



ACCELERATING INNOVATION



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3-1182- Optimizing Compressor Air Headers: A Case Study of Advanced Regulatory Control Implementation

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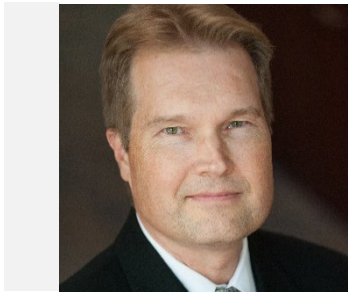
Jose Arguello

Automation Engineer/Emerson North America Compressor Team



Chris Williams

Sr. Controls Associate/Alpek Polyester



Juha Lehtinen

Sr. Systems Engineer/ R.E.Mason





Agenda

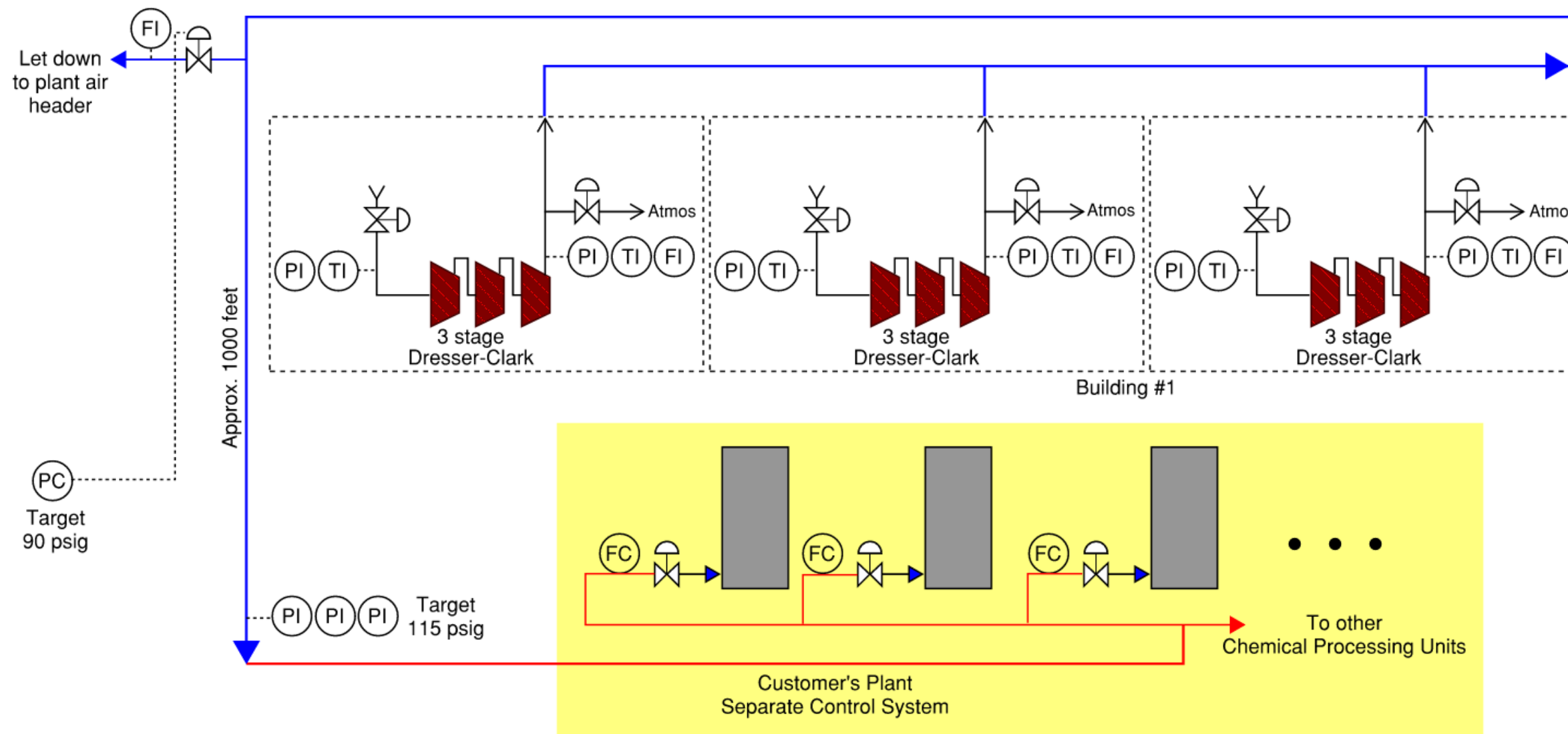
Agenda

Chris Williams	The Challenge
