft.w.c.
7.5 hp, 1,760 rpm, 3 ph, 480v, 9.2a
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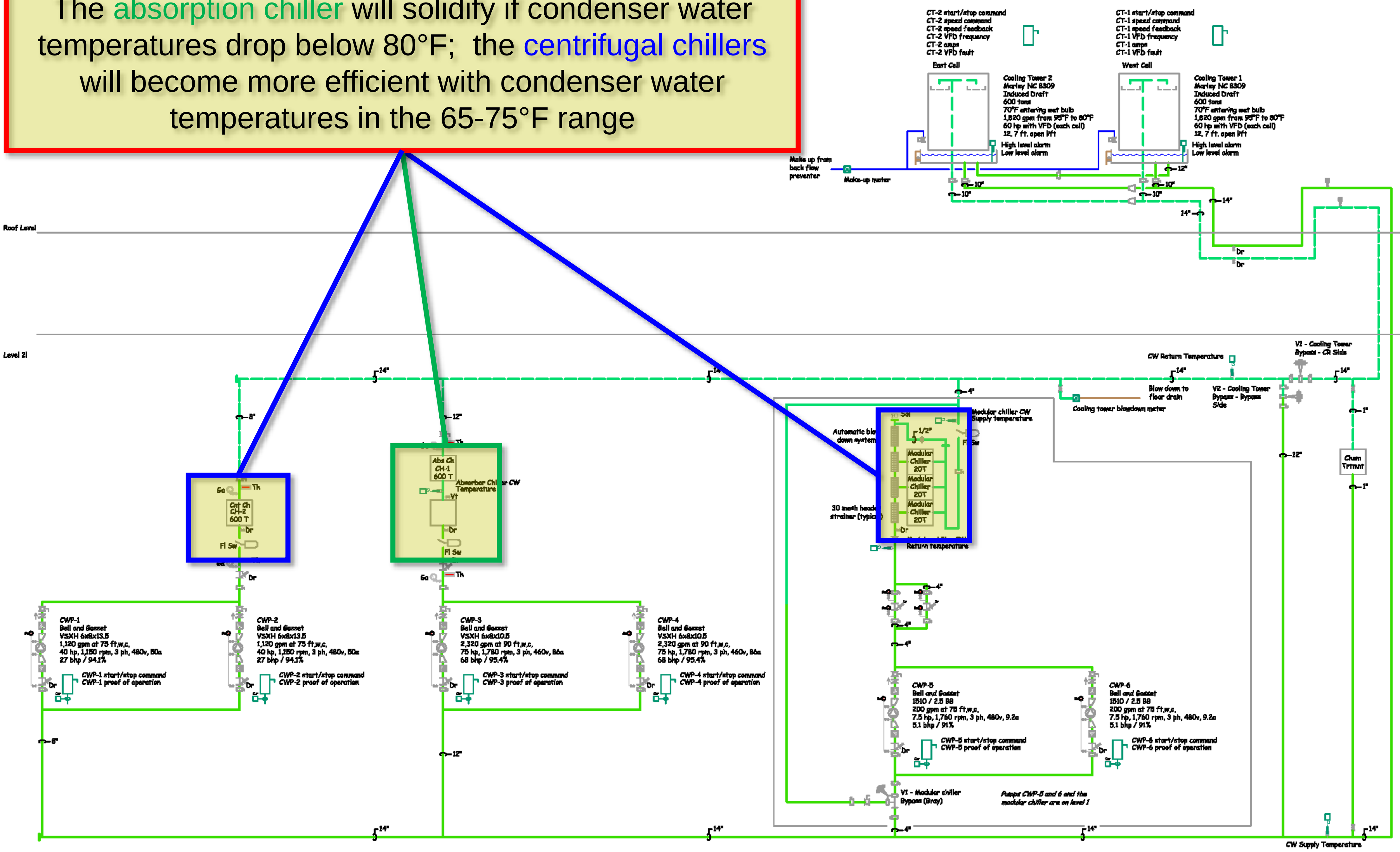
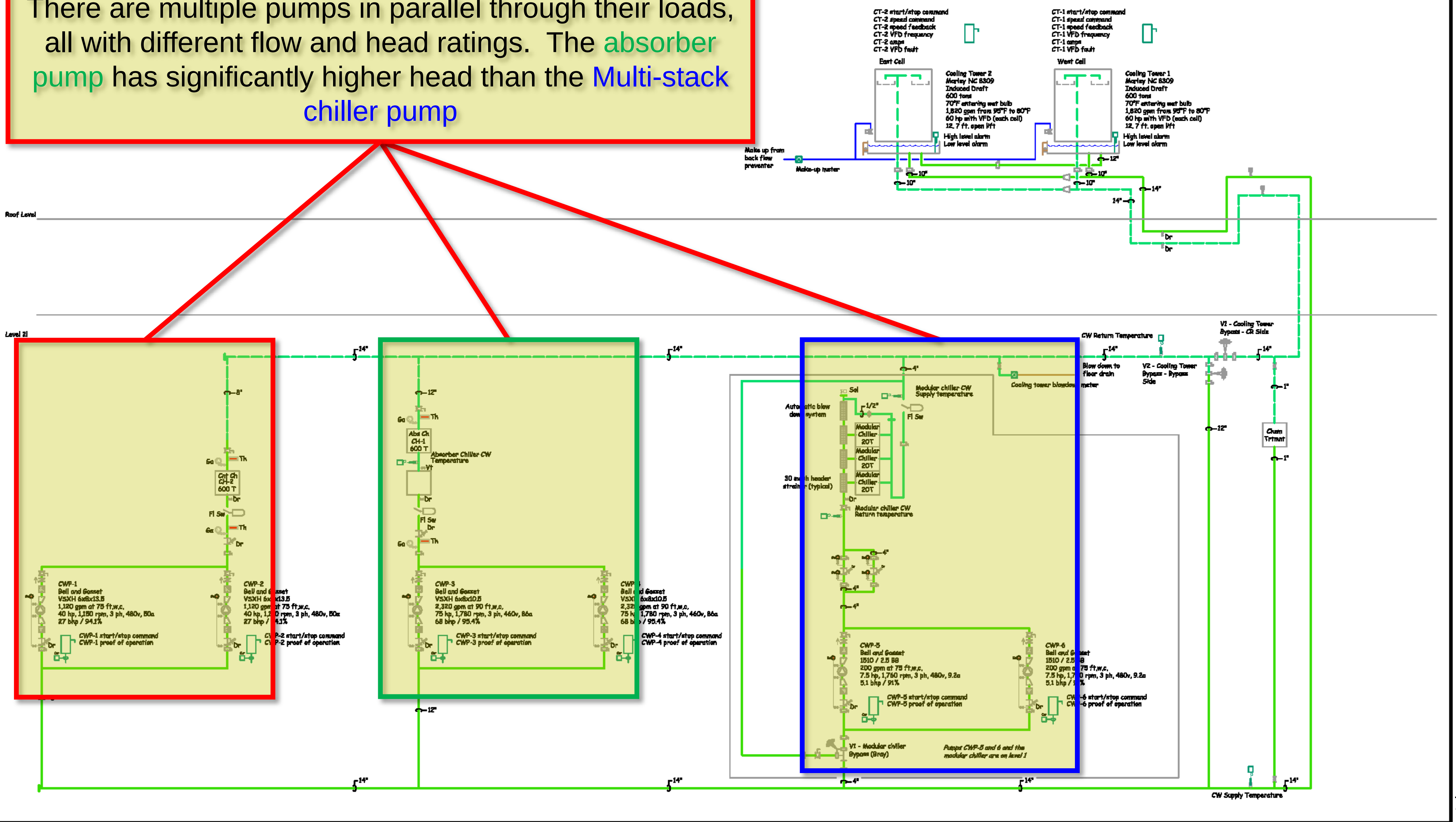
CWP-5 start/stop command
CWP-5 proof of operation
CWP-6
CWP-6 start/stop command
CWP-6 proof of operation
V1 - Modular chiller Bypass (Gray)
Pumps CWP-5 and 6 and the modular chiller are on level 1
Chem Trtmnt
CW Supply Temperature

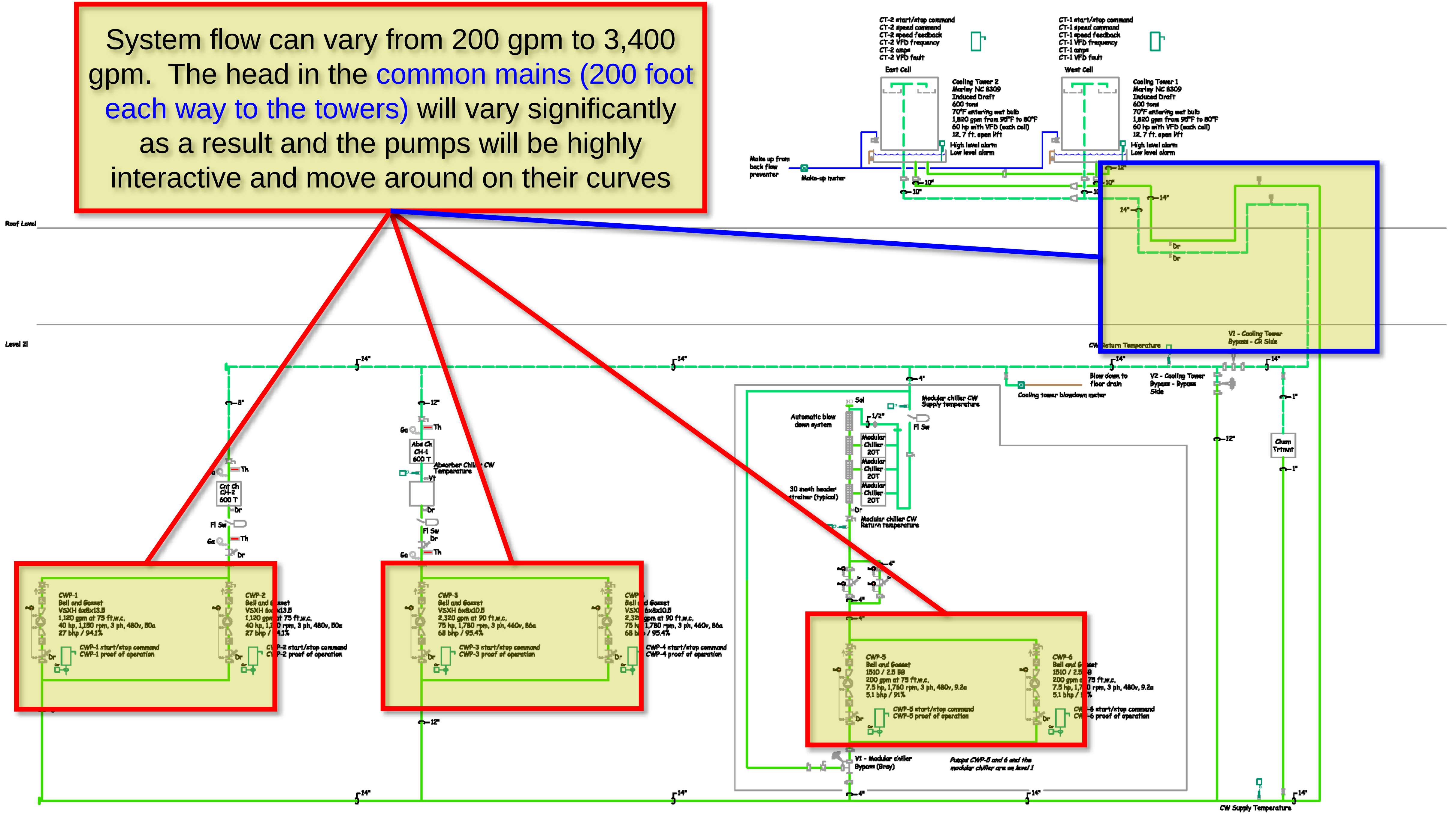
The absorption chiller will solidify if condenser water temperatures drop below 80°F; the centrifugal chillers will become more efficient with condenser water temperatures in the 65-75°F range



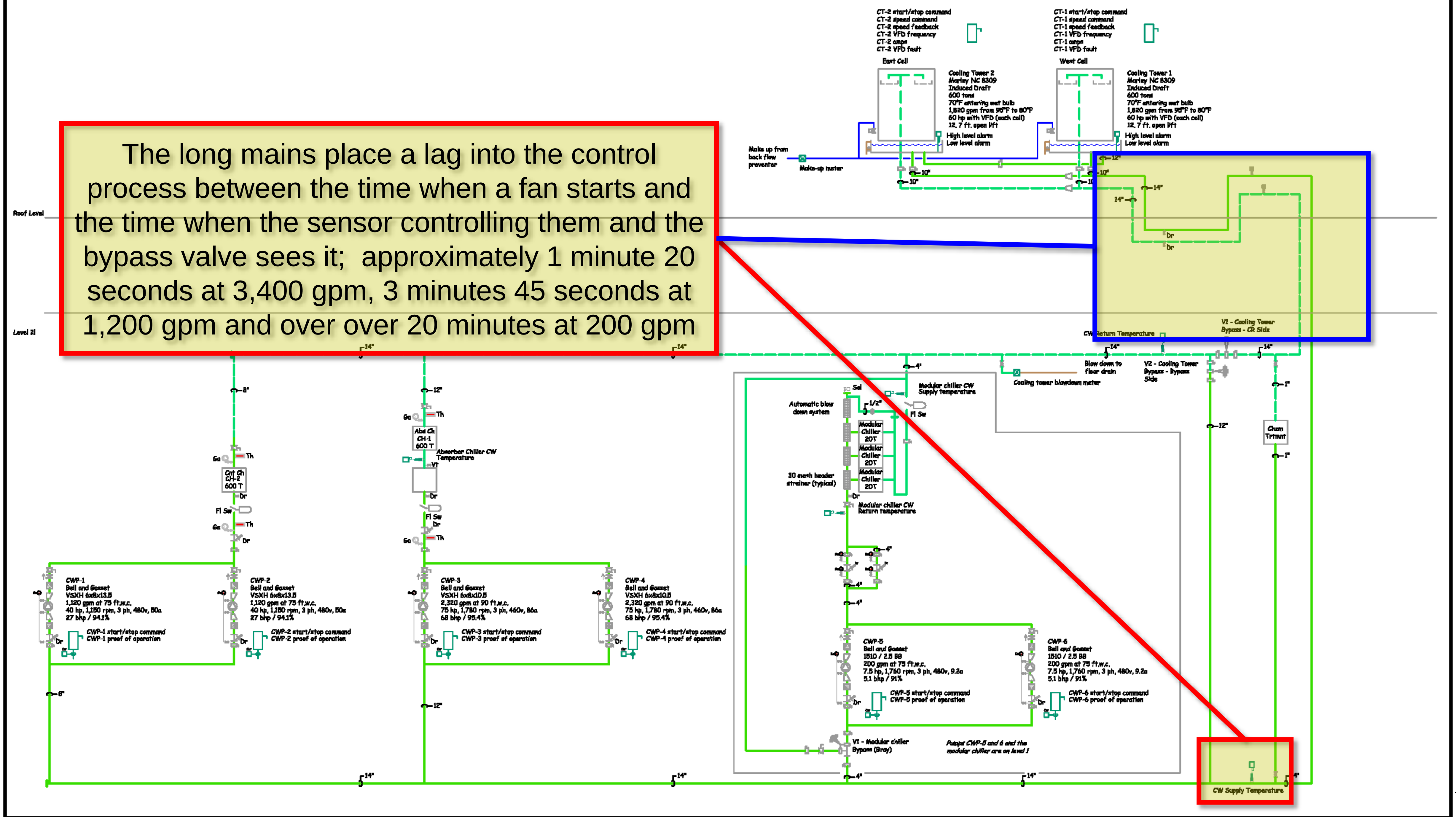
There are multiple pumps in parallel through their loads, all with different flow and head ratings. The absorber pump has significantly higher head than the Multi-stack chiller pump



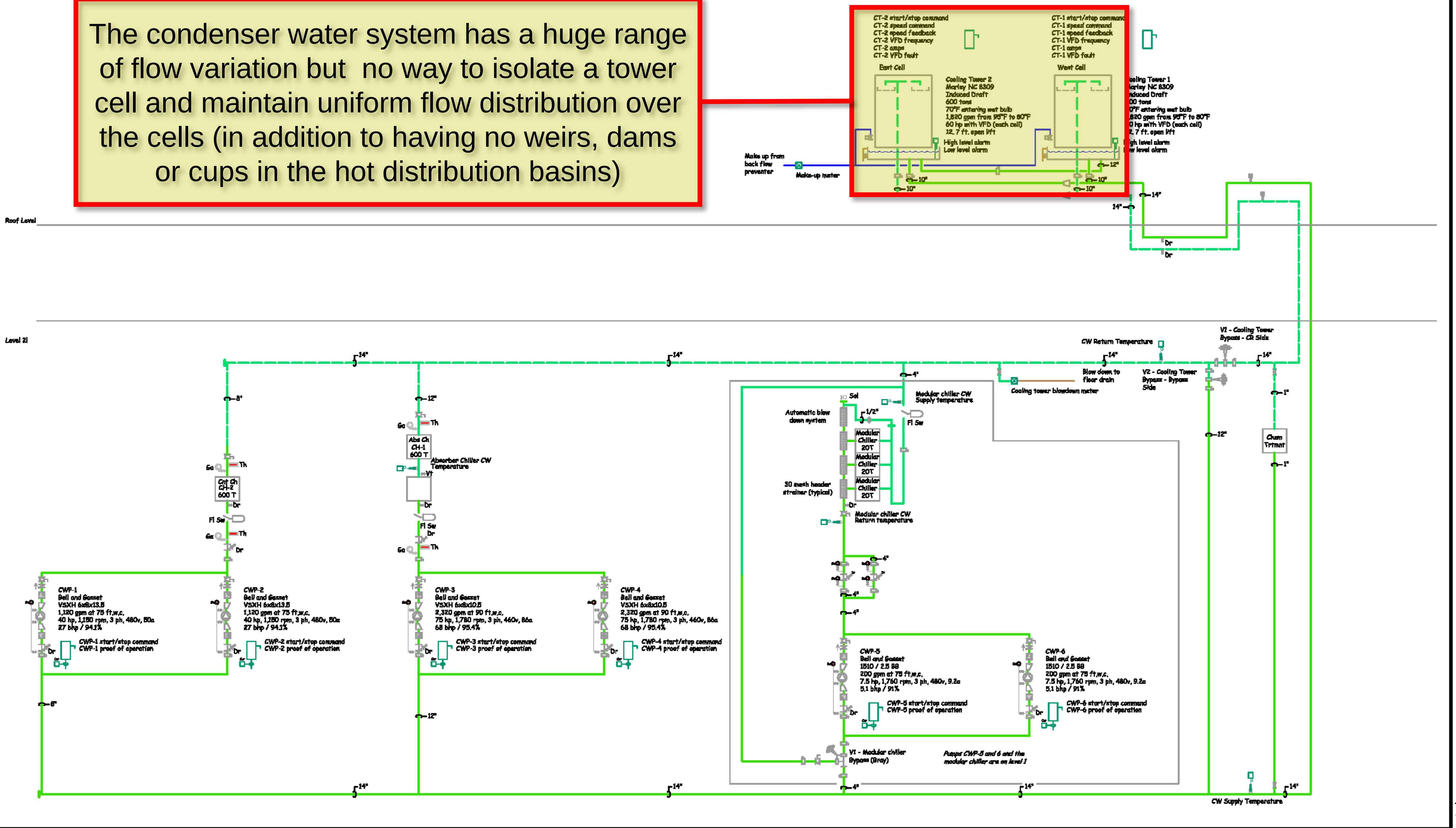
System flow can vary from 200 gpm to 3,400 gpm. The head in the common mains (200 foot each way to the towers) will vary significantly as a result and the pumps will be highly interactive and move around on their curves



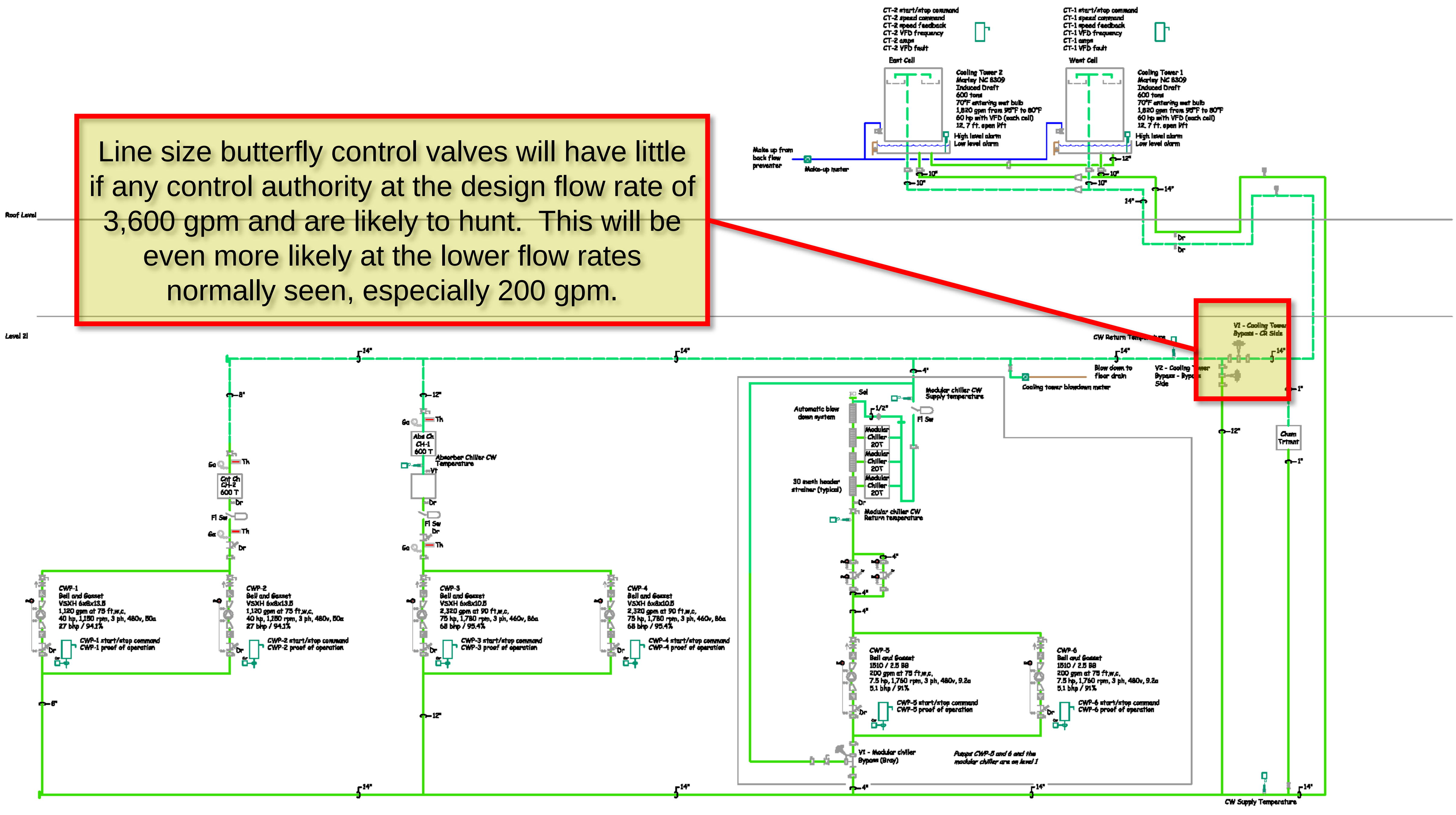
The long mains place a lag into the control process between the time when a fan starts and the time when the sensor controlling them and the bypass valve sees it; approximately 1 minute 20 seconds at 3,400 gpm, 3 minutes 45 seconds at 1,200 gpm and over over 20 minutes at 200 gpm