Jose Arguello	The Solution: SmartProcess™ Compressor Control by DeltaV
Juha Lehtinen	The Solution: Surge Testing and Tuning
Jose Arguello	The Solution: Load Control
Jose Arguello	The Solution: Load Balance
Jose Arguello	The Solution: Master Header Pressure Control
Chris Williams	Results

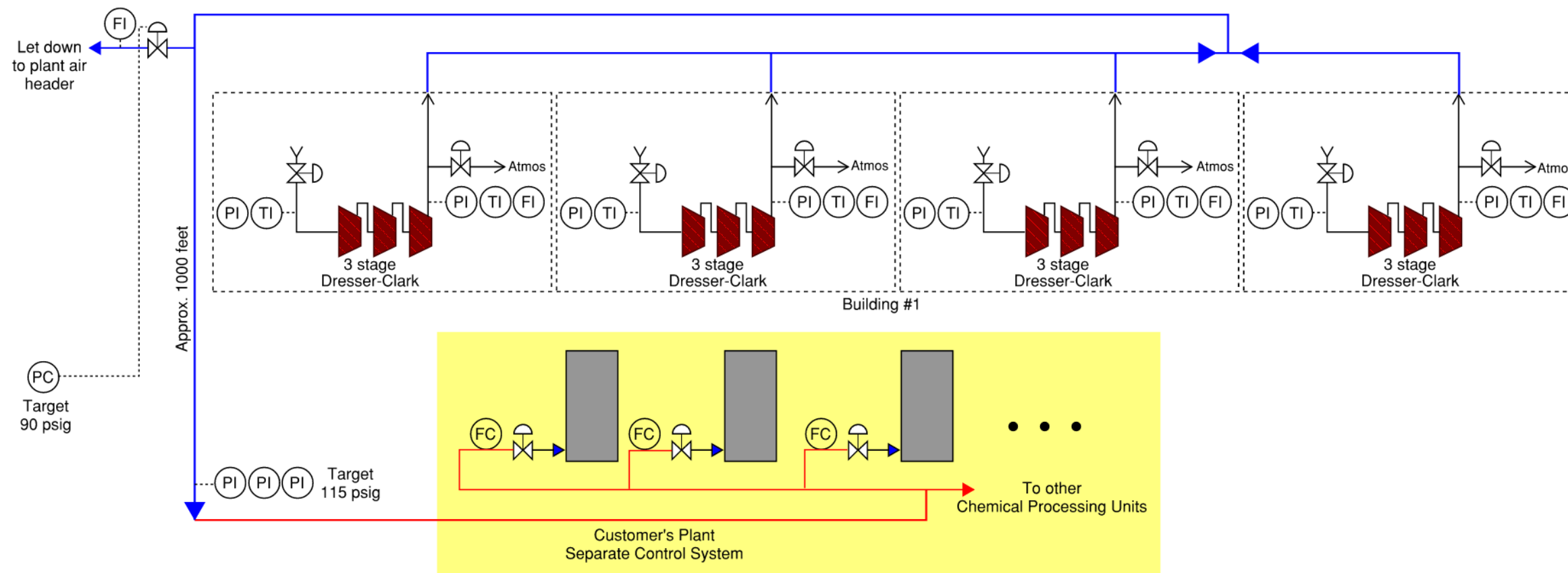
The Challenge

- The plant has been in service for over 50 years
- Compressor controls are a mish-mash of deferent vendors on various states of obsolete hardware
- Many of the experts have retired and few were in the pipeline to replace them

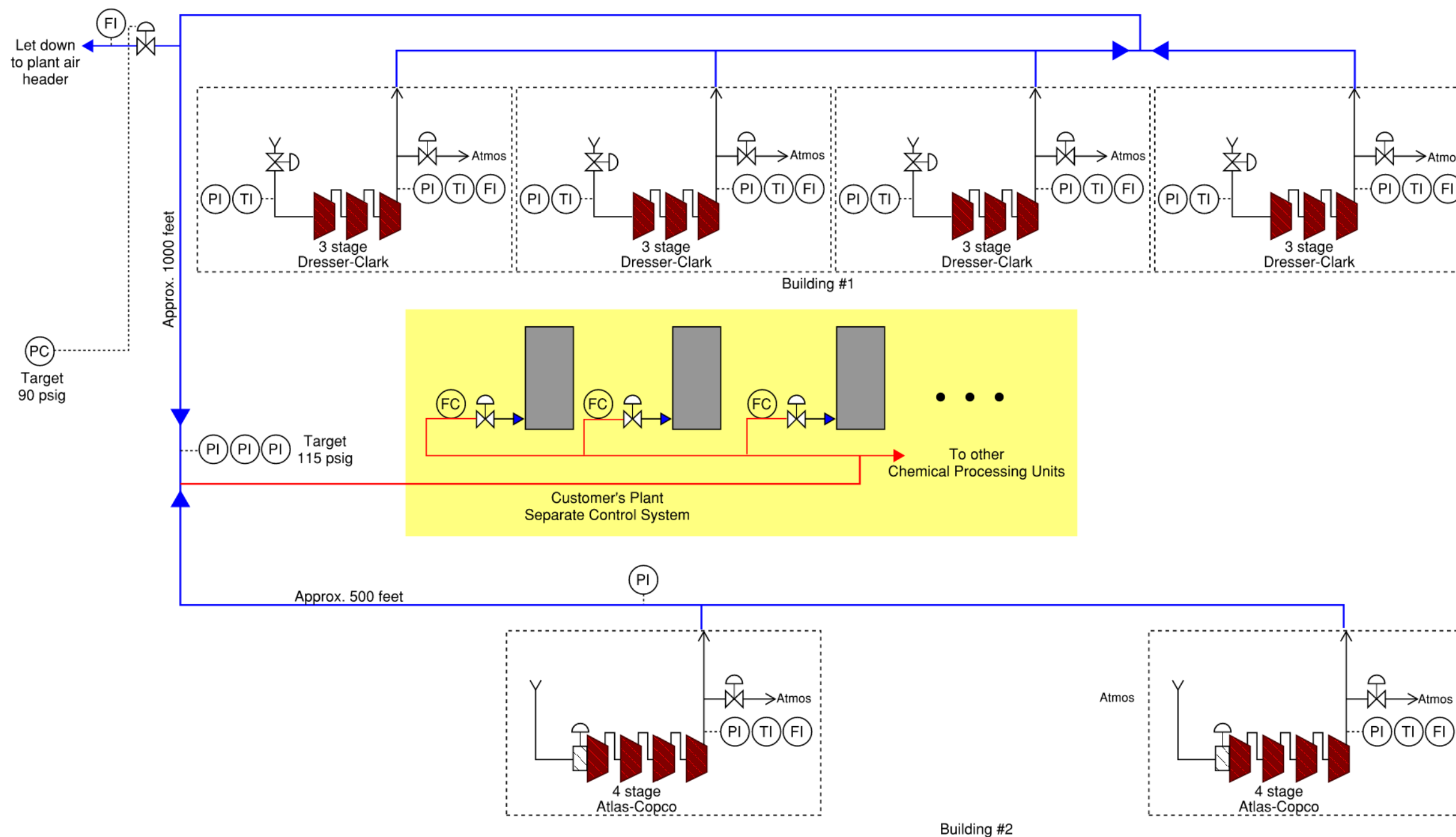
In the beginning, we built a plant