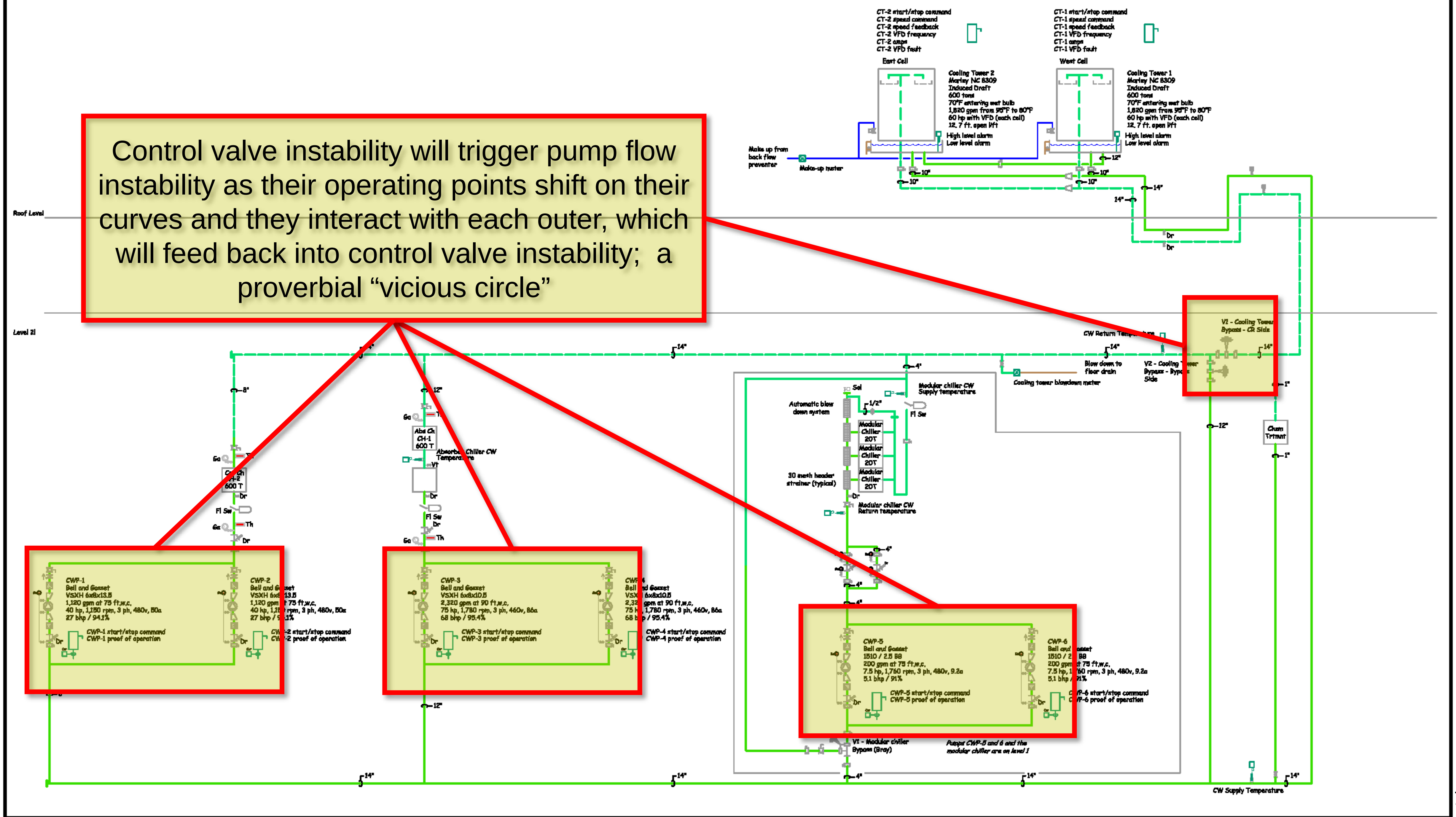
The condenser water system has a huge range of flow variation but no way to isolate a tower cell and maintain uniform flow distribution over the cells (in addition to having no weirs, dams or cups in the hot distribution basins)



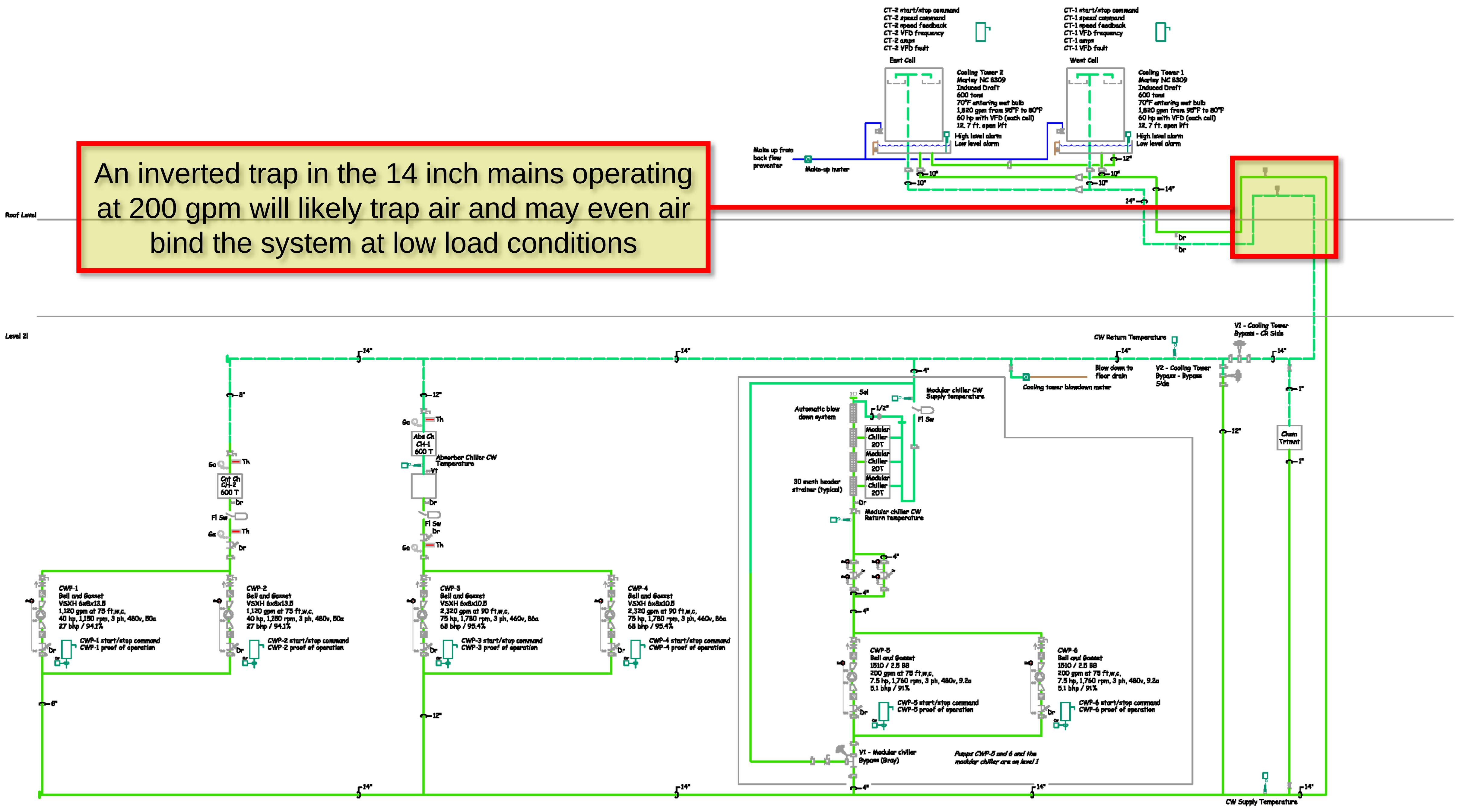
Line size butterfly control valves will have little if any control authority at the design flow rate of 3,600 gpm and are likely to hunt. This will be even more likely at the lower flow rates normally seen, especially 200 gpm.



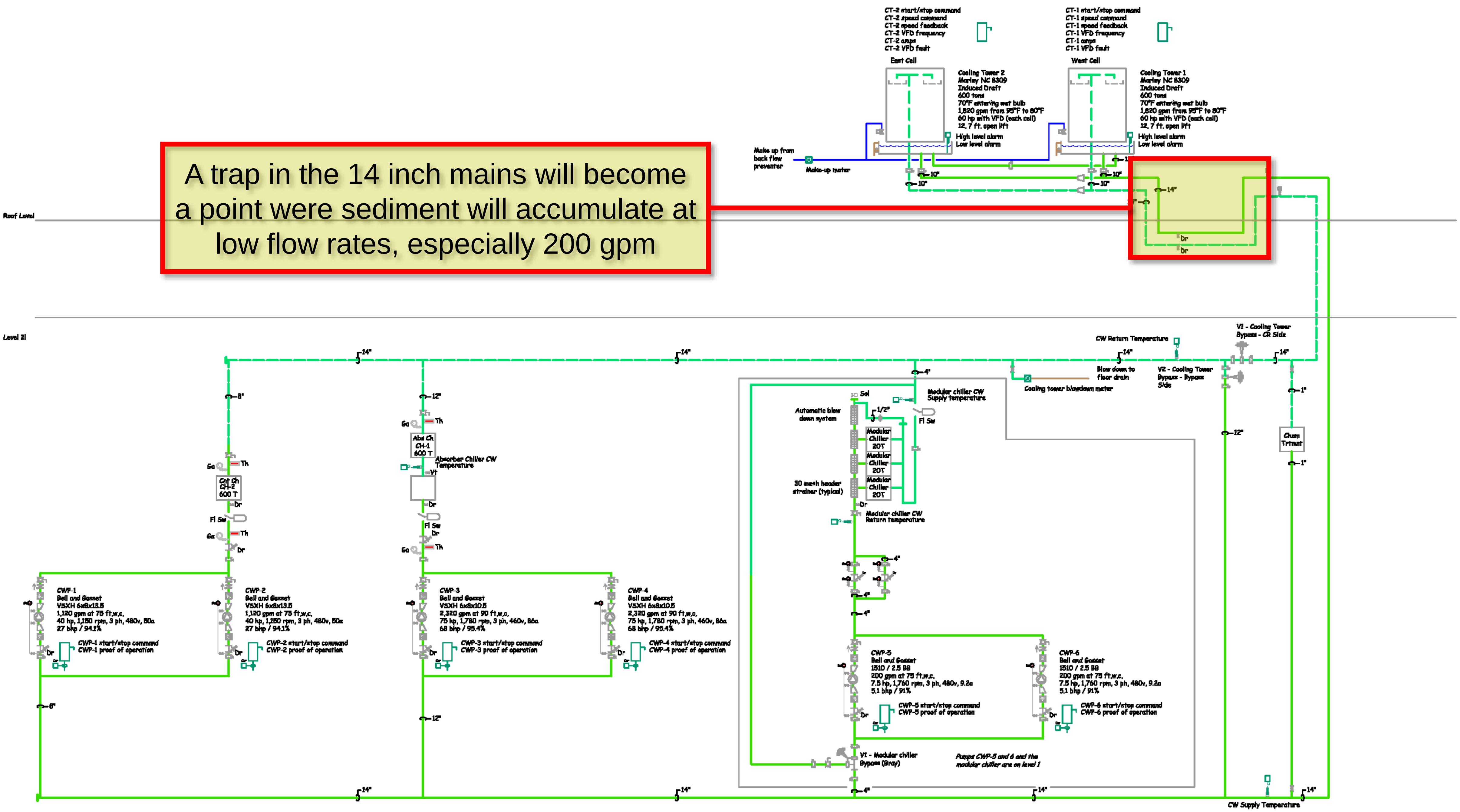
Control valve instability will trigger pump flow instability as their operating points shift on their curves and they interact with each outer, which will feed back into control valve instability; a proverbial “vicious circle”



An inverted trap in the 14 inch mains operating at 200 gpm will likely trap air and may even air bind the system at low load conditions

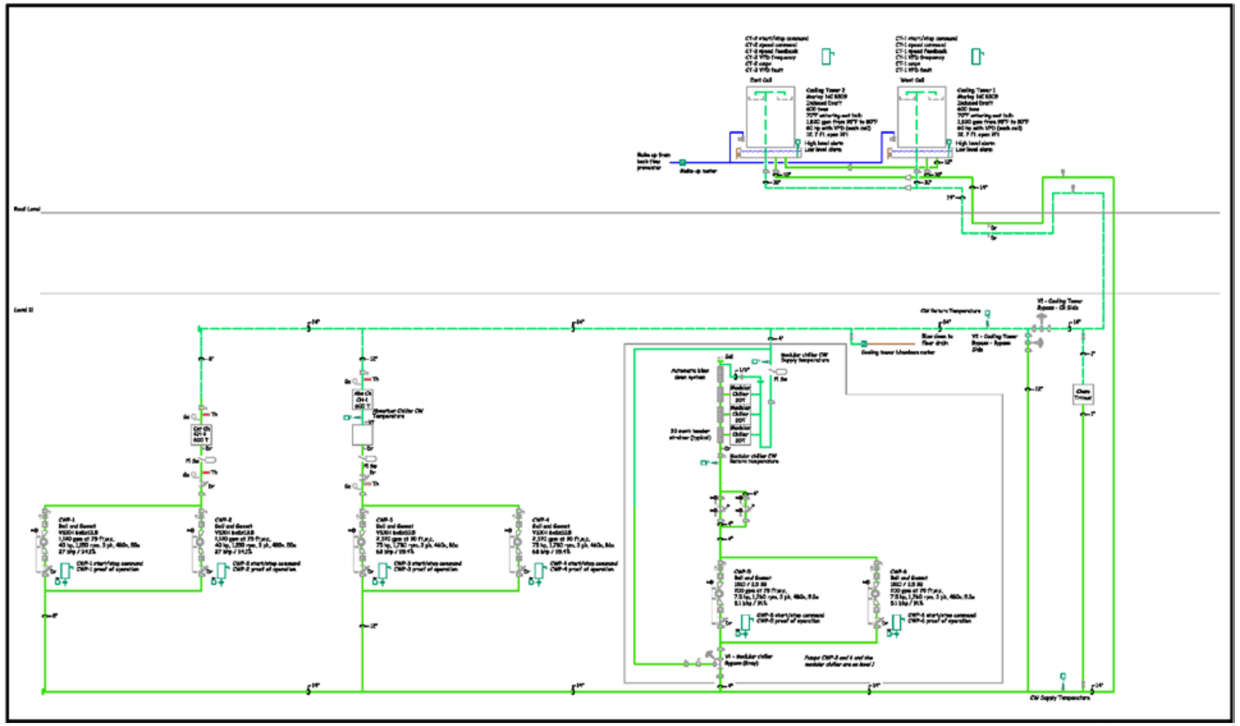


A trap in the 14 inch mains will become a point were sediment will accumulate at low flow rates, especially 200 gpm



Developing a System Diagram

- A good way to learn the system prior to going on site
- Focusing on one system can be helpful
- “Untangling” can be helpful
- A good way to spot problems
- Once field verified, it’s a valuable commissioning resource

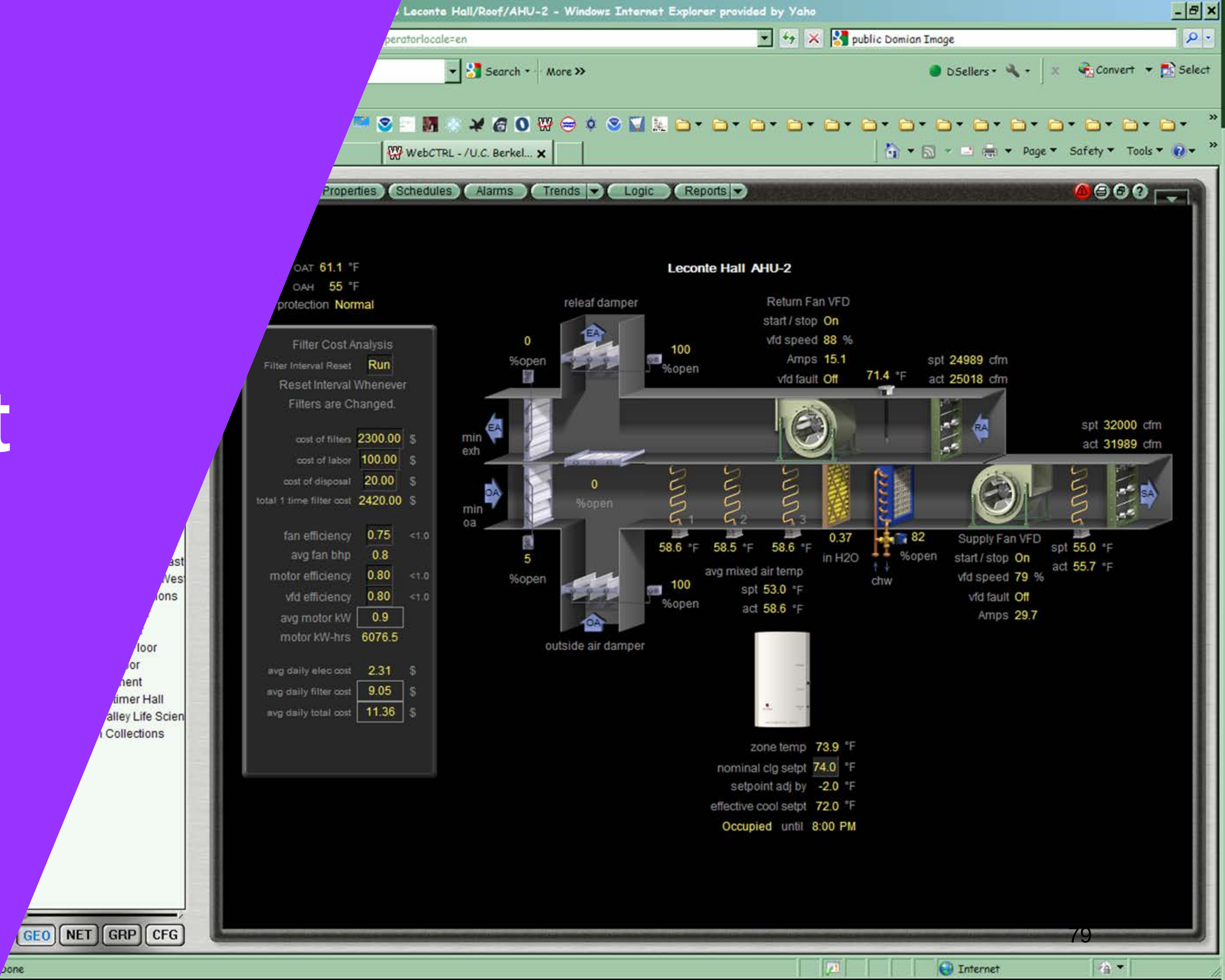


My “System Diagram” for the Condenser Water System

A Resource for Learning to Do System Diagrams

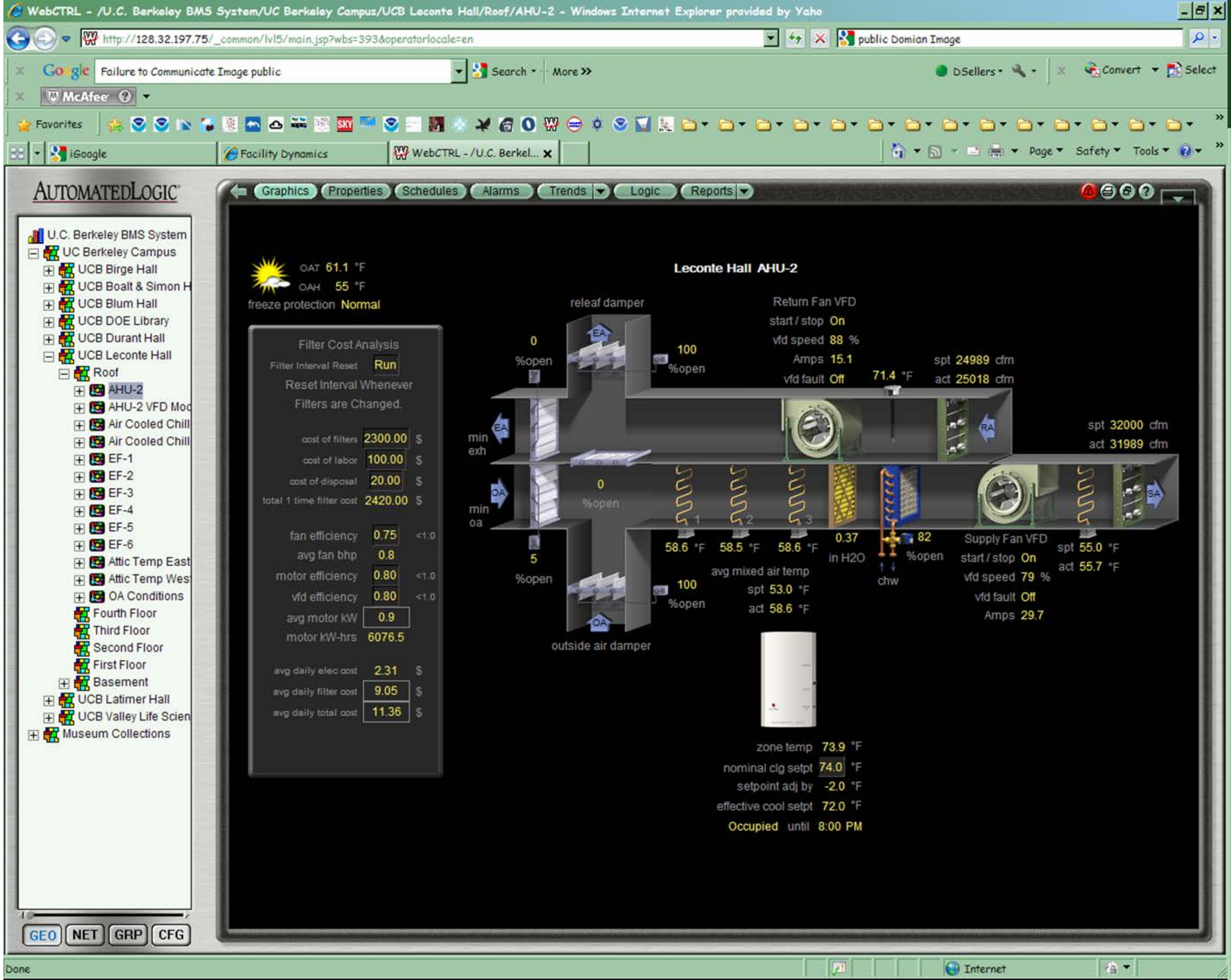
https://av8rdas.wordpress.com/category/system-diagrams/

Heading Out to Test



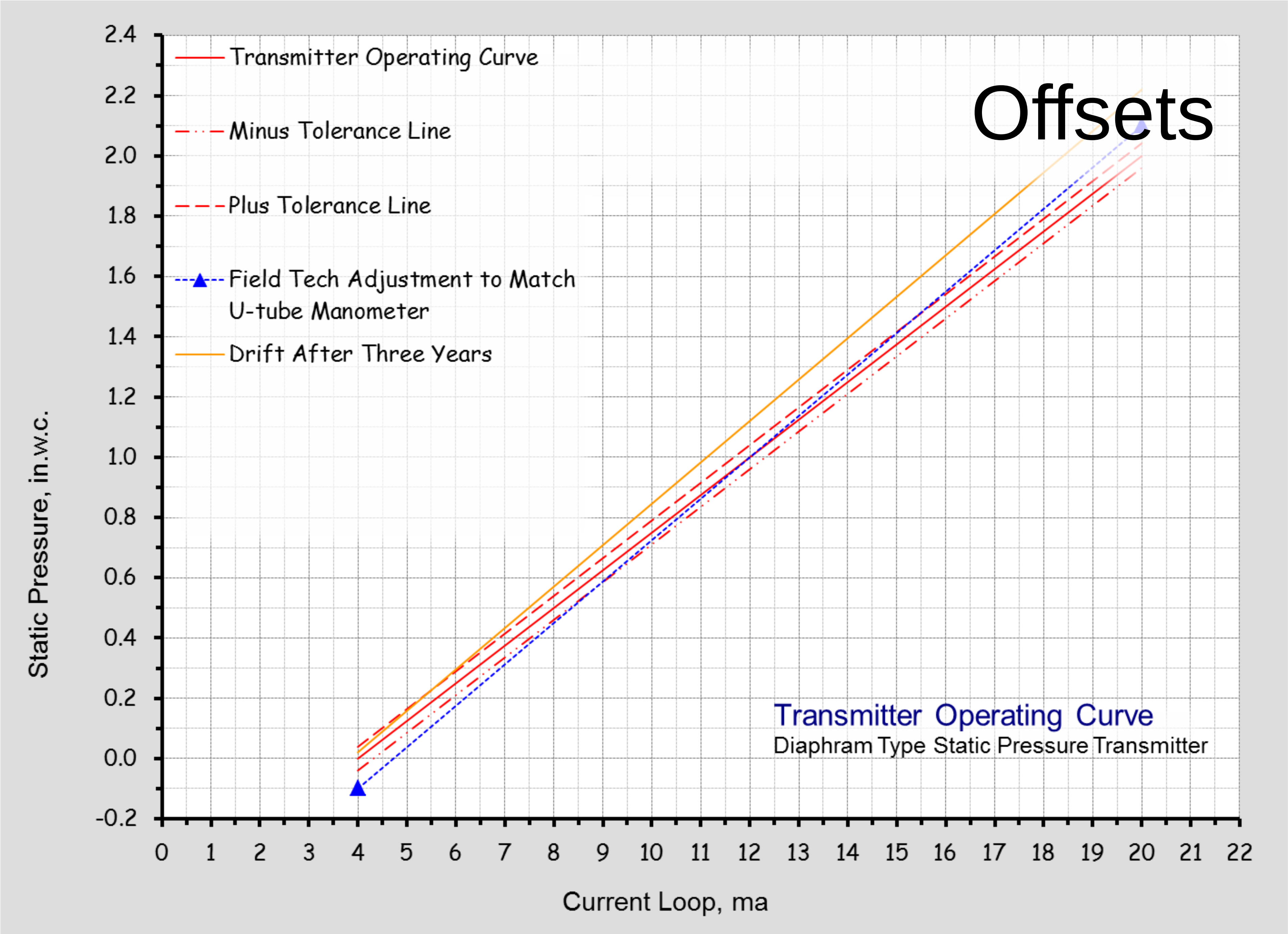
Is the System Ready?

- The control system is the first step in commissioning the *controlled* system
- Is it the control system remotely accessible?
- Is control vendor ready?
  - Point to point checks complete
  - Software verified

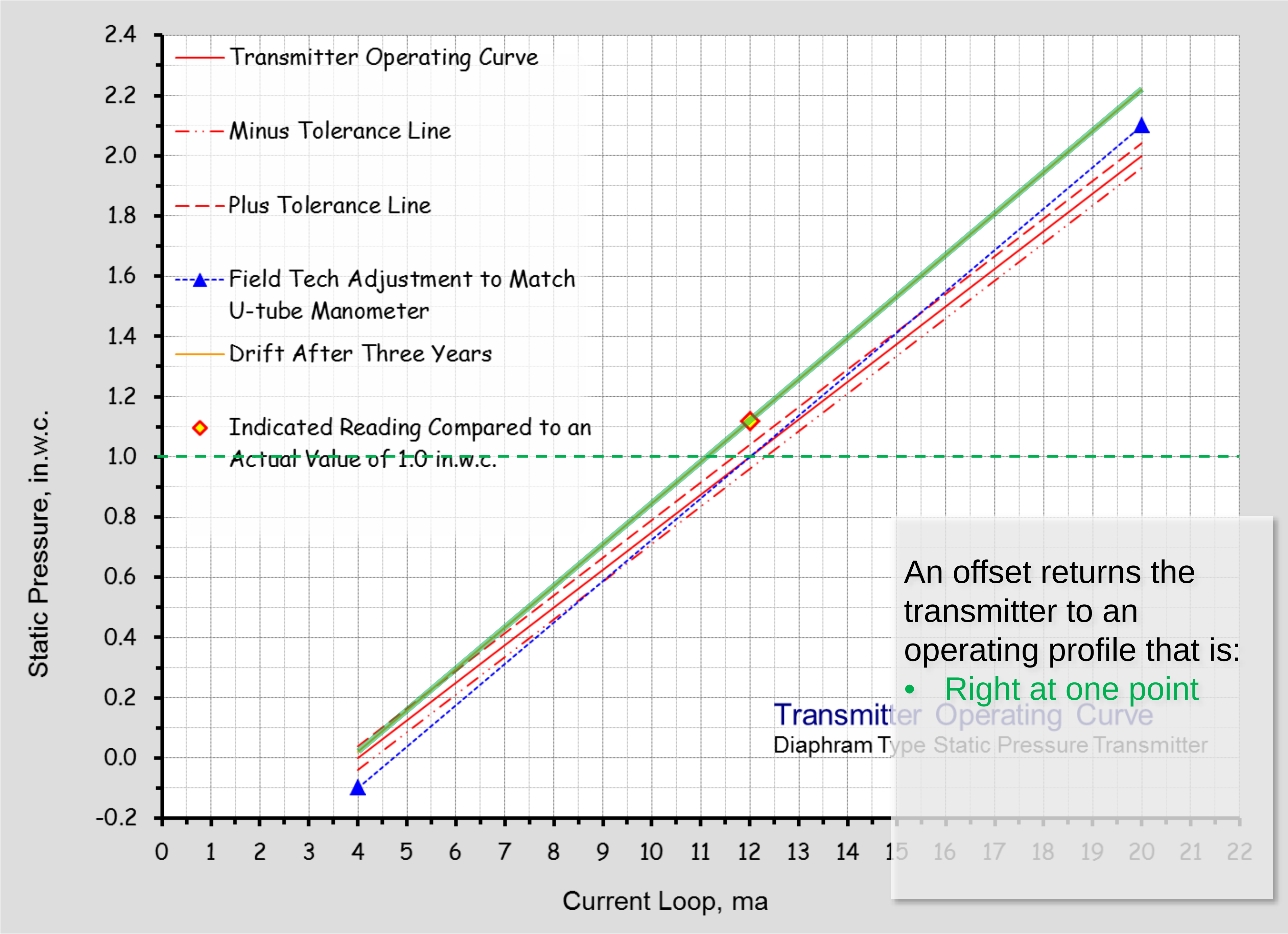


Calibration and Point to Point Checks

Offsets

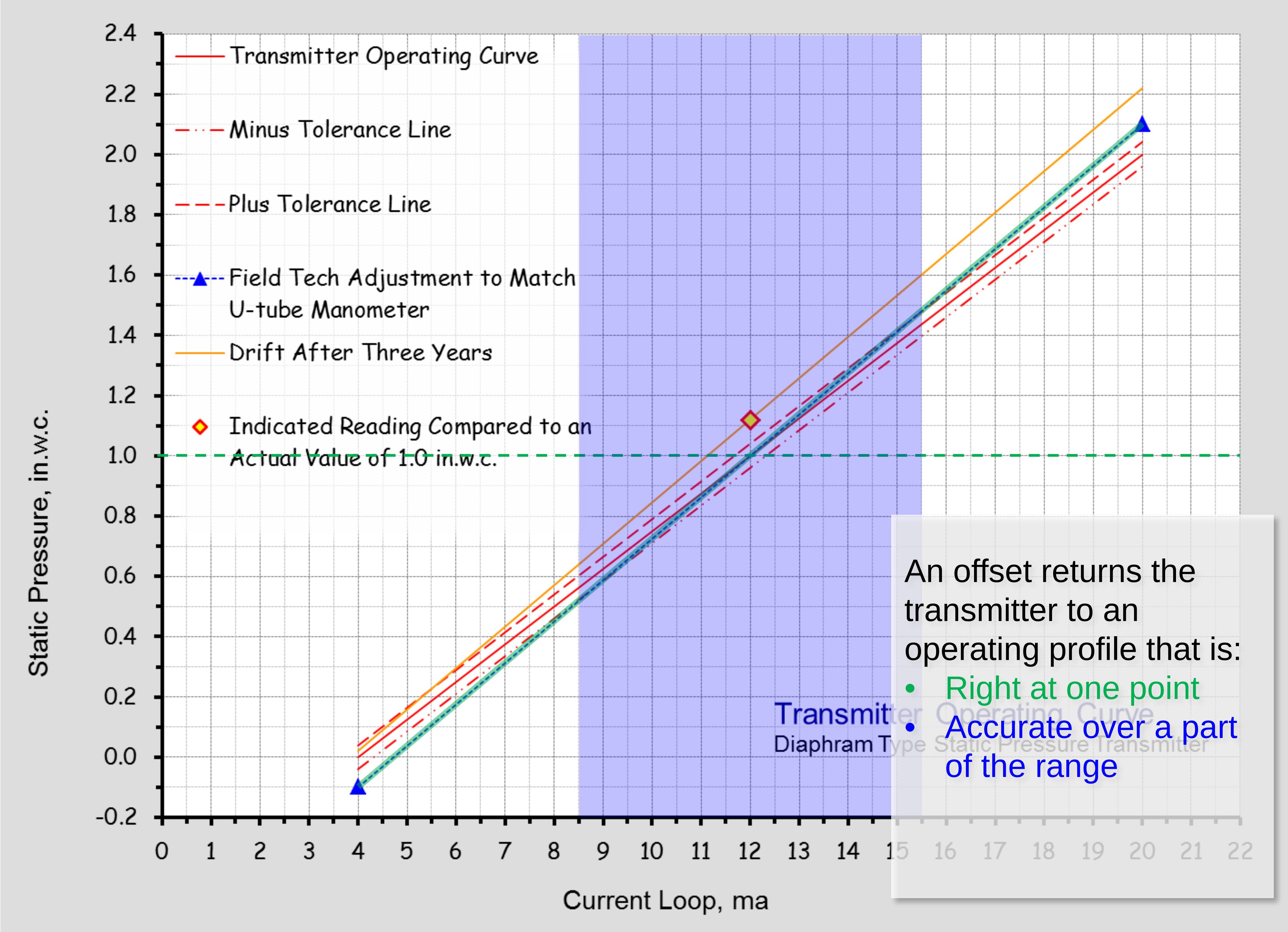


Transmitter Operating Curve
Minus Tolerance Line
Plus Tolerance Line
Field Tech Adjustment to Match U-tube Manometer
Drift After Three Years
Transmitter Operating Curve
Diaphram Type Static Pressure Transmitter
Static Pressure, in.w.c.
Current Loop, ma
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22



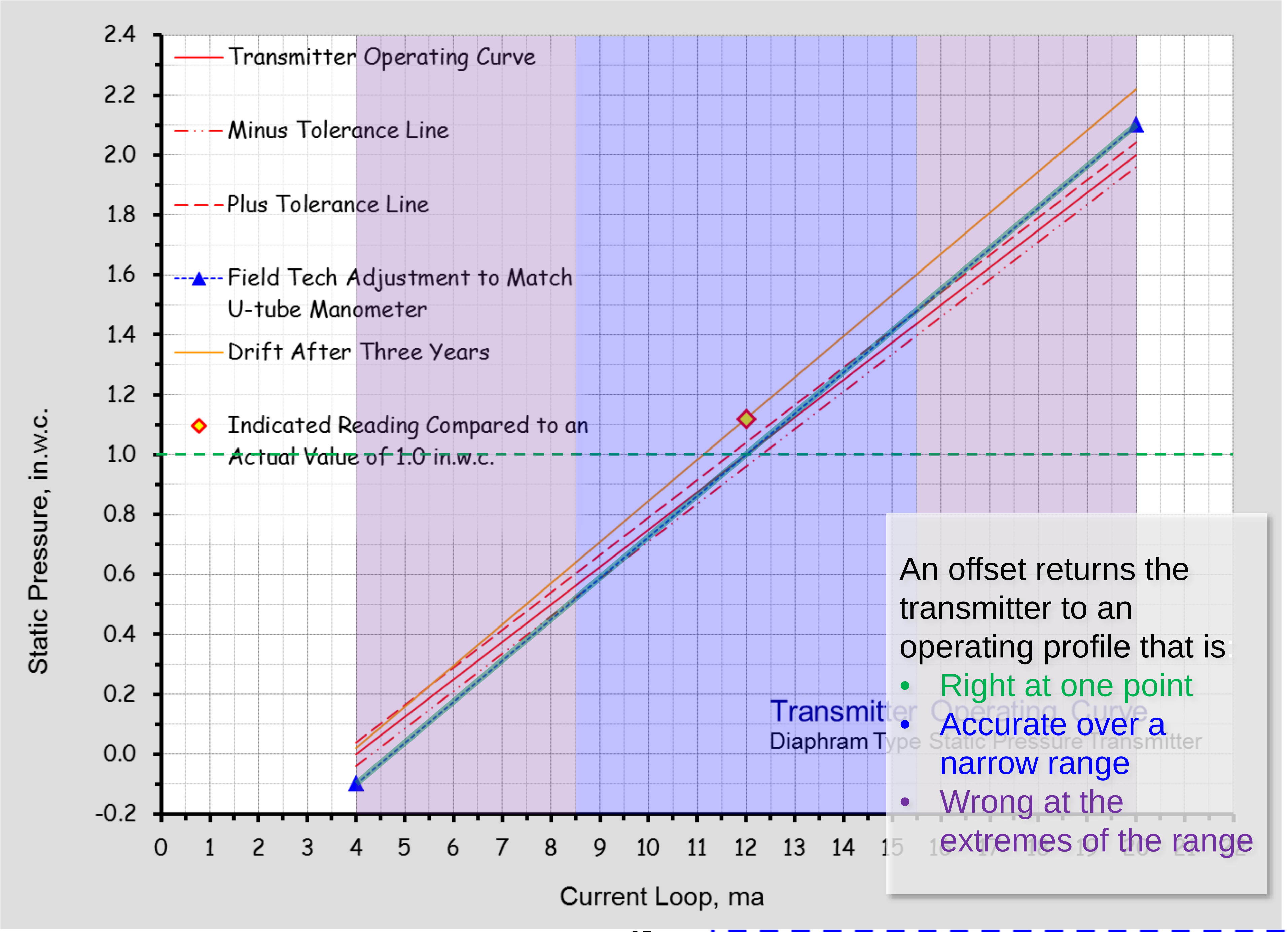
An offset returns the transmitter to an operating profile that is:

- Right at one point



An offset returns the transmitter to an operating profile that is:

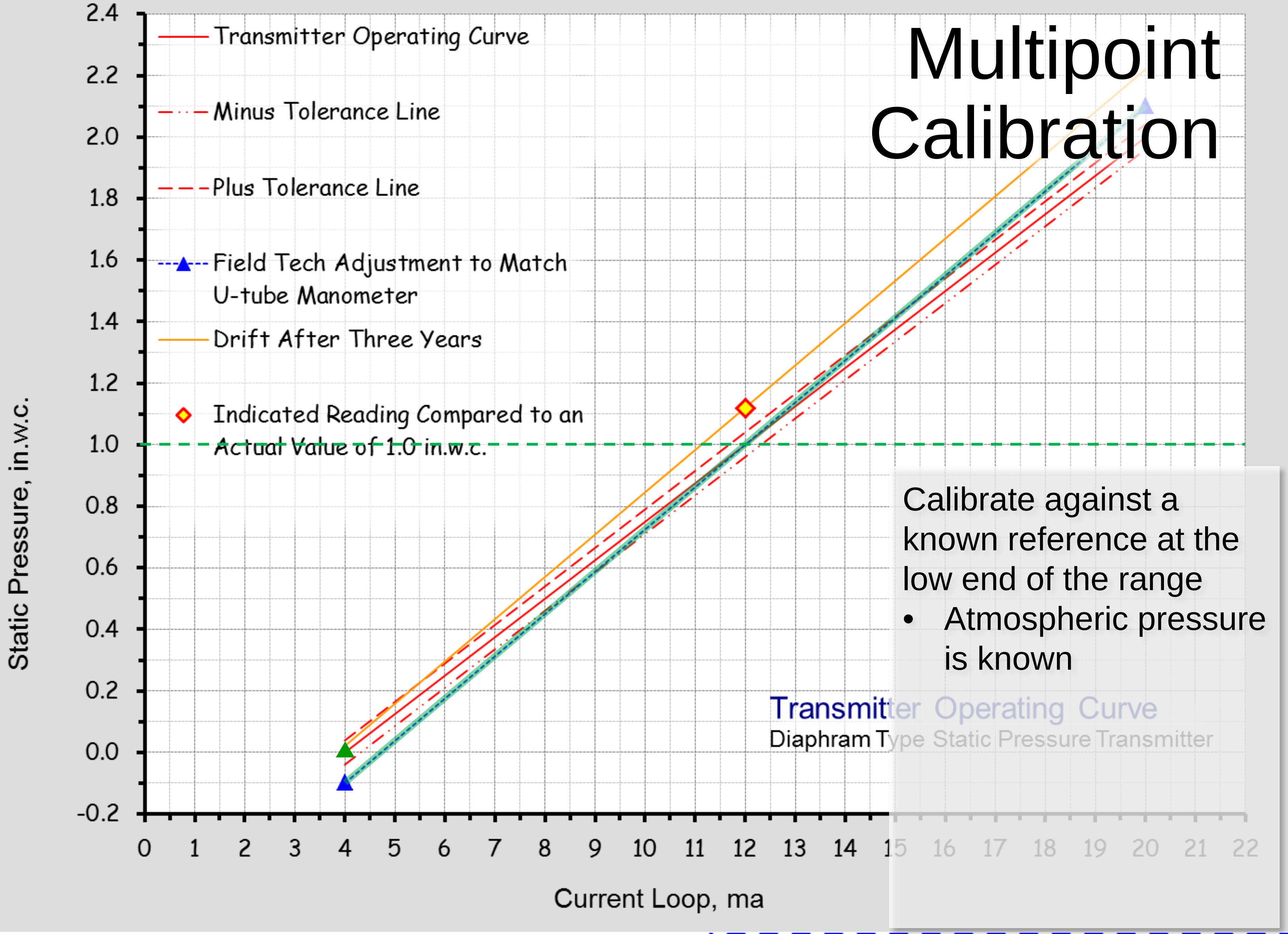
- Right at one point
- Accurate over a part of the range



An offset returns the transmitter to an operating profile that is

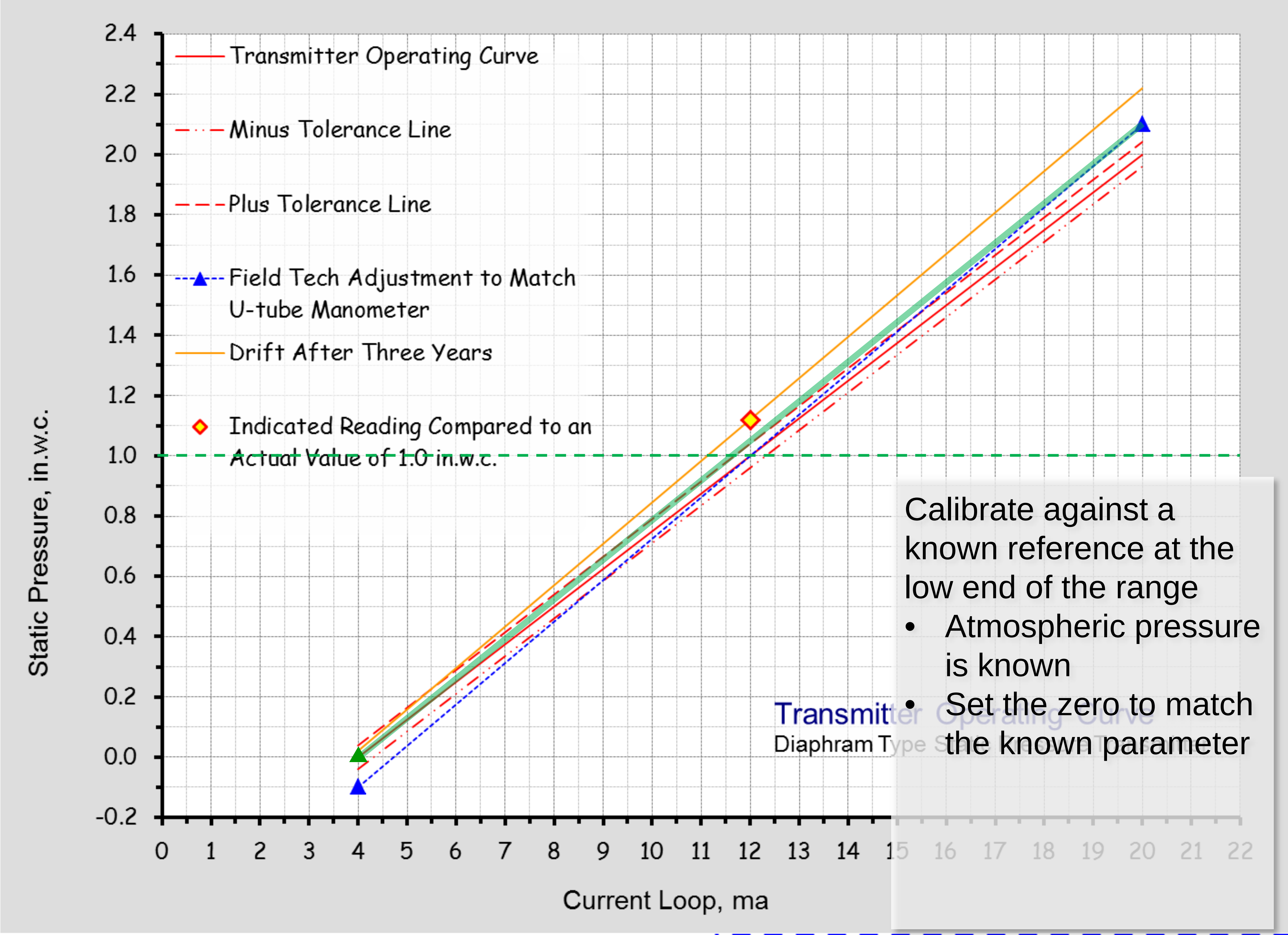
- Right at one point
- Accurate over a narrow range
- Wrong at the extremes of the range