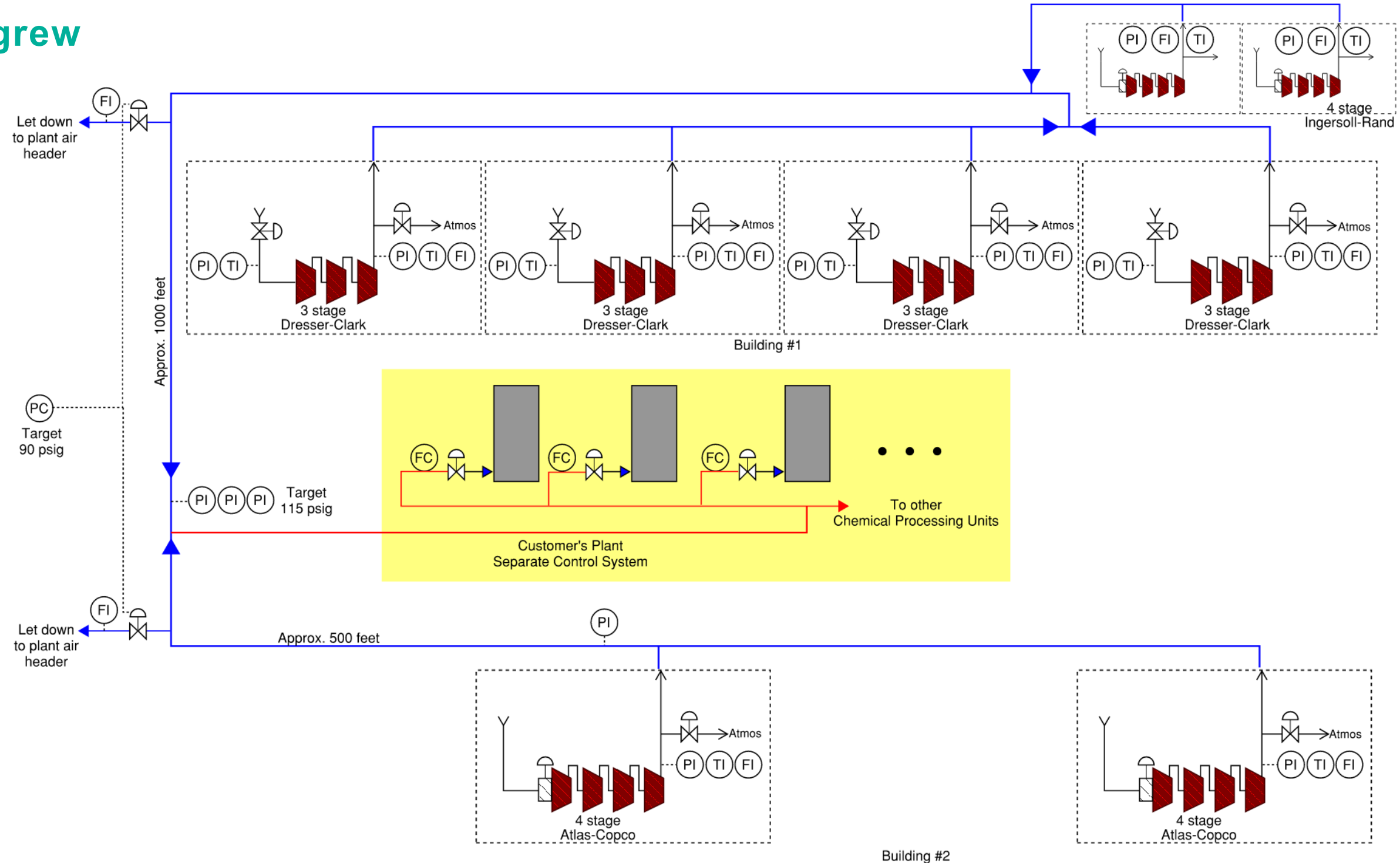
Then the plant grew