Multipoint Calibration



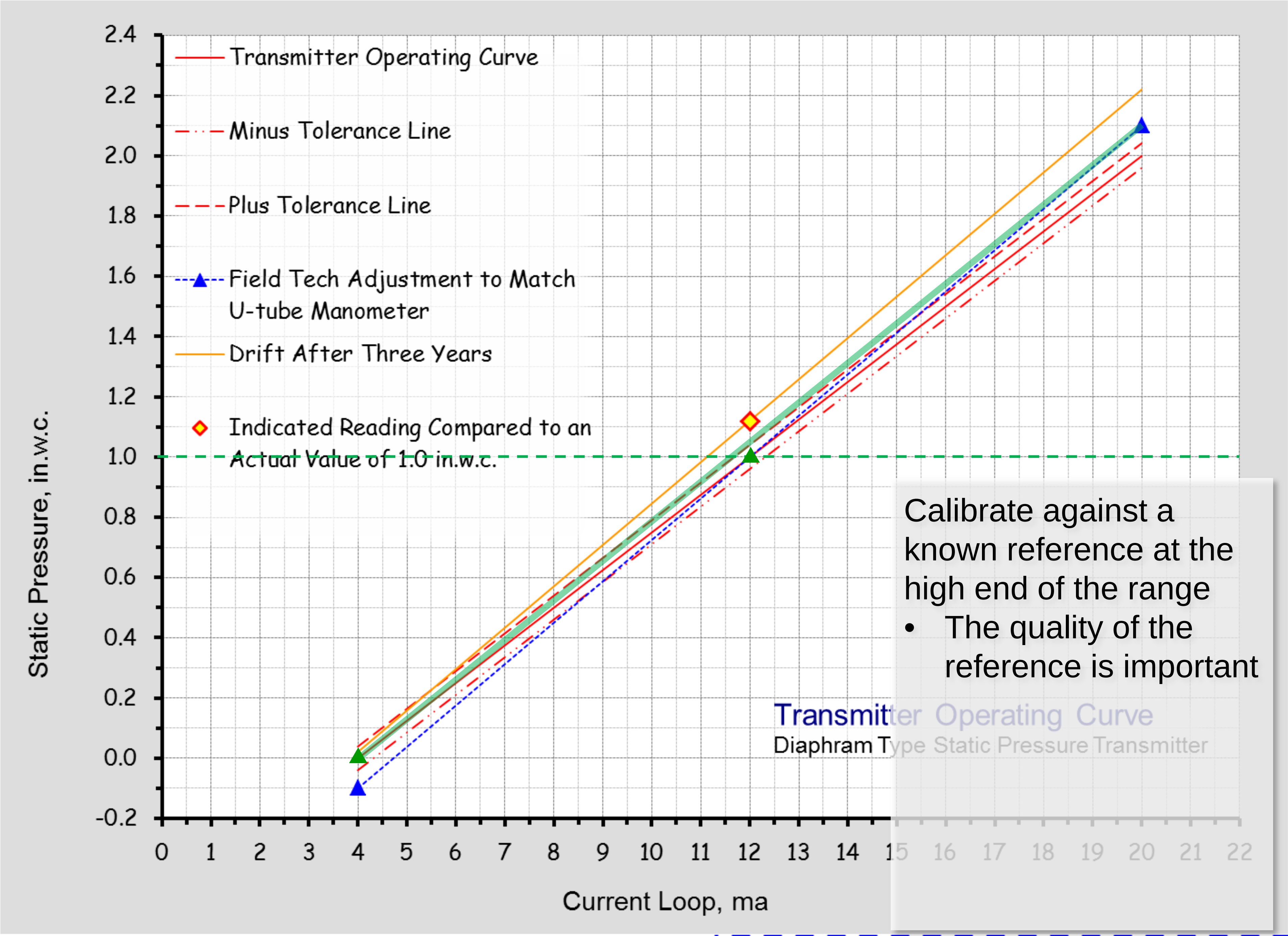
Calibrate against a known reference at the low end of the range

- Atmospheric pressure is known



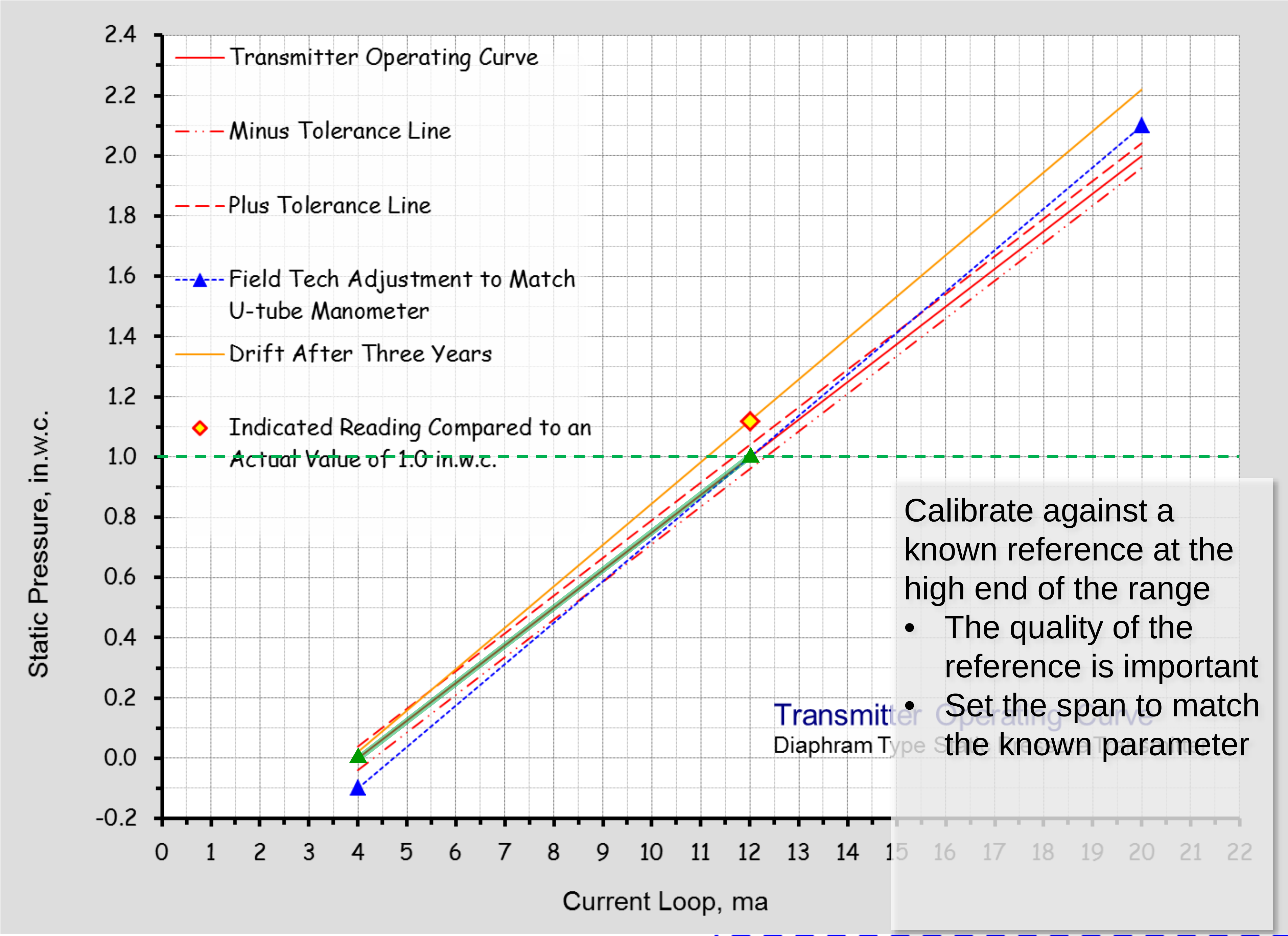
Calibrate against a known reference at the low end of the range

- Atmospheric pressure is known
- Set the zero to match the known parameter



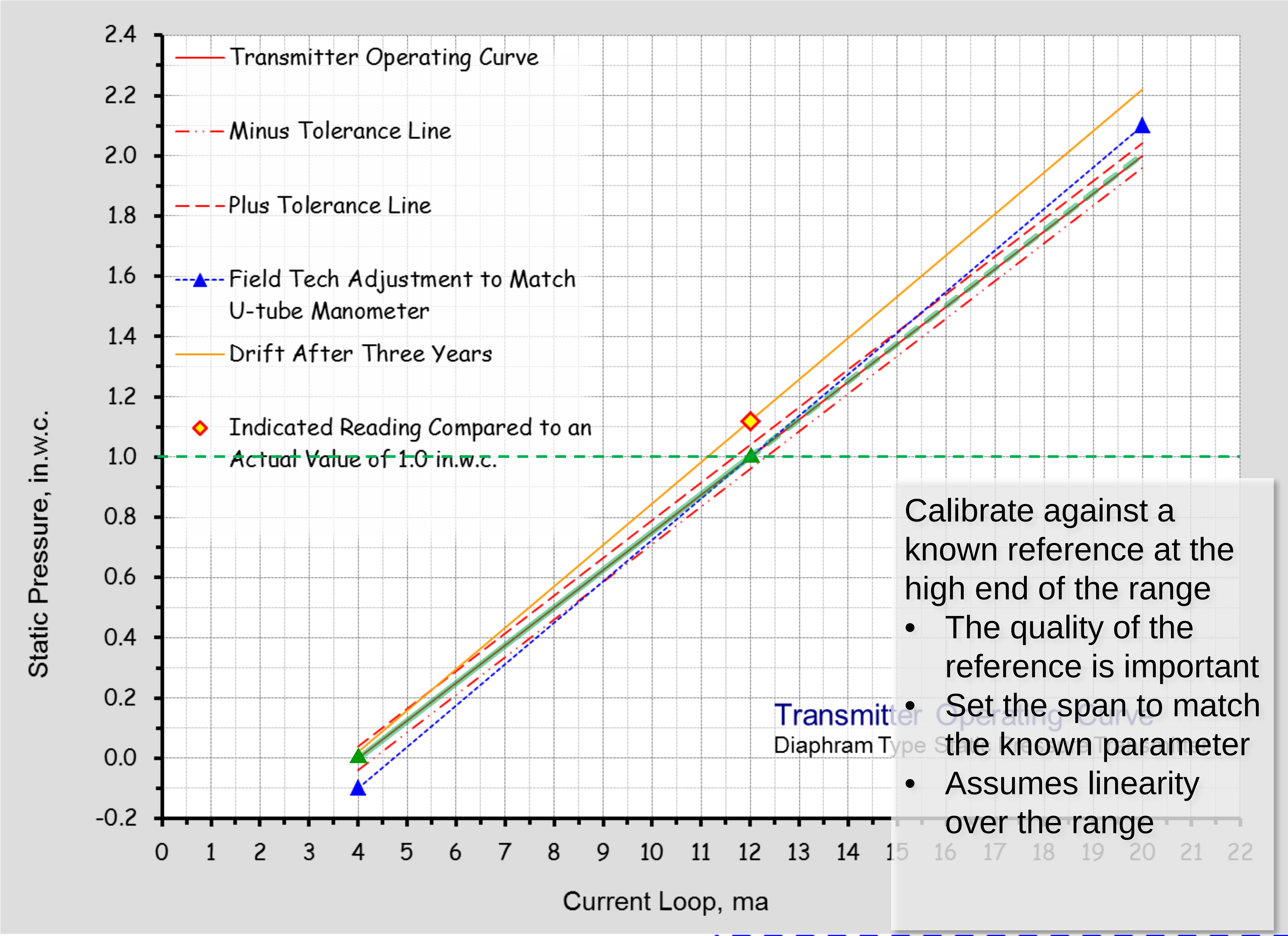
Calibrate against a known reference at the high end of the range

- The quality of the reference is important



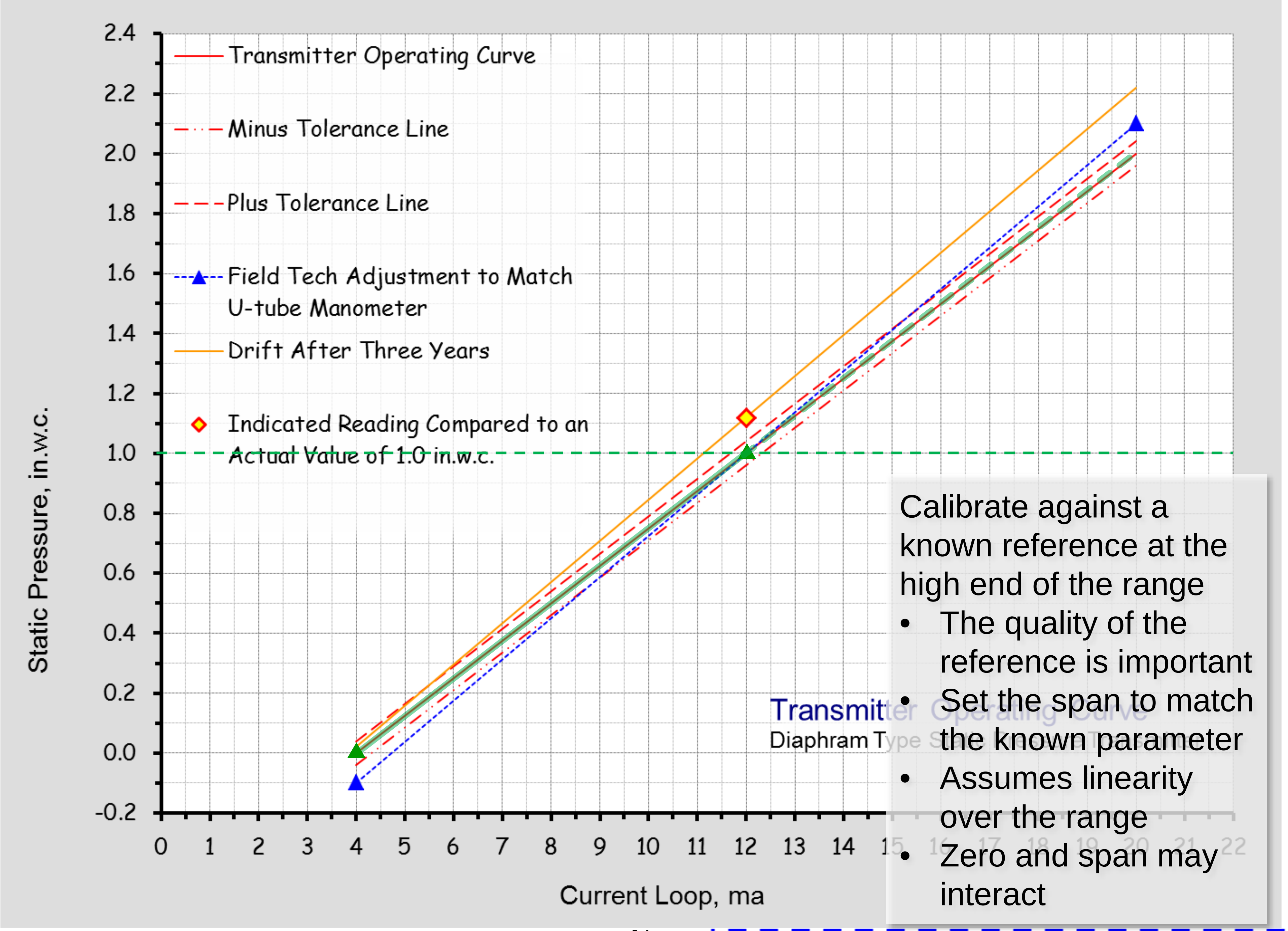
Calibrate against a known reference at the high end of the range

- The quality of the reference is important
- Set the span to match the known parameter



Calibrate against a known reference at the high end of the range

- The quality of the reference is important
- Set the span to match the known parameter
- Assumes linearity over the range



Calibrate against a known reference at the high end of the range

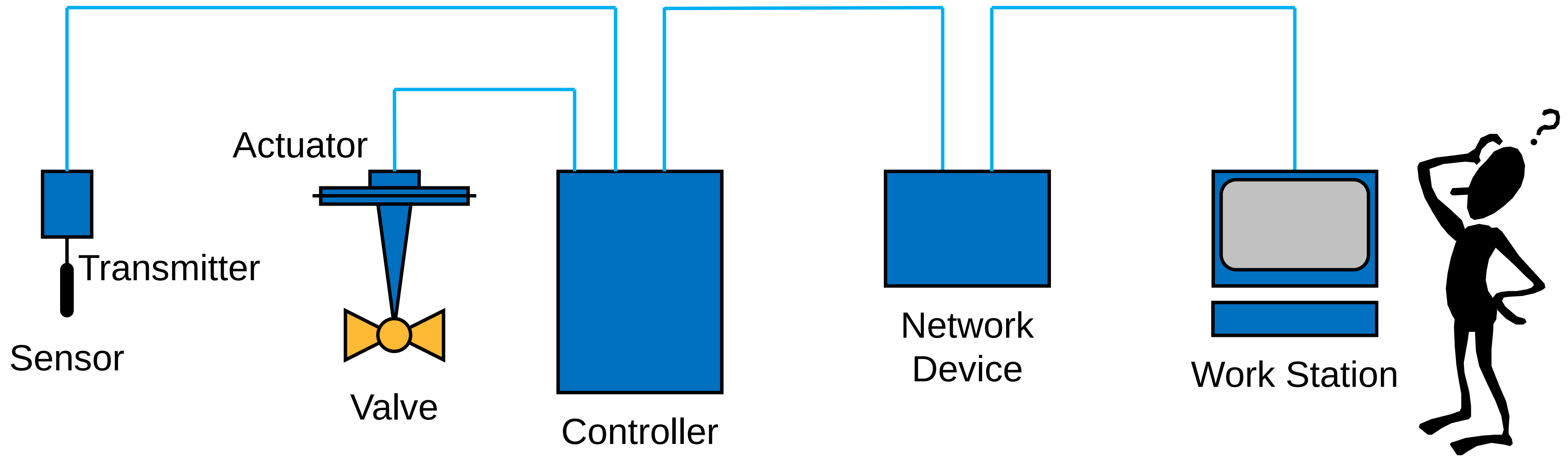
- The quality of the reference is important
- Set the span to match the known parameter
- Assumes linearity over the range
- Zero and span may interact

What You See is What You Get;

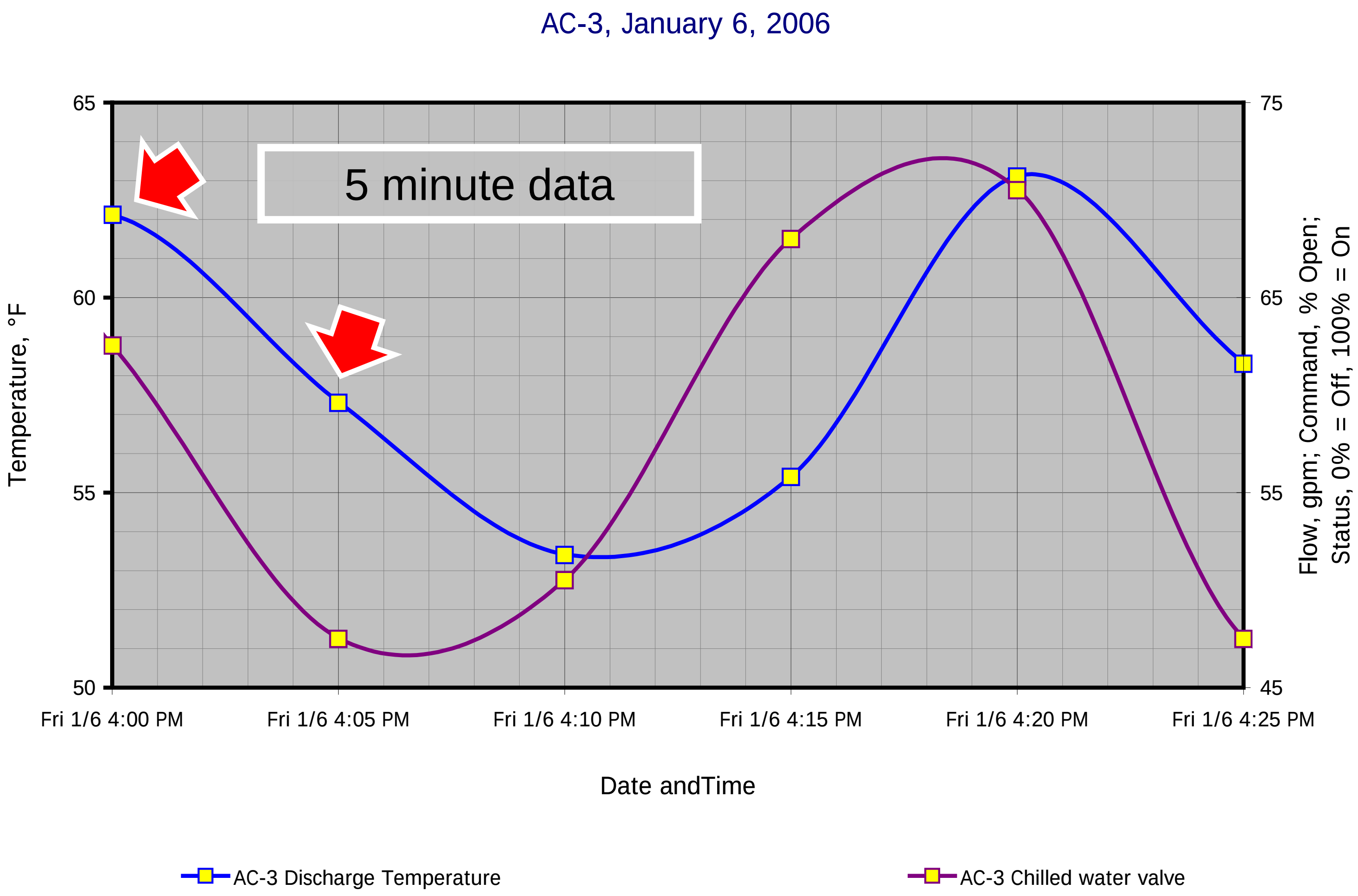
Maybe …

… or maybe not

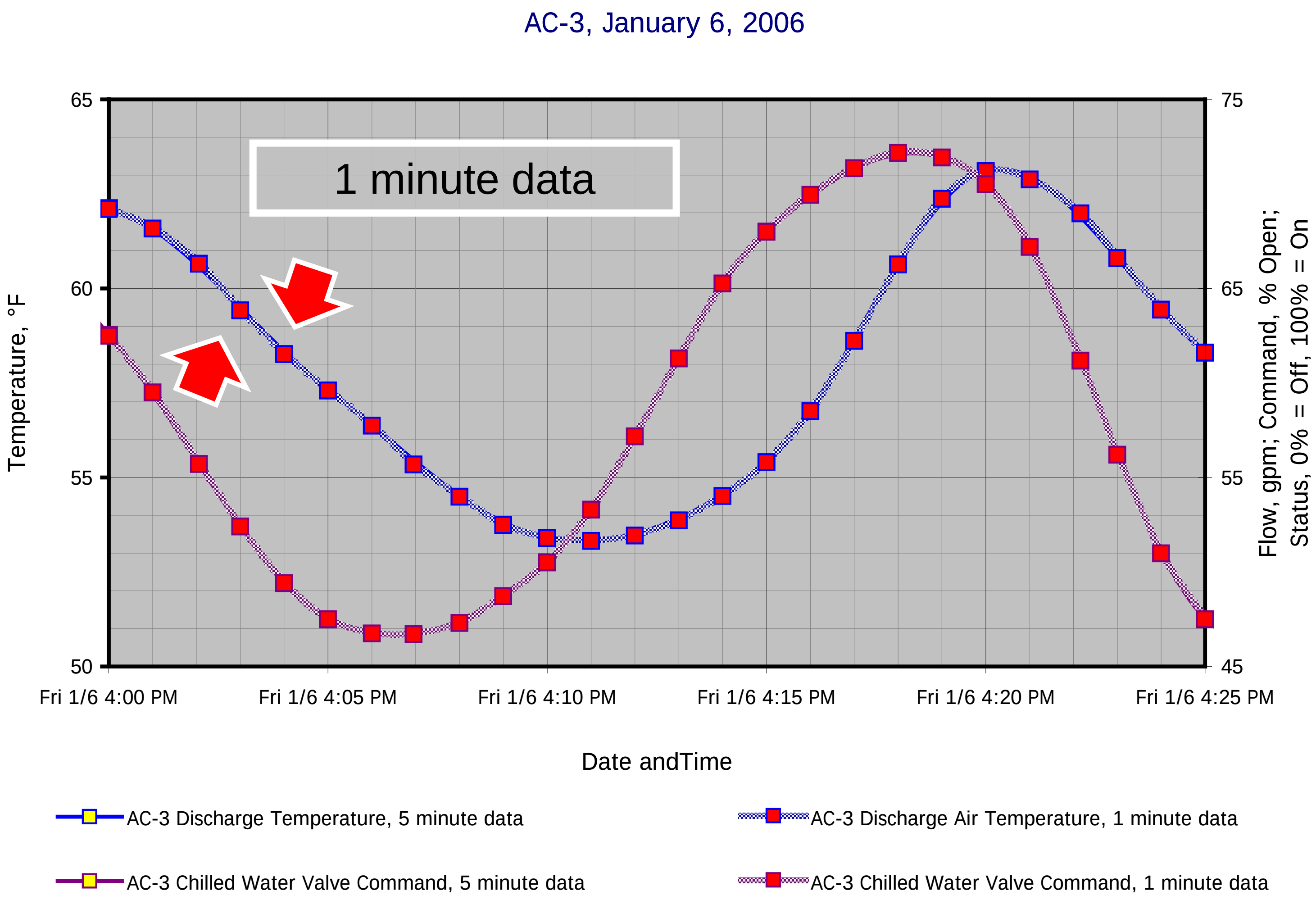
- There are many elements between the sensor and the observer and the observer and the actuator
- All of them can impact accuracy, precision, and performance



What You Sense is What You Get;

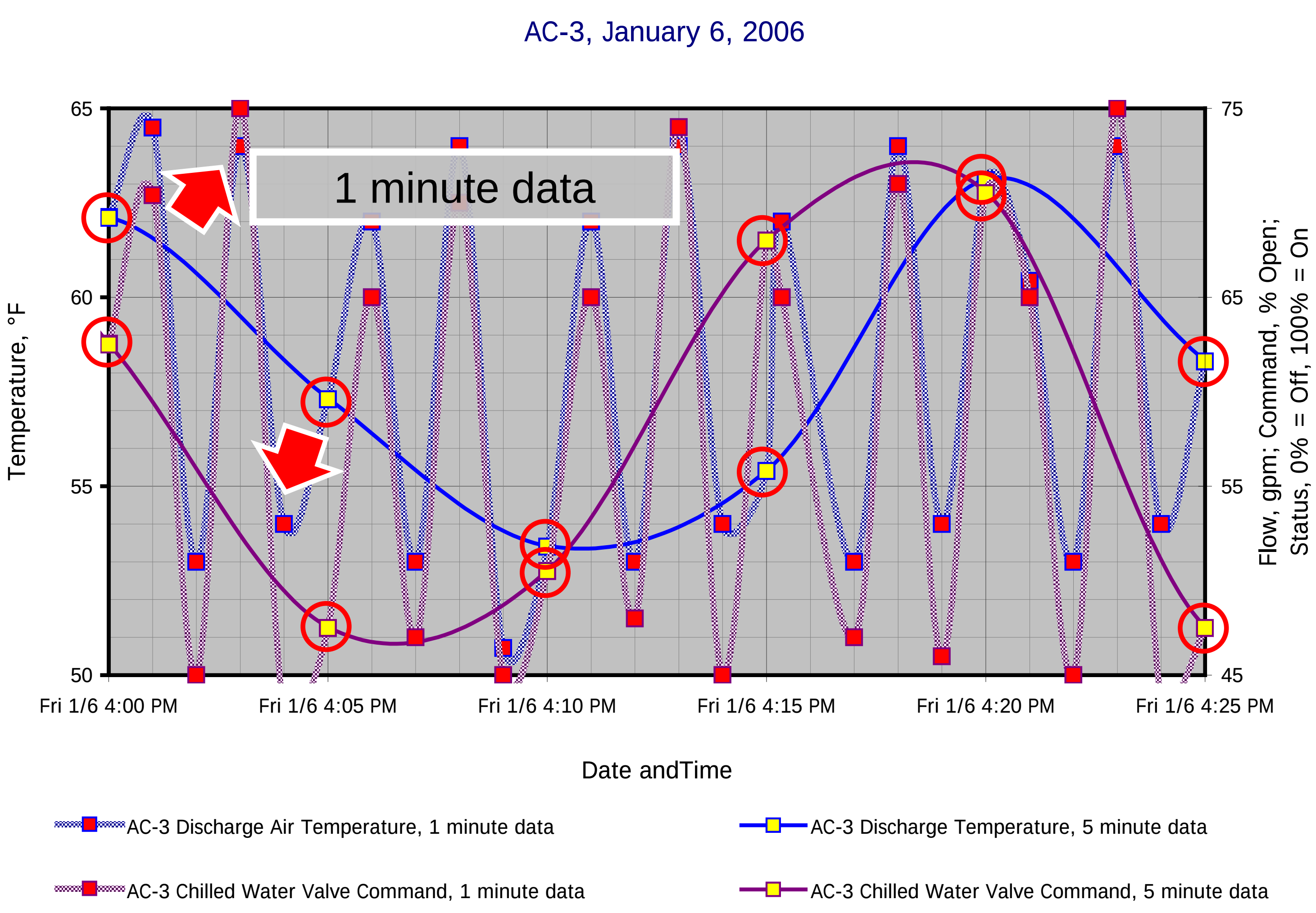


What You Sense is What You Get;
Maybe …



What You Sense is What You Get;

Or Maybe Not!



The Nyquist Theorem a.k.a the Sampling Theorem

How Fast is Fast Enough

$$f_s \geq 2 \times f_c$$

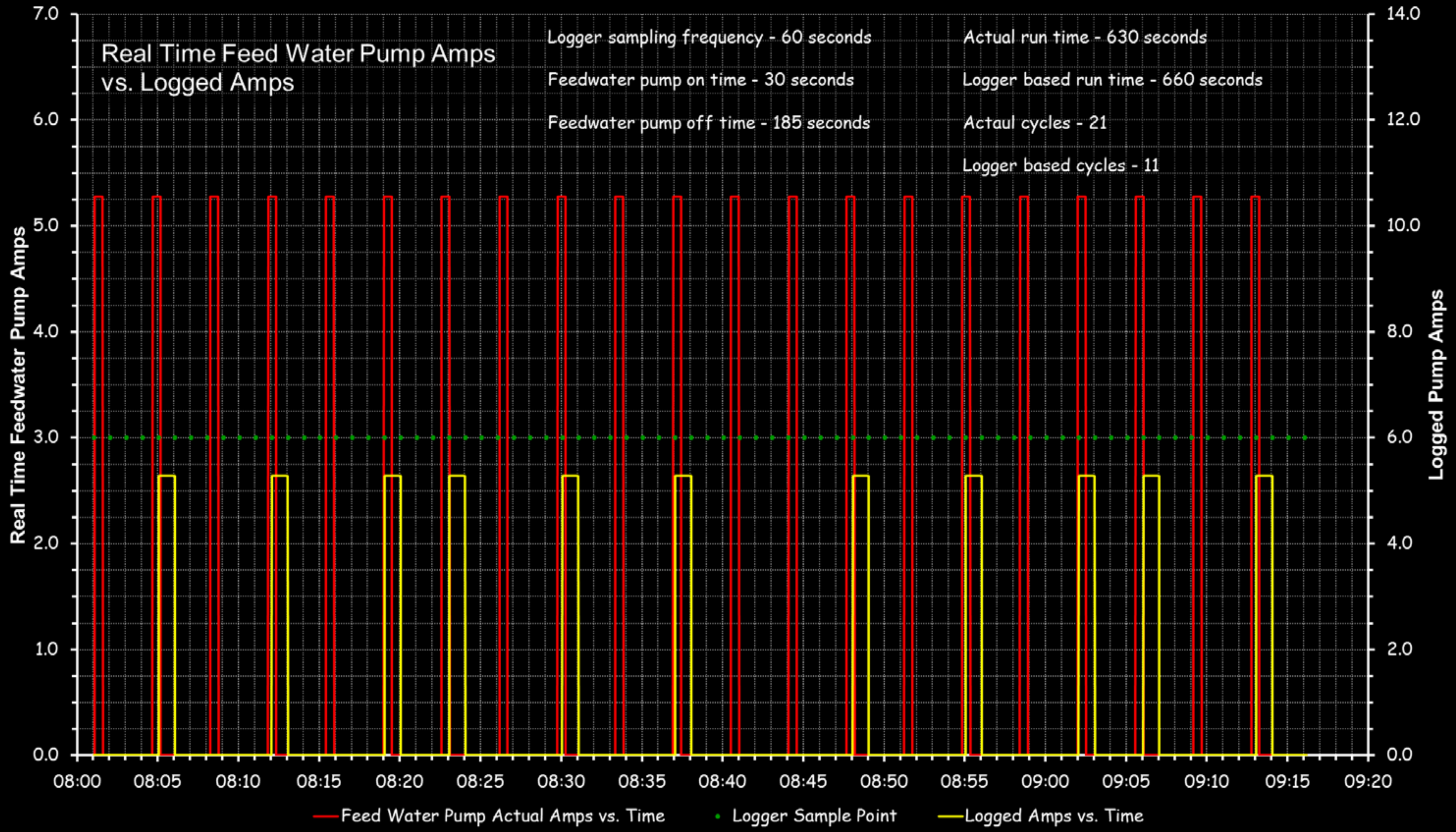
Where:

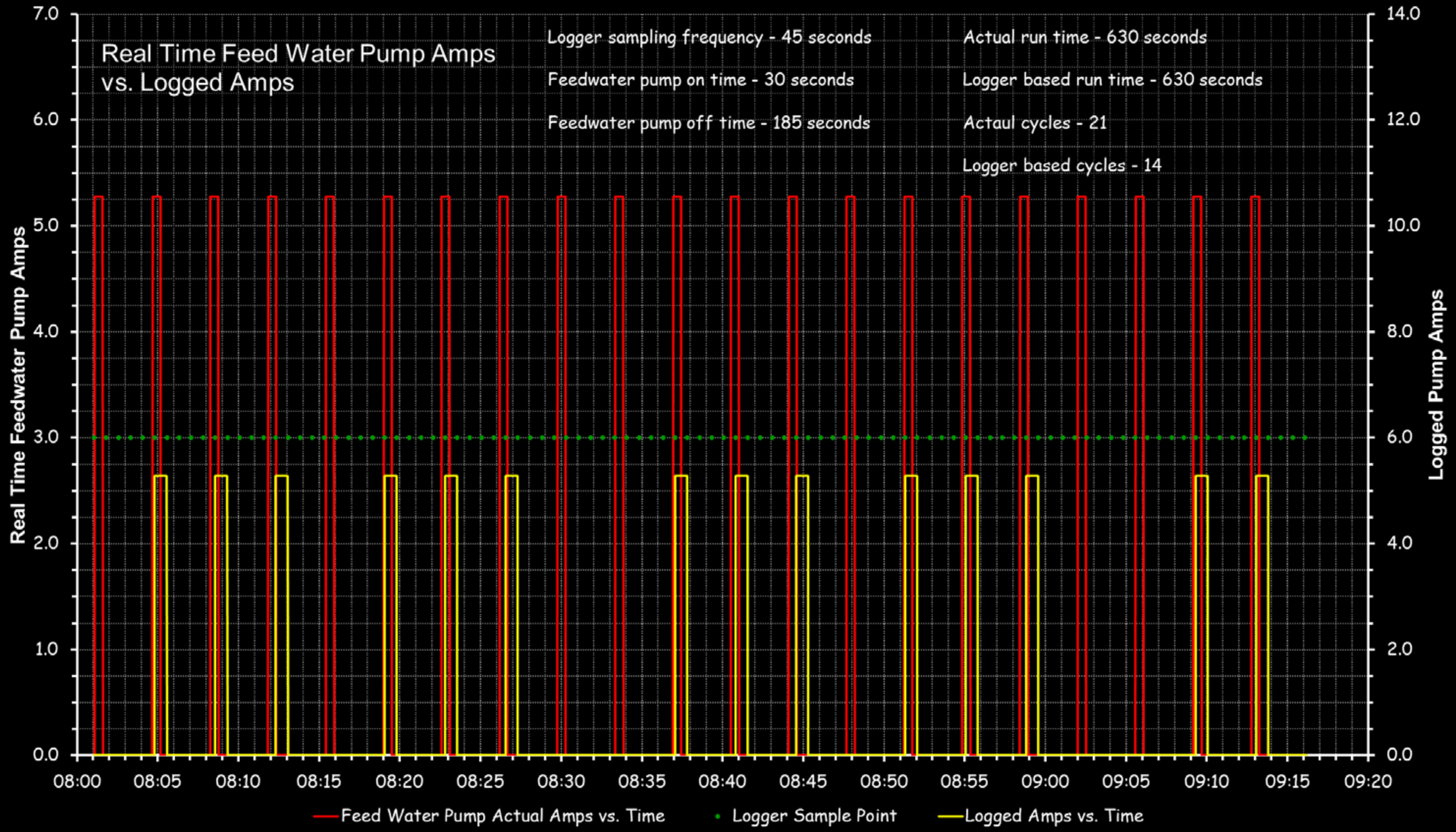
f_s = The sampling frequency

f_c = The highest frequency contained in the signal

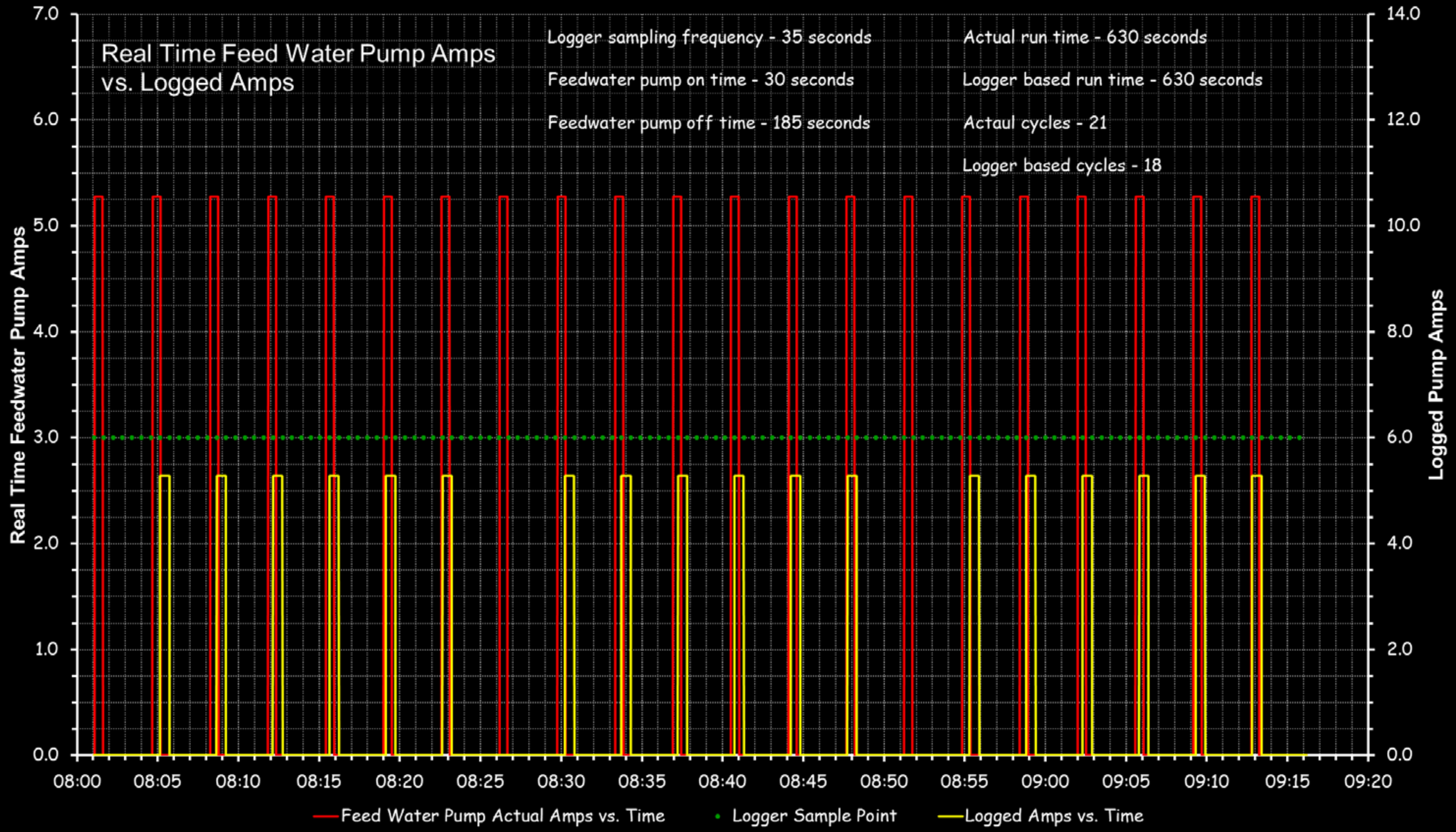
In words:

The sampling frequency should be at least twice the highest frequency contained in the signal.

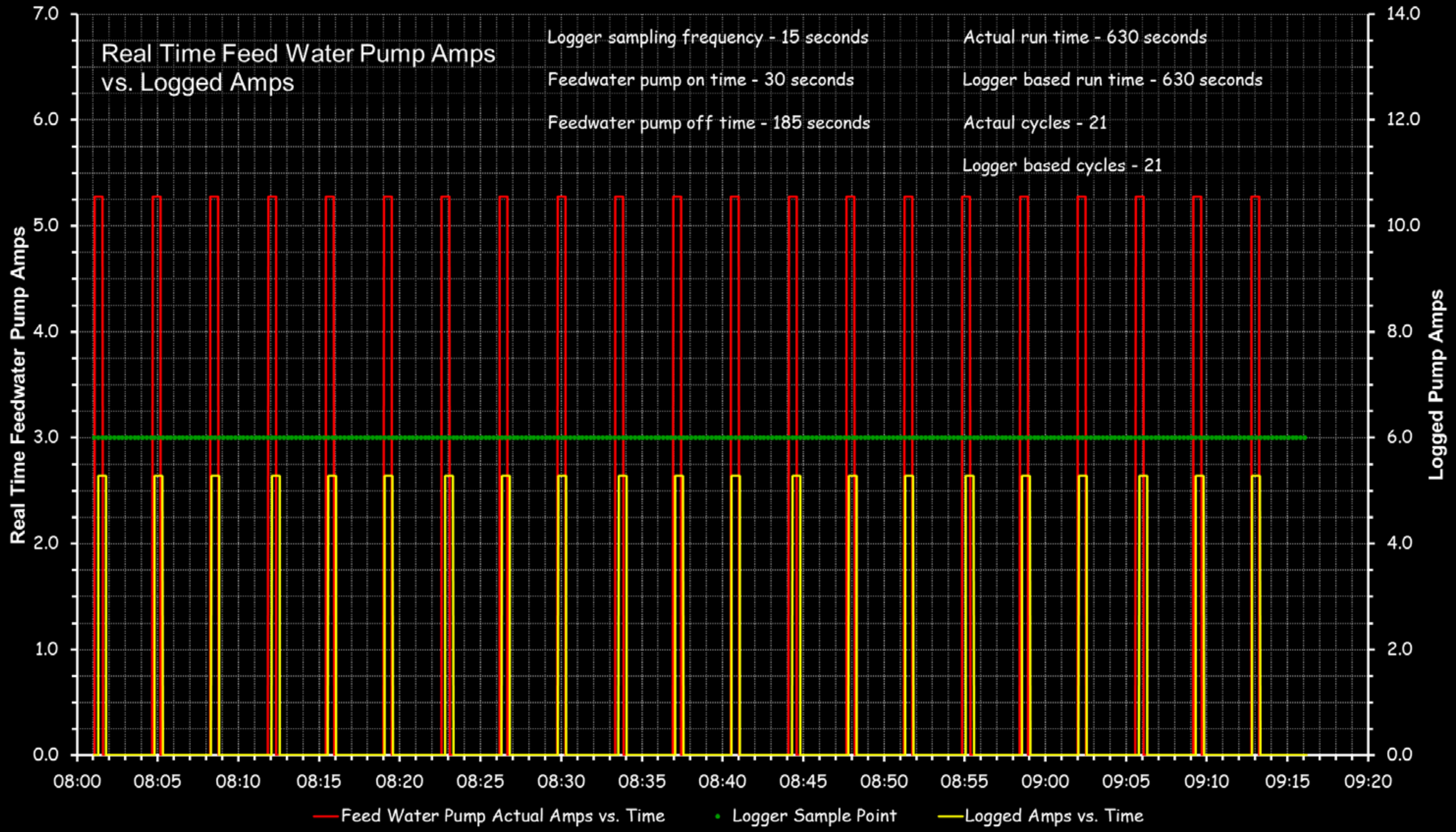

Real Time Feed Water Pump Amps vs. Logged Amps
Logger sampling frequency - 60 seconds
Feedwater pump on time - 30 seconds
Feedwater pump off time - 185 seconds
Actual run time - 630 seconds
Logger based run time - 660 seconds
Actaul cycles - 21
Logger based cycles - 11
Real Time Feedwater Pump Amps
Logged Pump Amps
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
08:00
08:05
08:10
08:15
08:20
08:25
08:30
08:35
08:40
08:45
08:50
08:55
09:00
09:05
09:10
09:15
09:20
Feed Water Pump Actual Amps vs. Time
Logger Sample Point
Logged Amps vs. Time