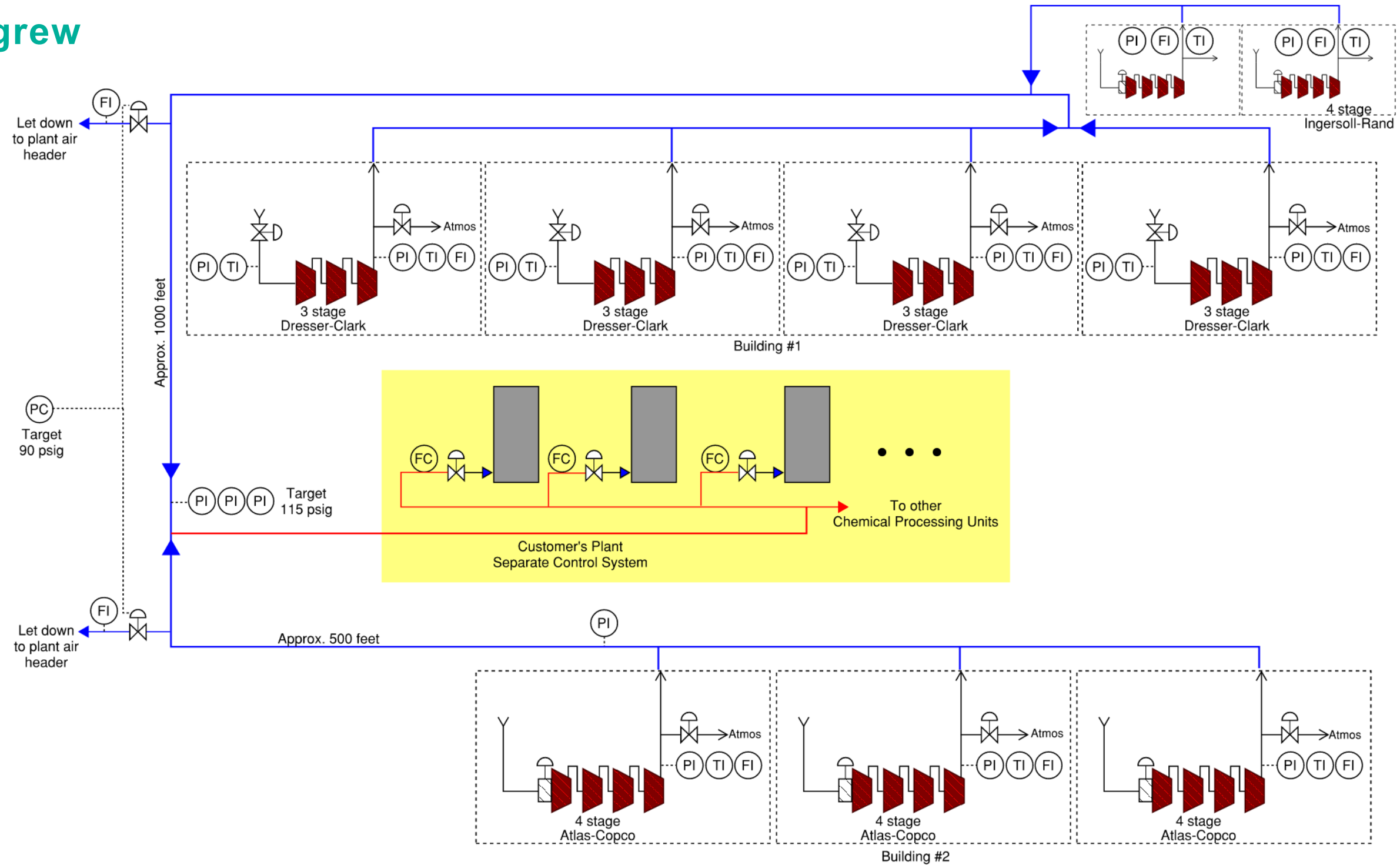
And grew



And grew