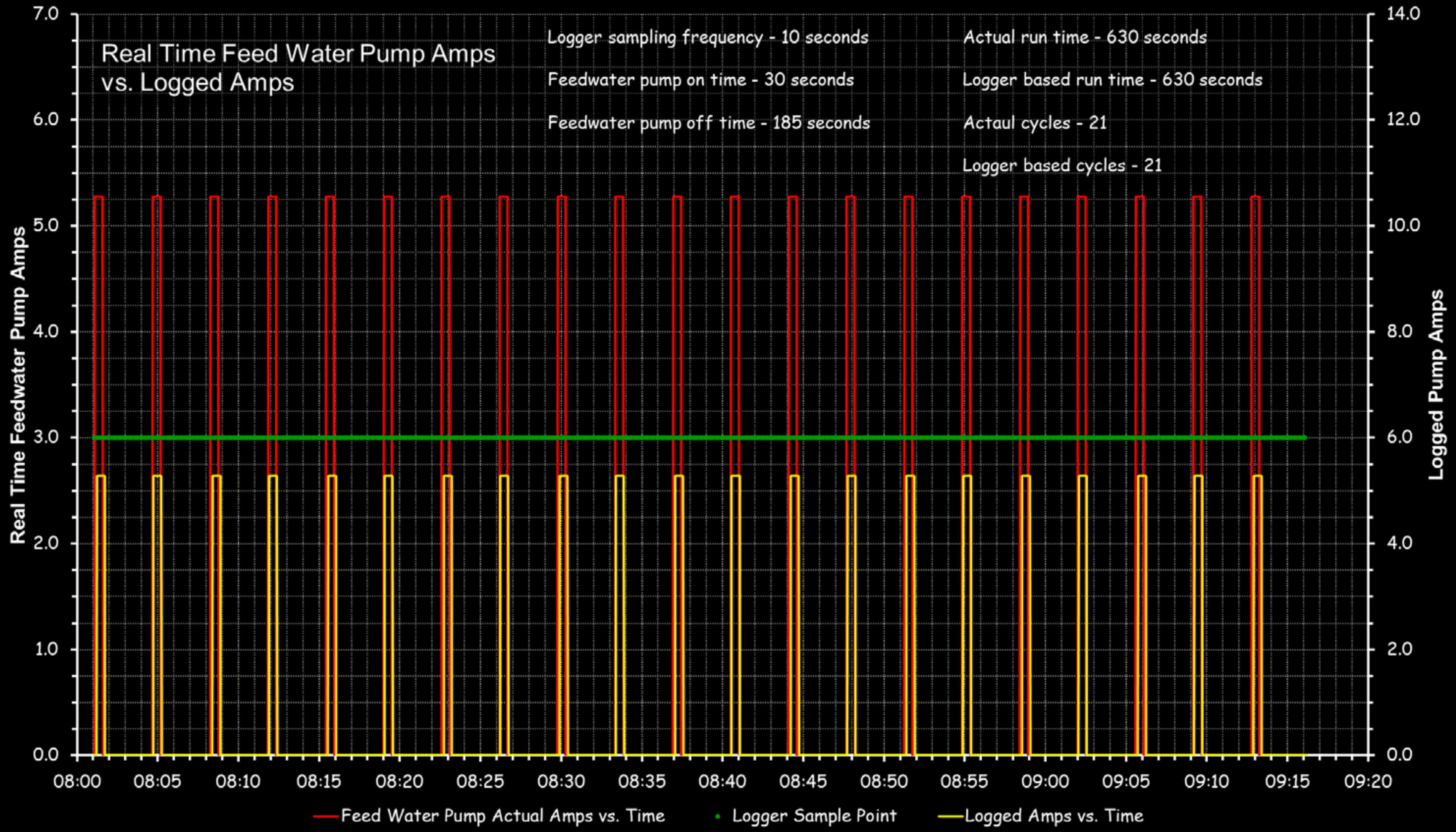
Real Time Feed Water Pump Amps vs. Logged Amps
Logger sampling frequency - 45 seconds
Feedwater pump on time - 30 seconds
Feedwater pump off time - 185 seconds
Actual run time - 630 seconds
Logger based run time - 630 seconds
Actaul cycles - 21
Logger based cycles - 14
Real Time Feedwater Pump Amps
Logged Pump Amps
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
08:00
08:05
08:10
08:15
08:20
08:25
08:30
08:35
08:40
08:45
08:50
08:55
09:00
09:05
09:10
09:15
09:20
Feed Water Pump Actual Amps vs. Time
Logger Sample Point
Logged Amps vs. Time



Real Time Feed Water Pump Amps
vs. Logged Amps
Logger sampling frequency - 35 seconds
Feedwater pump on time - 30 seconds
Feedwater pump off time - 185 seconds
Actual run time - 630 seconds
Logger based run time - 630 seconds
Actaul cycles - 21
Logger based cycles - 18
Real Time Feedwater Pump Amps
Logged Pump Amps
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
08:00
08:05
08:10
08:15
08:20
08:25
08:30
08:35
08:40
08:45
08:50
08:55
09:00
09:05
09:10
09:15
09:20
Feed Water Pump Actual Amps vs. Time
Logger Sample Point
Logged Amps vs. Time



Real Time Feed Water Pump Amps
vs. Logged Amps
Logger sampling frequency - 15 seconds
Feedwater pump on time - 30 seconds
Feedwater pump off time - 185 seconds
Actual run time - 630 seconds
Logger based run time - 630 seconds
Actaul cycles - 21
Logger based cycles - 21
Real Time Feedwater Pump Amps
Logged Pump Amps
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
08:00
08:05
08:10
08:15
08:20
08:25
08:30
08:35
08:40
08:45
08:50
08:55
09:00
09:05
09:10
09:15
09:20
Feed Water Pump Actual Amps vs. Time
Logger Sample Point
Logged Amps vs. Time



Real Time Feed Water Pump Amps
vs. Logged Amps
Logger sampling frequency - 10 seconds
Feedwater pump on time - 30 seconds
Feedwater pump off time - 185 seconds
Actual run time - 630 seconds
Logger based run time - 630 seconds
Actaul cycles - 21
Logger based cycles - 21
Real Time Feedwater Pump Amps
Logged Pump Amps
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
08:00
08:05
08:10
08:15
08:20
08:25
08:30
08:35
08:40
08:45
08:50
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09:00
09:05
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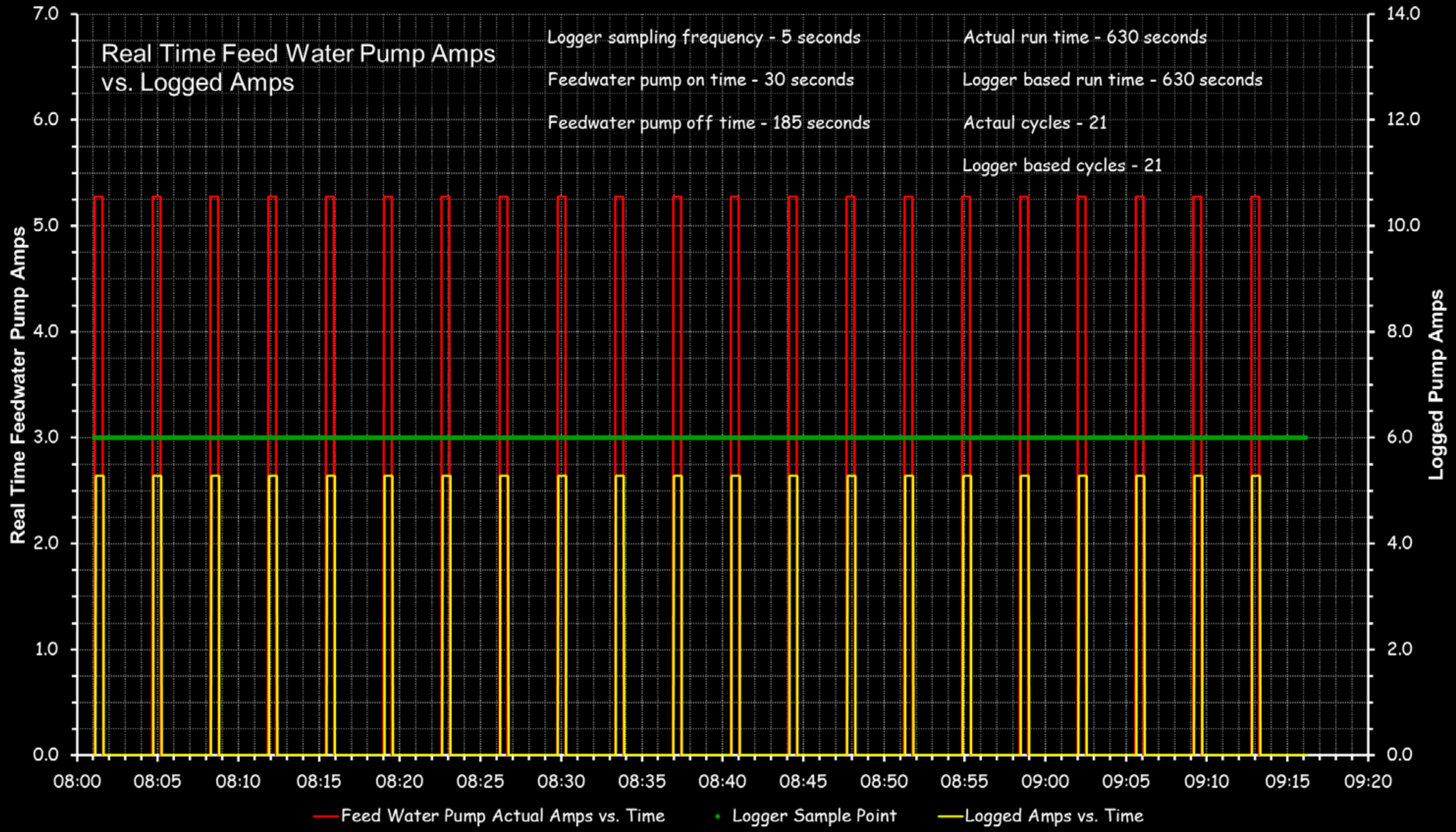
09:15
09:20
Feed Water Pump Actual Amps vs. Time
Logger Sample Point
Logged Amps vs. Time



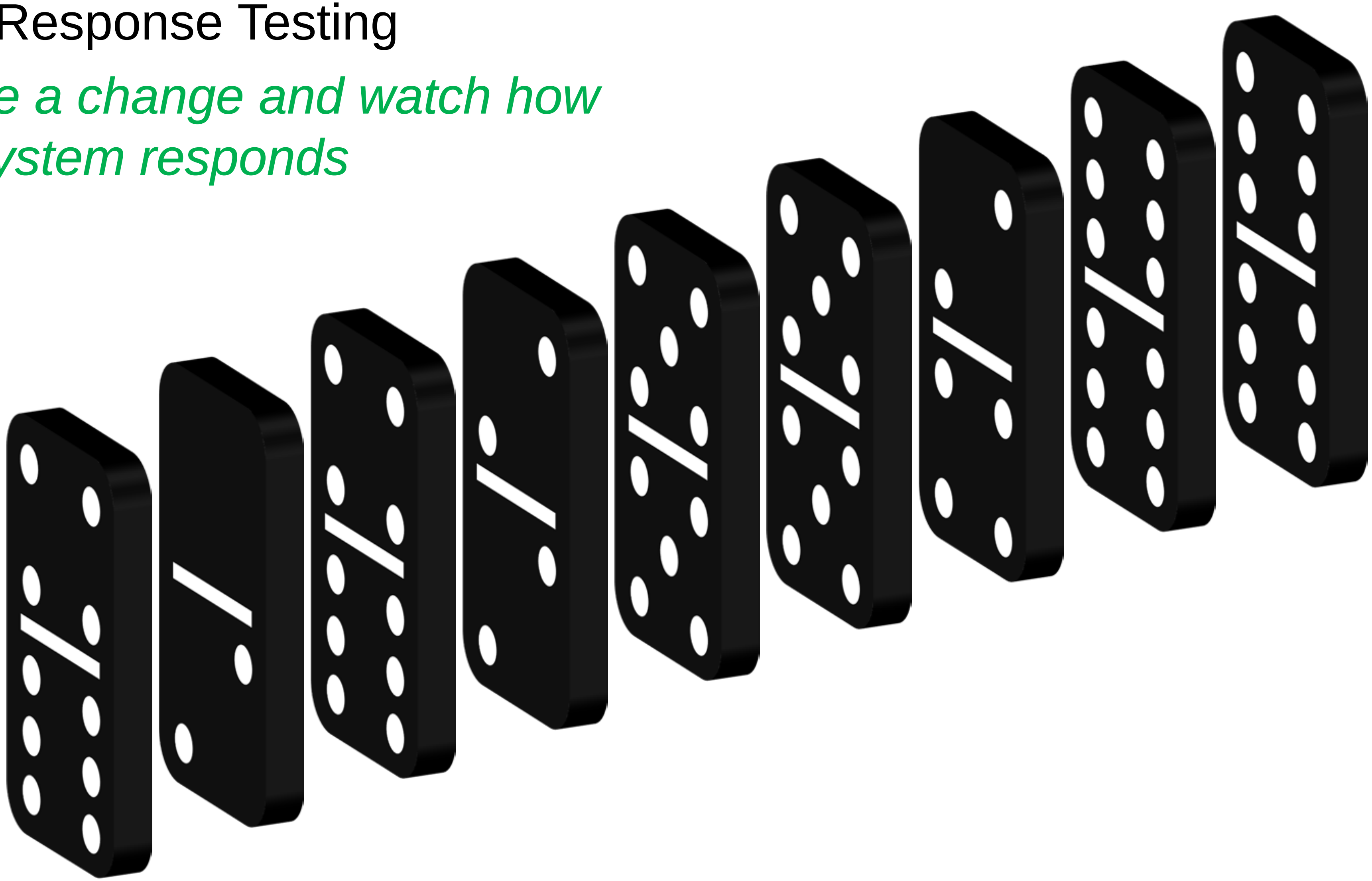
More on aliasing and sensor accuracy in the field can be found at:
https://av8rdas.wordpress.com/2016/03/16/aliasing-and-other-factors-affecting-the-accuracy-of-field-data/

Functional Testing

Forced vs. Natural Response Testing

Forced Response Testing

I force a change and watch how the system responds



Forced vs. Natural Response Testing

Forced Response Testing

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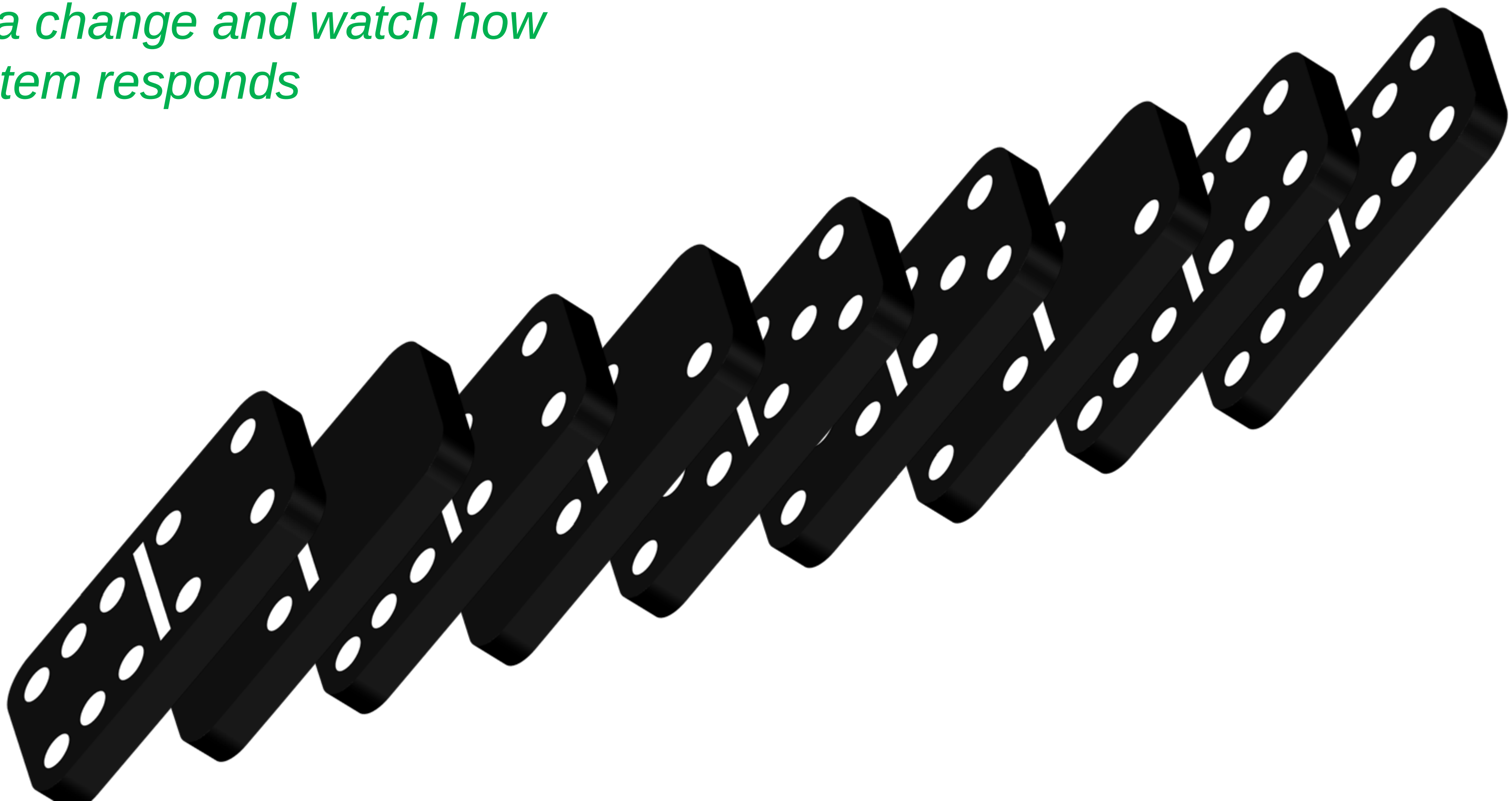


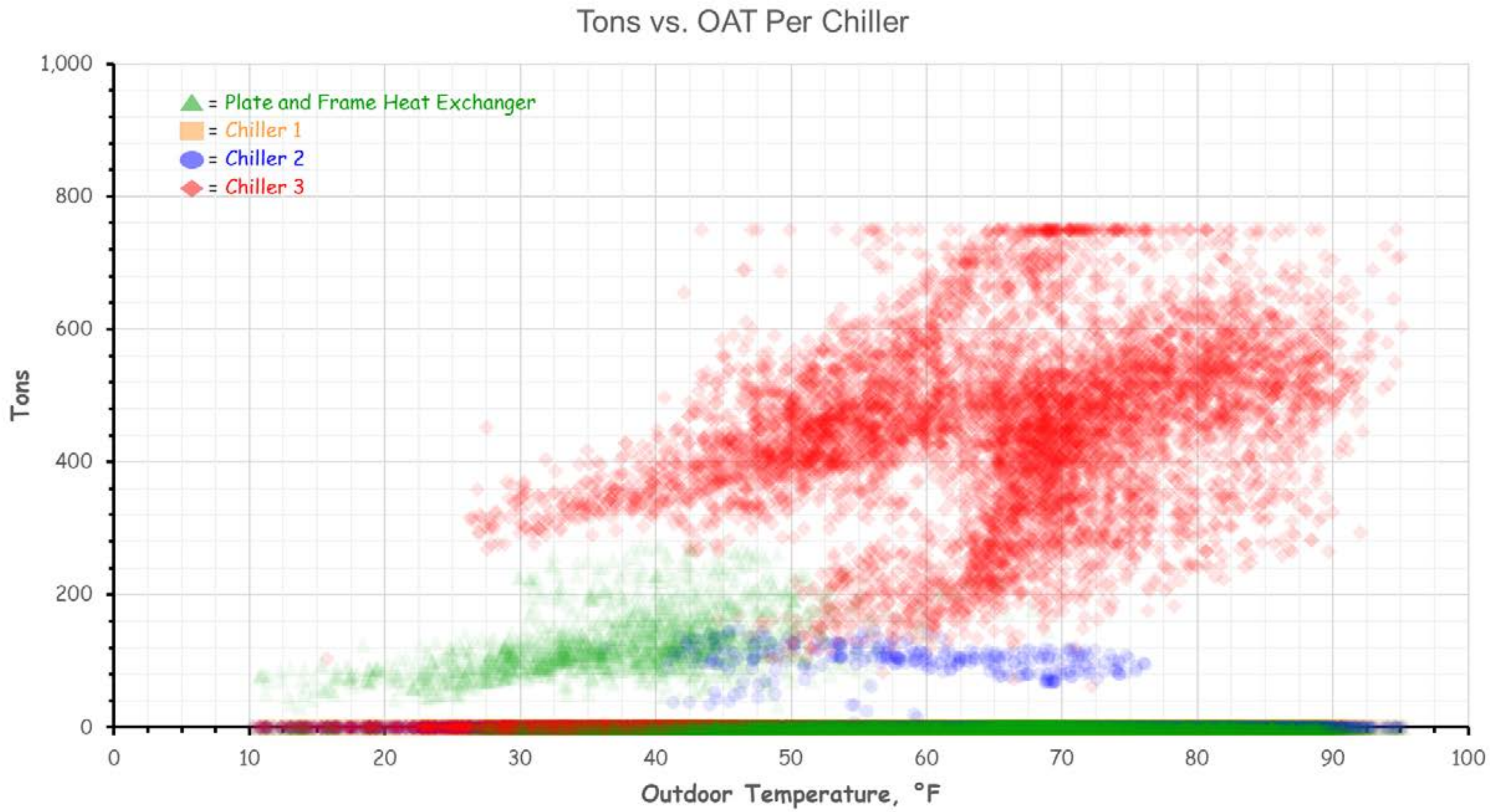
Forced vs. Natural Response Testing

Forced Response Testing

I force a change and watch how the system responds

Natural Response Testing

I observe how a system responds to the normal course of events



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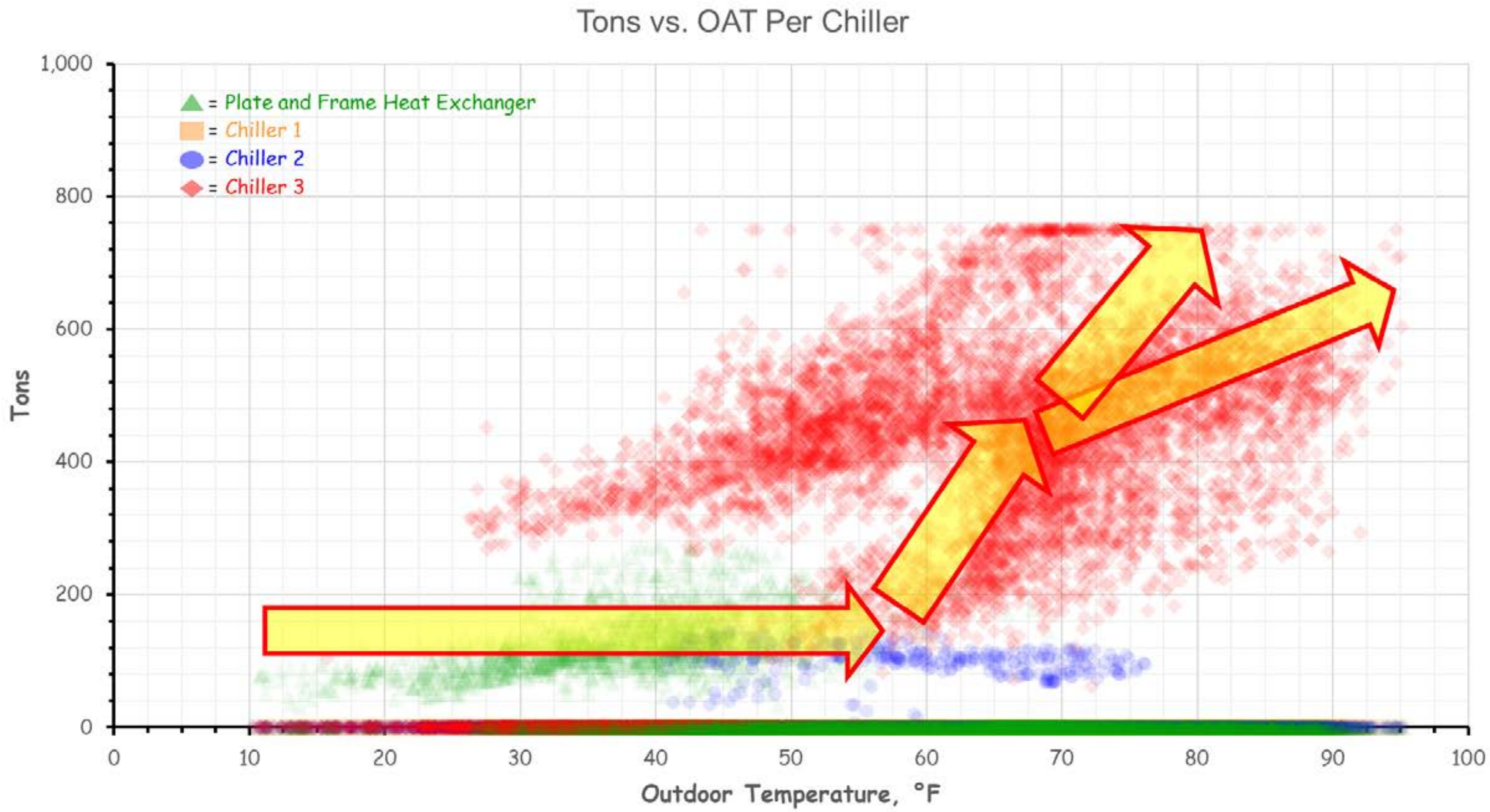

Forced vs. Natural Response Testing

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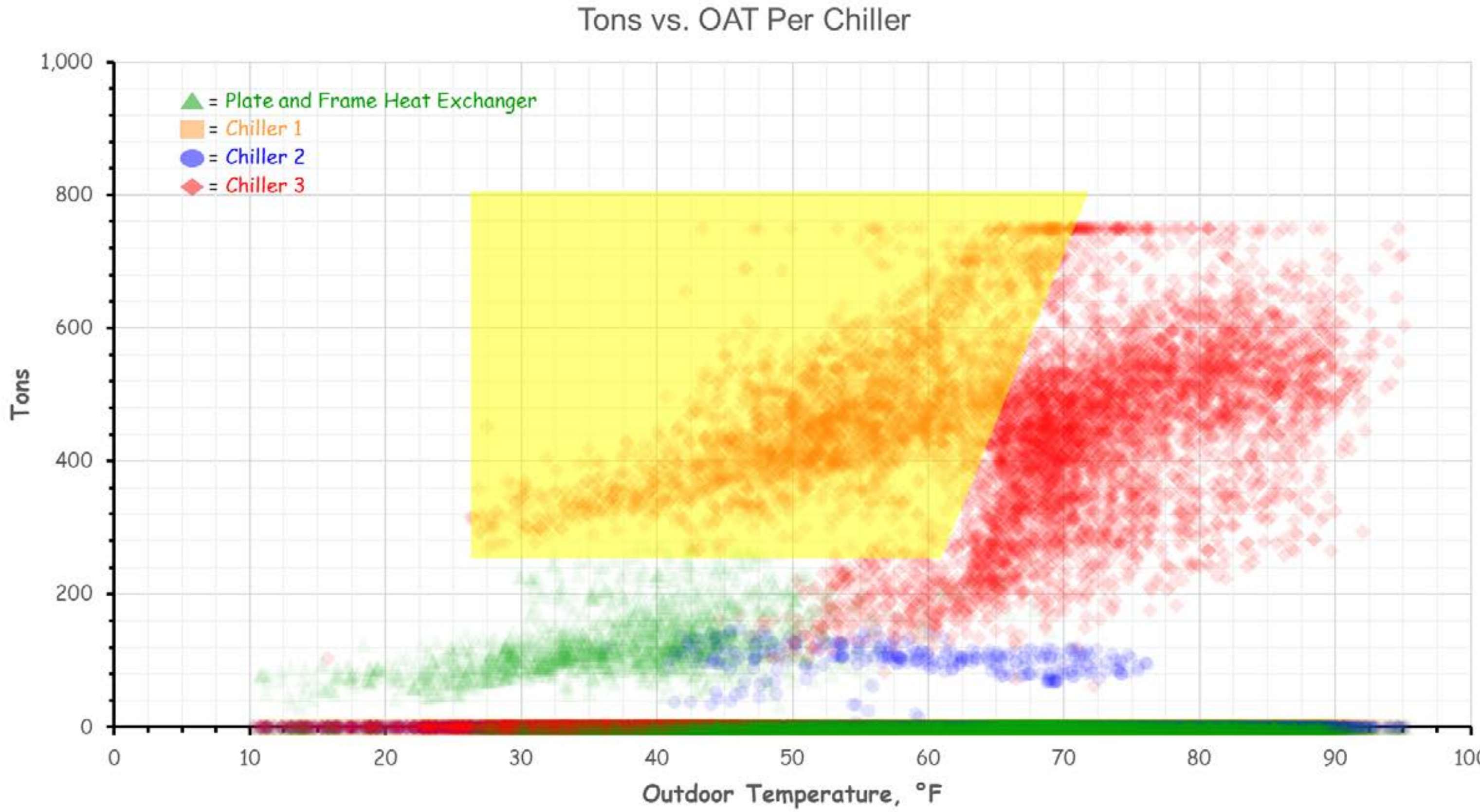
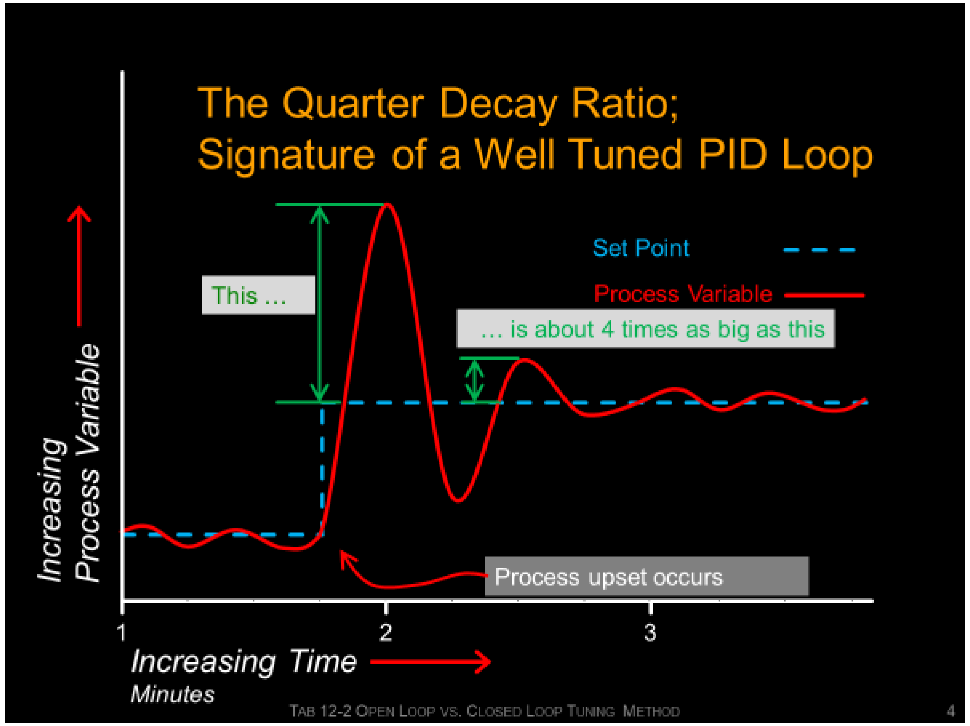


Forced vs. Natural Response Testing

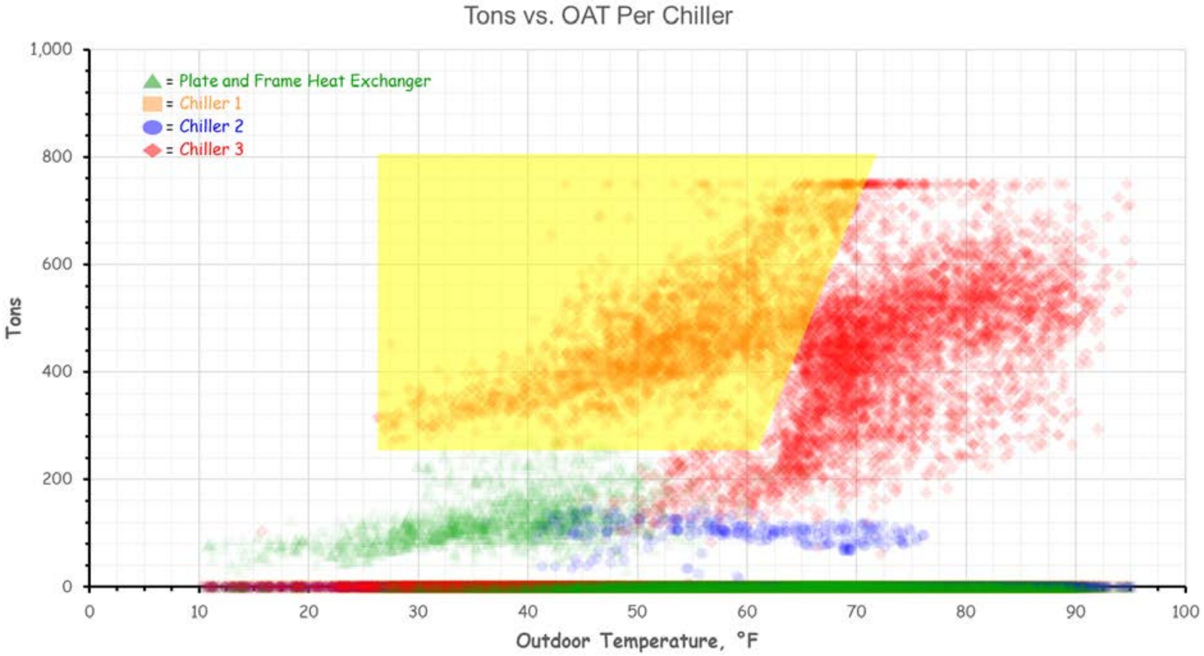
Forced Response Testing

Loop tuning is a forced response test …



Natural Response Testing

I observe how a system responds to the normal course of events

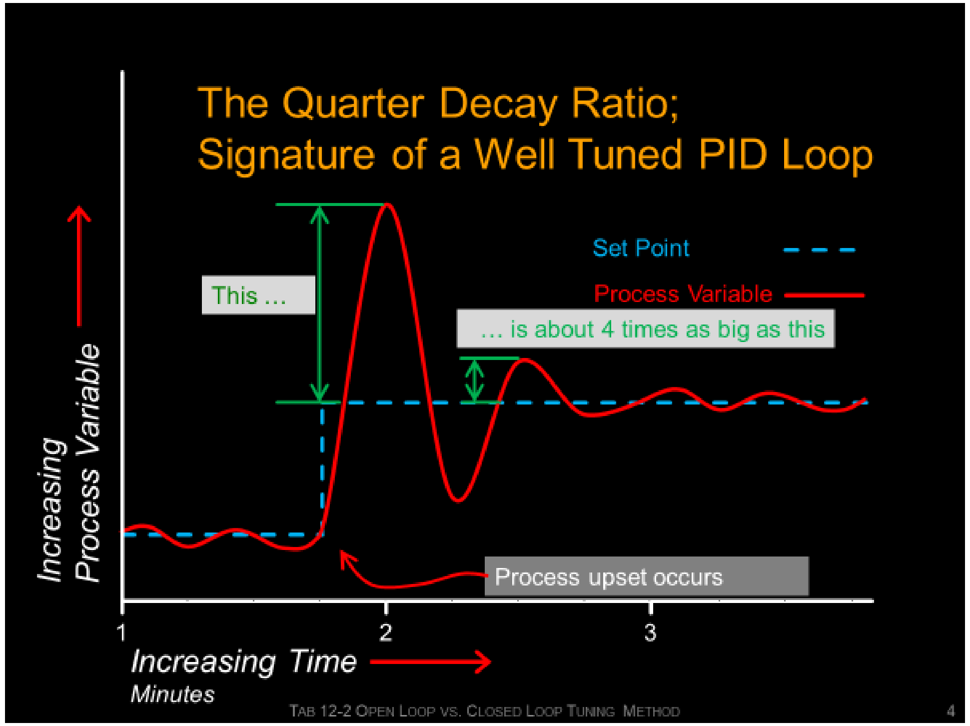


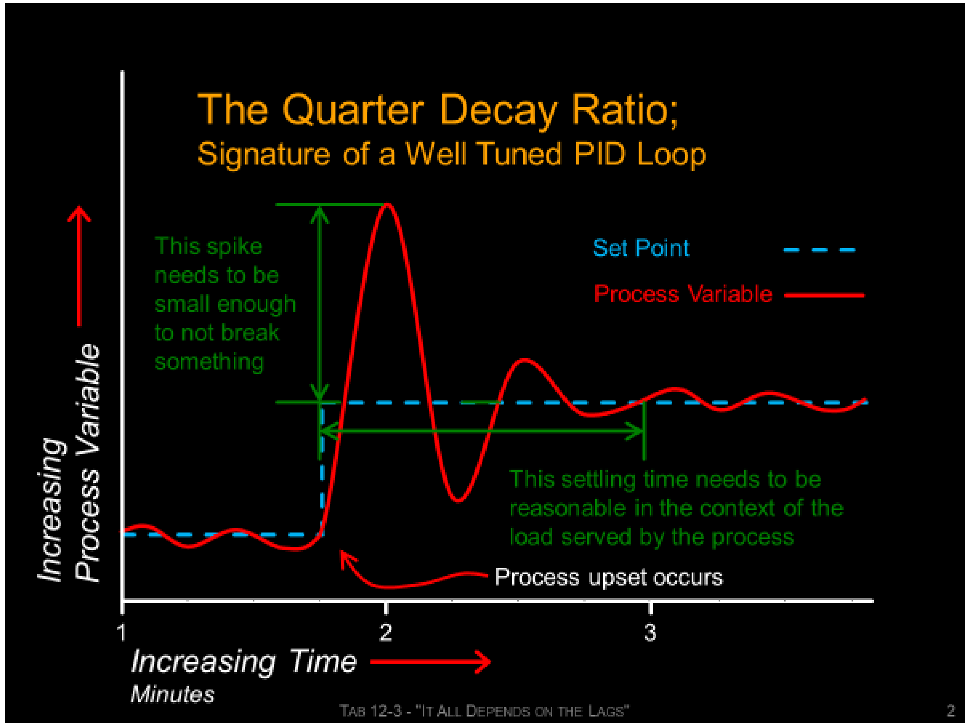
Forced vs. Natural Response Testing

Forced Response Testing

Loop tuning is a forced response test …

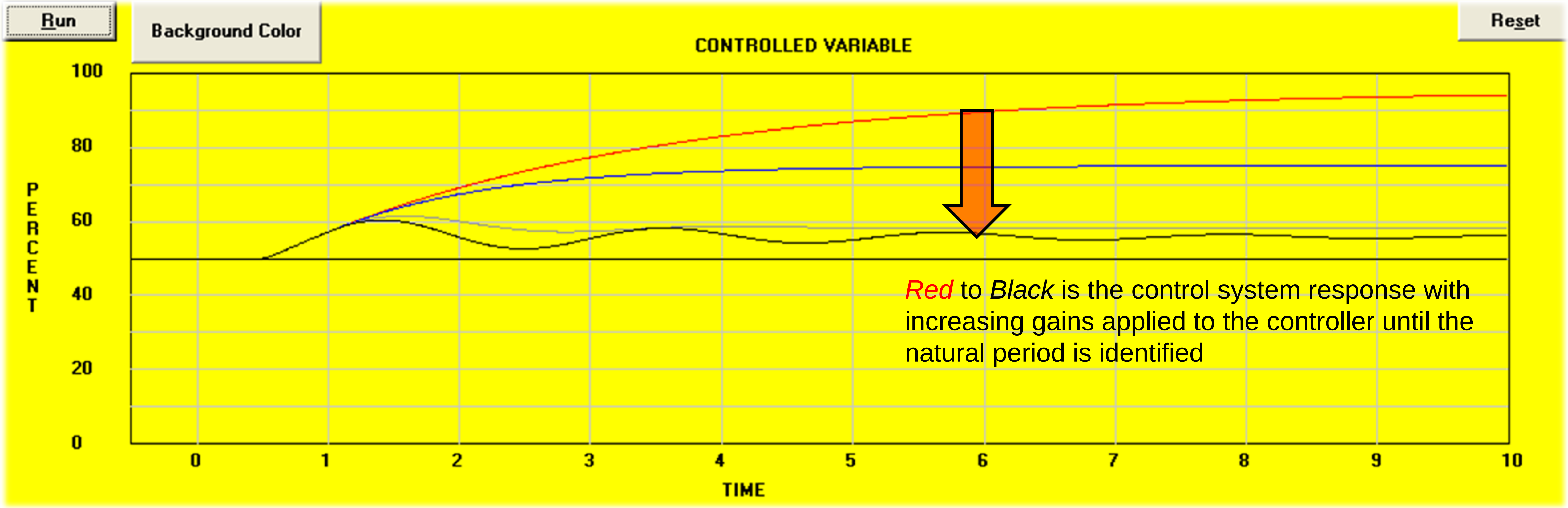
… with some important constraints



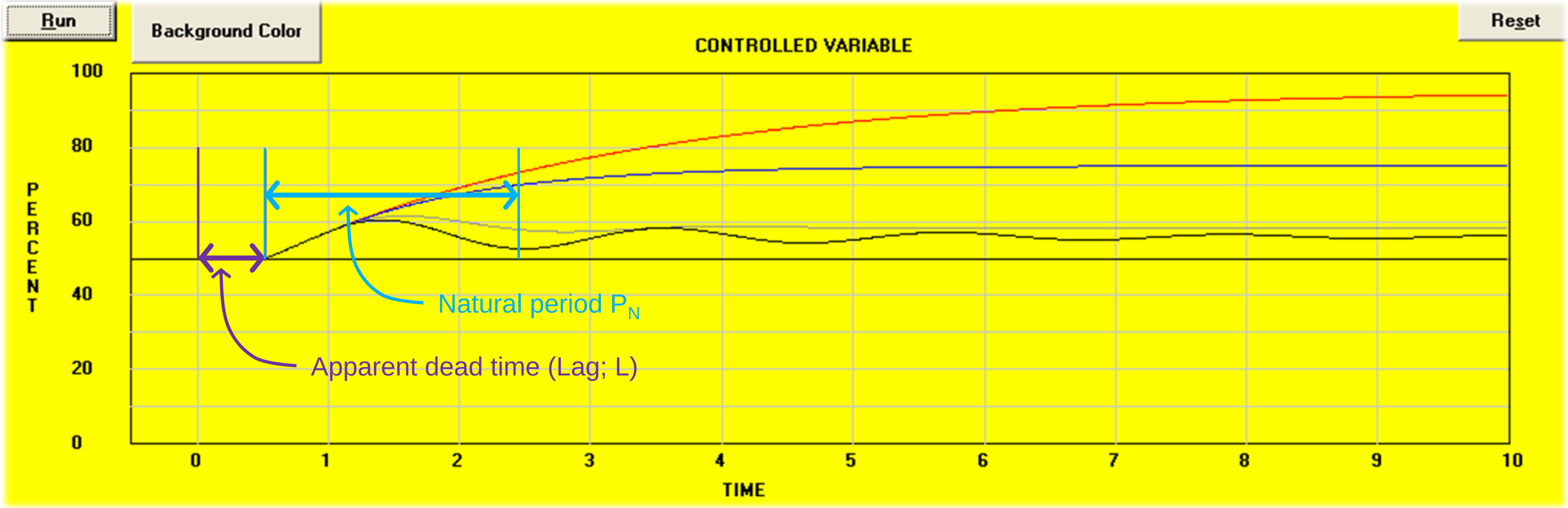


The Open Loop Tuning Method

Insight into Handling the Constraints

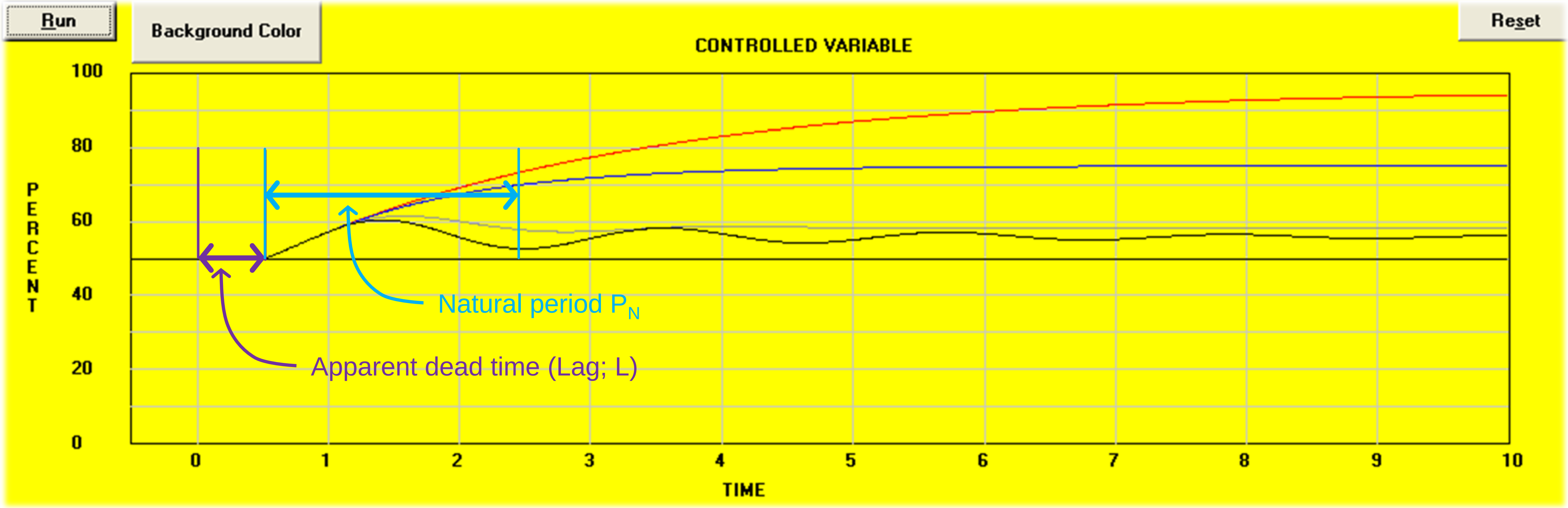


The Open Loop Tuning Method
Insight into Handling the Constraints



The Open Loop Tuning Method

Insight into Handling the Constraints



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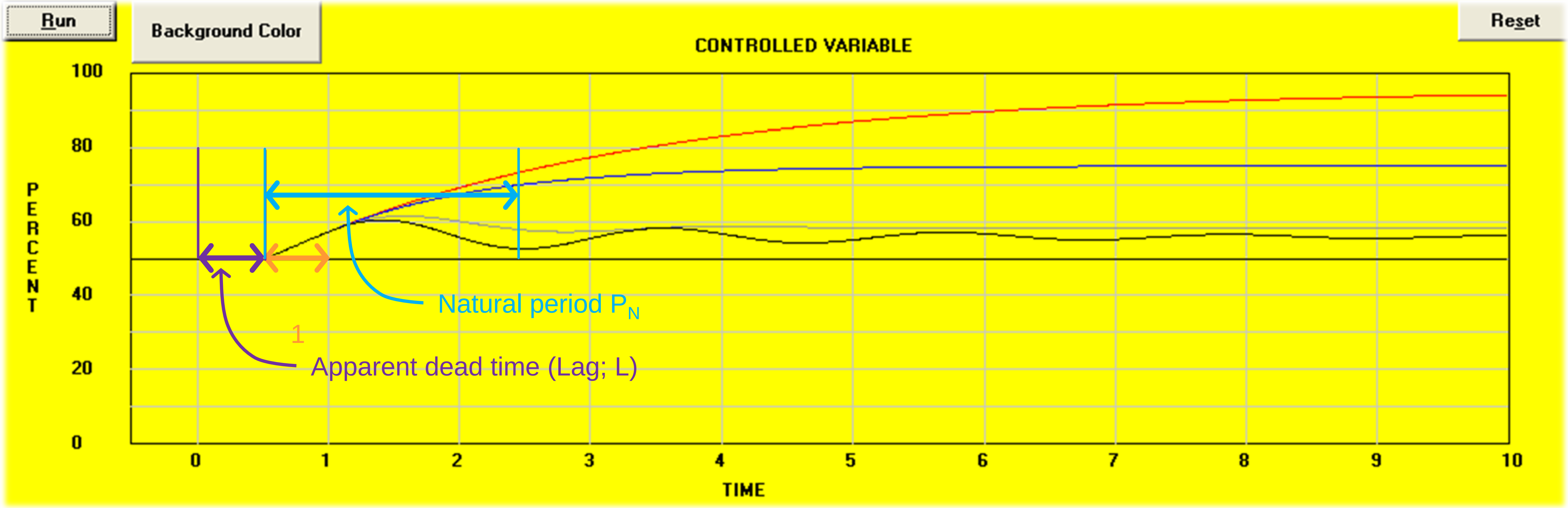
Insight into Handling the Constraints



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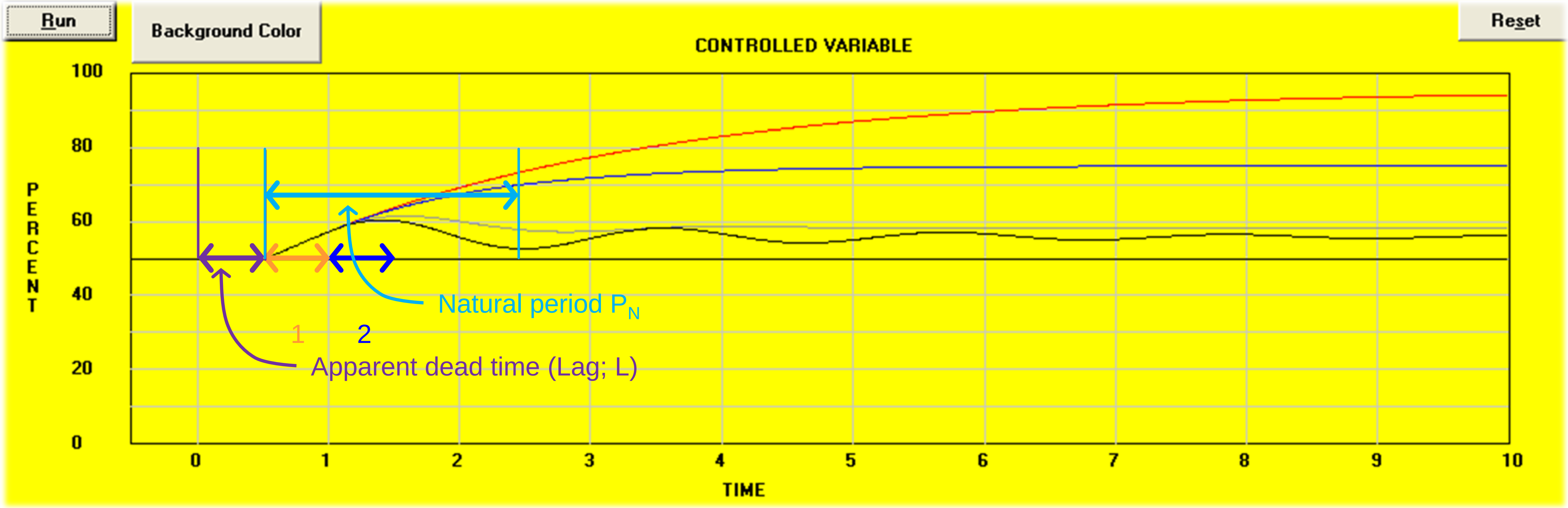
Insight into Handling the Constraints



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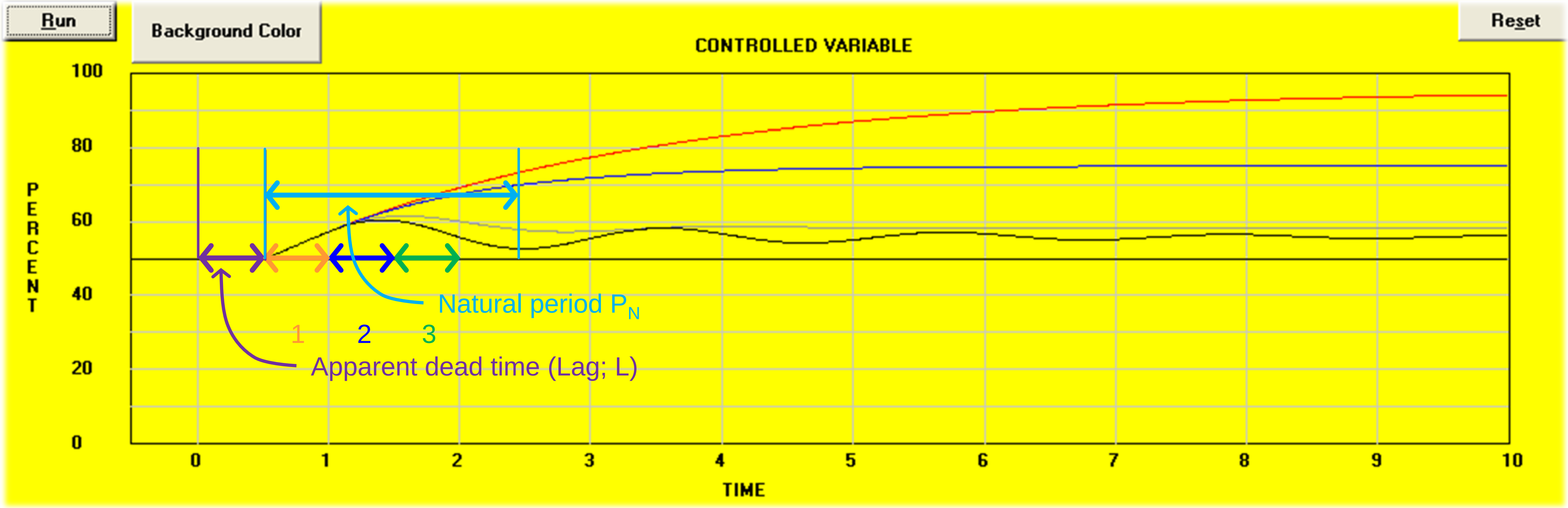
Insight into Handling the Constraints



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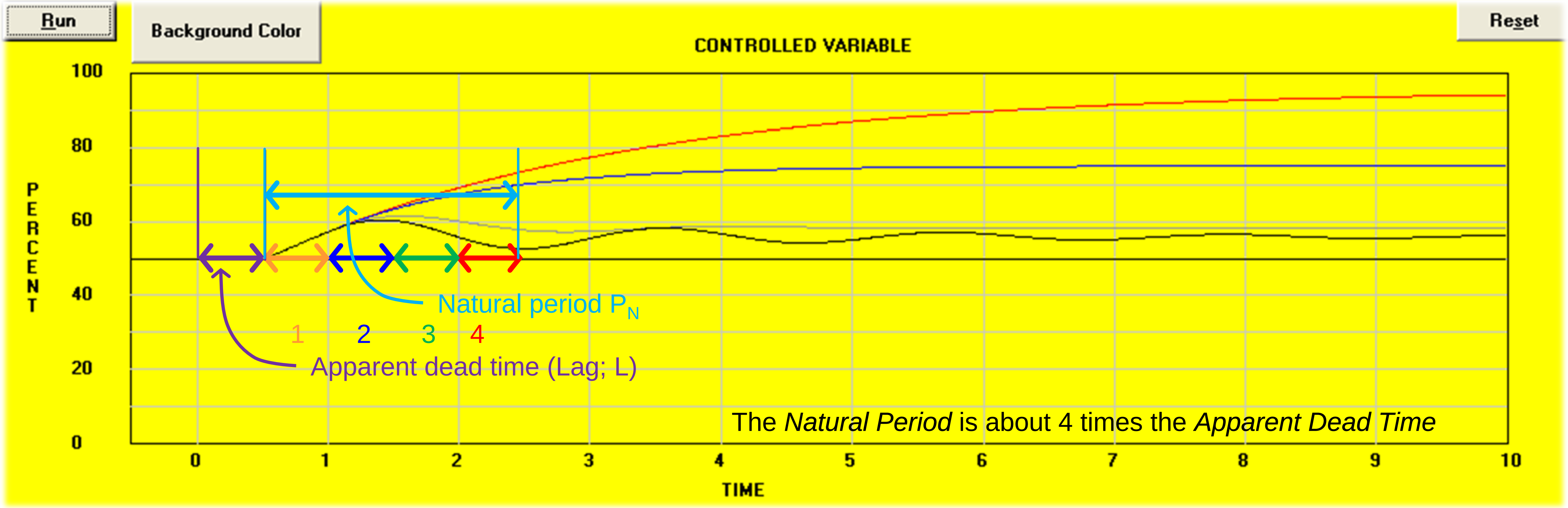

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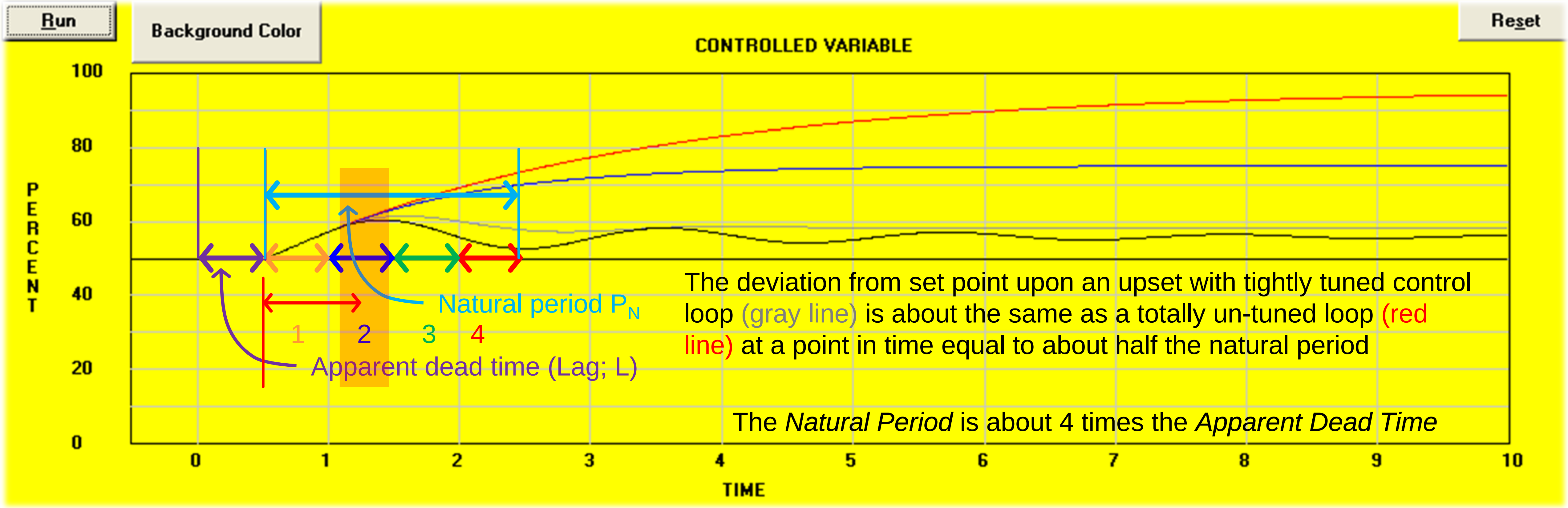
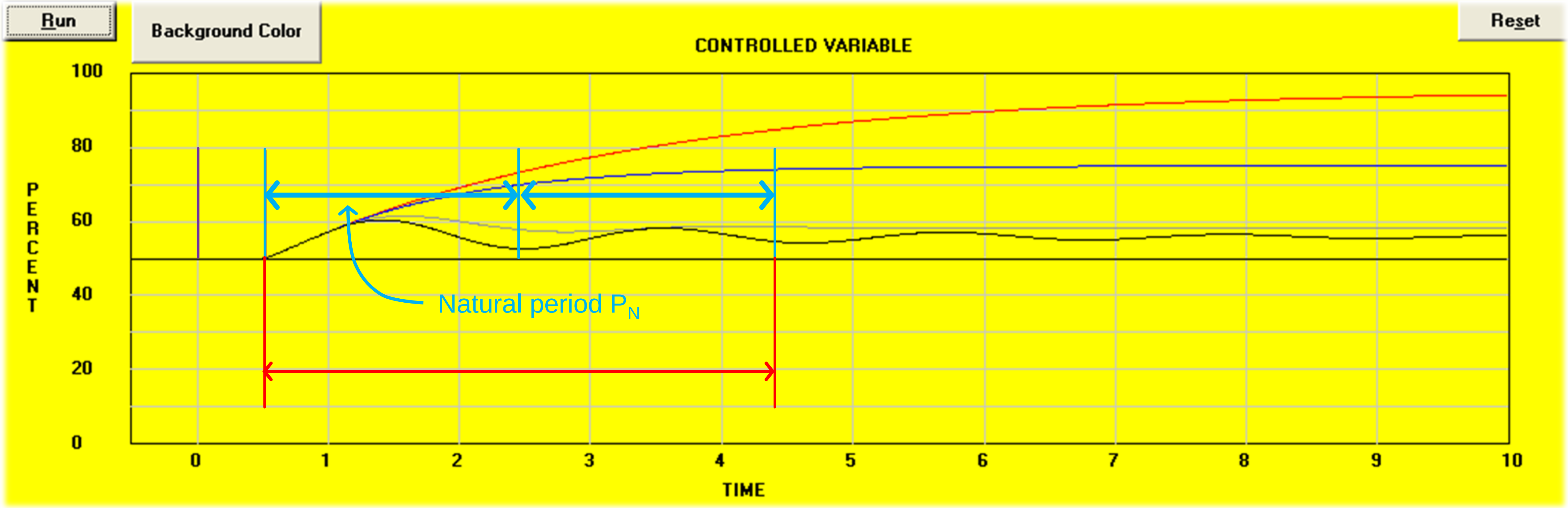


The Open Loop Tuning Method

Insight into Handling the Constraints



Getting Rid of Lags;

Sometimes It's Easier than Others

Easier

1. Add positioning relays to valve and damper actuators
2. Install faster actuators (particularly applicable to electric actuators)
3. Reduce the thermal lag associated with wells by not using them
4. Use tighter linkages to minimize hysteresis
5. Use ramps instead of acceleration and deceleration times in VFDs

Harder

1. Reducing transportation times
2. Reducing the thermal lags associated with the size of the machinery (zmass of coils, fans, duct, pipe, etc.)

A Bit More About Ramps

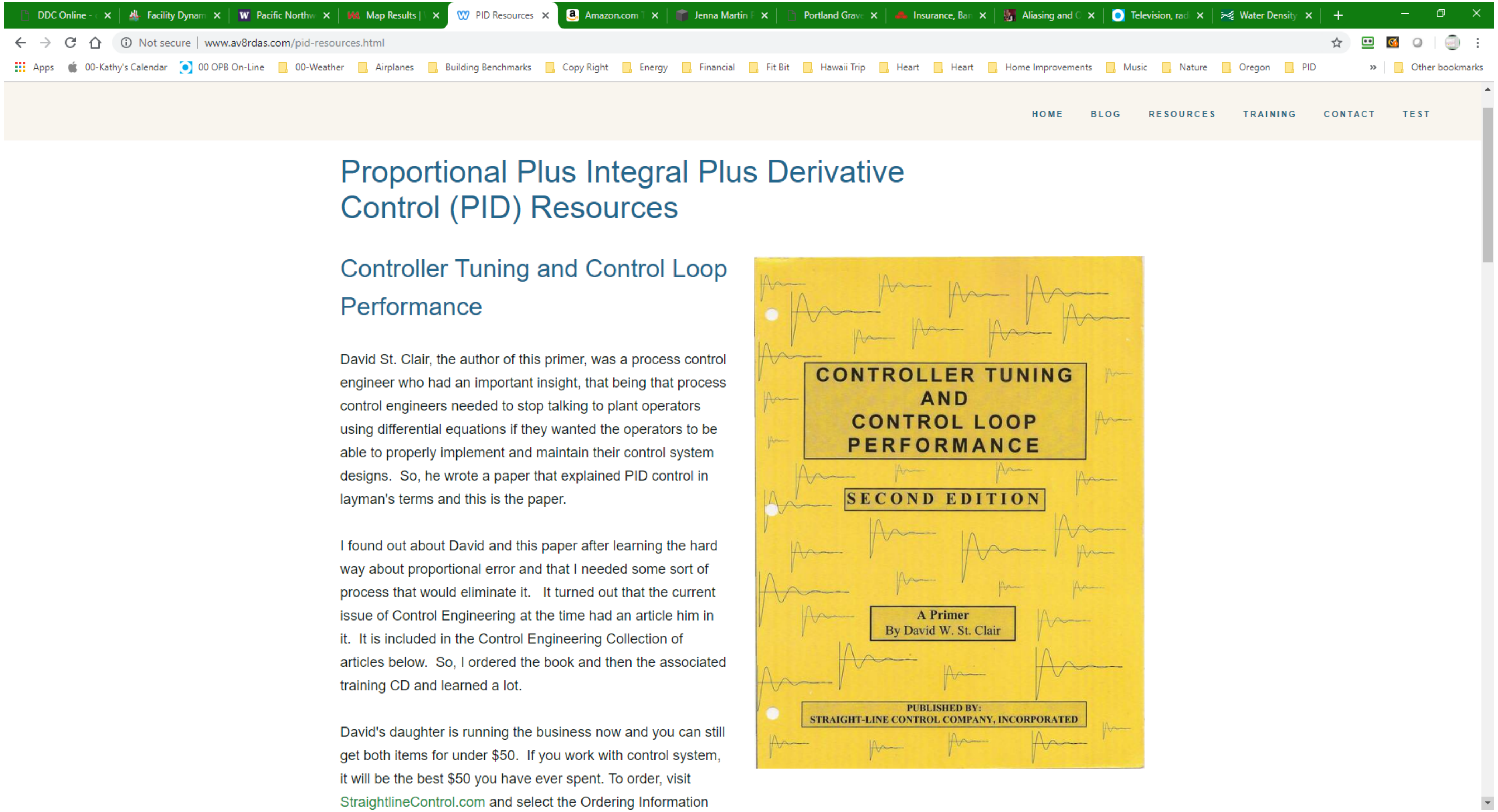
Acceleration and Deceleration times

- Apply all of the time, any time there is a change in the process
  - An acceleration setting of1hz/second slows things down at start up and any time there is a change between control point and set point
  - This introduces a permanent lag into the control process

Ramps

- Only apply when the set point is outside some window relative to the control point
  - Ramps will only apply if the difference between the set point and control point is large (outside of some predefined window)
  - If the set point and control point are inside the window, then the lag associated with the ramp drops out of the picture
  - As a result, the response to a minor variation in set point is much faster than the response to a step change (start up or set point change

Tuning Resources



www.av8rdas.com/pid-resources.html

HOME BLOG RESOURCES TRAINING CONTACT TEST

Proportional Plus Integral Plus Derivative Control (PID) Resources

Controller Tuning and Control Loop Performance

David St. Clair, the author of this primer, was a process control engineer who had an important insight, that being that process control engineers needed to stop talking to plant operators using differential equations if they wanted the operators to be able to properly implement and maintain their control system designs. So, he wrote a paper that explained PID control in layman's terms and this is the paper.

I found out about David and this paper after learning the hard way about proportional error and that I needed some sort of process that would eliminate it. It turned out that the current issue of Control Engineering at the time had an article him in it. It is included in the Control Engineering Collection of articles below. So, I ordered the book and then the associated training CD and learned a lot.

David's daughter is running the business now and you can still get both items for under $50. If you work with control system, it will be the best $50 you have ever spent. To order, visit StraightlineControl.com and select the Ordering Information

Mother Nature Writes Great Functional Test

If lightning is the anger of the gods, then the gods are concerned mostly about trees

Attributed to Lao-Tzu, Ancient Chinese philosopher from the 6th Century BC

Image courtesy the Cloud Appreciation Society Image Gallery

https://cloudappreciationsociety.org/gallery

Mother Nature Writes Great Functional Test

If time and budget are short:

- Verify the “domino’s” fall correctly
- Verify trends are up and running
- Randomly spot check
    - Point to point checks
    - Response times
    - Graphics

And use the control system’s trending capabilities and trend analysis to review testing by Mother Nature

A Practical Approach to Control System Cx

Performing Random Spot Checks

Simply Enforce Your Requirements

Step 1

- Reject equipment and materials that don’t meet the specification requirements

Step 2

- Complete the commissioning process
  - All processes running
  - All required trends running
  - Building in a normal cycle

Performing Random Spot Checks

Simply Enforce Your Requirements

Step 3

- Test for what you need

Need the fan to be running with-in 15 seconds of a command?

With Step 2 Completed:

1. *Put one person at the OWS and one person at the fan*
2. *Give them walkie-talkies*
3. *Synchronize their watches*
4. *Send a start command*
5. *Time how long it takes the fan to react*

Performing Random Spot Checks
Simply Enforce Your Requirements

Step 3

- Test for what you need

Need to know if the supply air temperature changes with-in 10 seconds of a real change?

With Step 2 Completed:

1. *Put one person at the OWS and one person at the sensor*
2. *Give them walkie-talkies*
3. *Synchronize their watches*
4. *Pull the sensor out of the duct*
5. *Time how long it takes the change to show up at the OWS*

Performing Random Spot Checks
Simply Enforce Your Requirements

Step 3

- Test for what you need

Need a graphic to populate in 60 seconds or less?

With Step 2 Completed:

1. *Call up complex graphics*
2. *Time how long it takes for them to populate*
3. *See if the data makes sense*
   - *Is the mixed air temperature between the OAT and the RAT?*
   - *Does the fan status match the current command to it?*

Ongoing Operations

Ongoing Operations

Repeat Preceding

Repeat Preceding

Repeat Preceding

Ongoing Operations

- Apply lessons learned
- Require (and financially support) a thorough control system design process for new work and renovations
- Monitor construction and use it as an opportunity to learn about your new systems and equipment
- Perform regular calibration and verification of your control equipment
- Periodically repeat functional tests and address any issues identified
- Leverage Mother Nature’s functional testing process by closely monitoring your performance and utility trends
- Become a “silver bullet”

Have Fun!

Questions?

Thank you for attending!

Visit our websites

www.FacilityDynamics.com

https://av8rdas.wordpress.com/ (Blog)

http://www.av8rdas.com/ (Commissioning Resources)