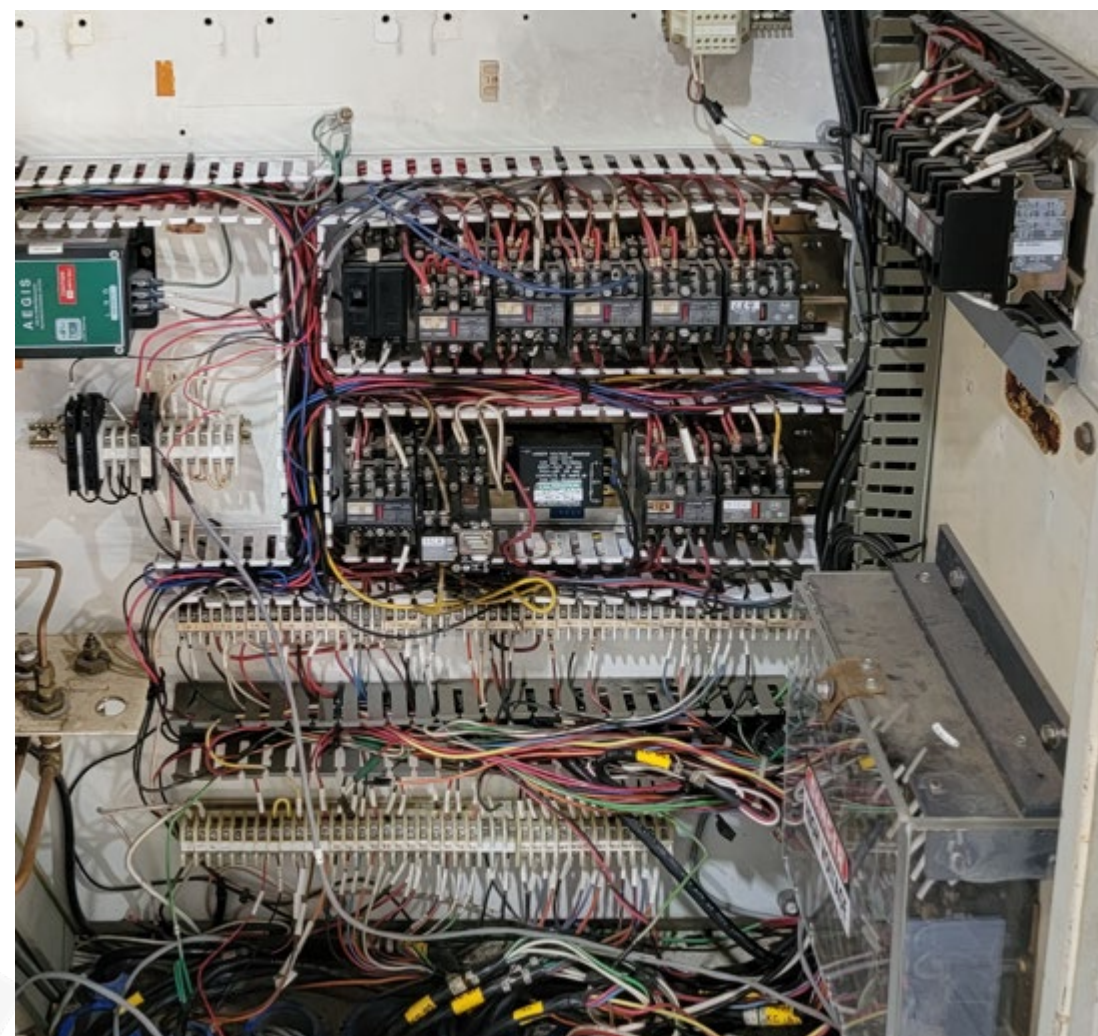
And grew



The controls were varied



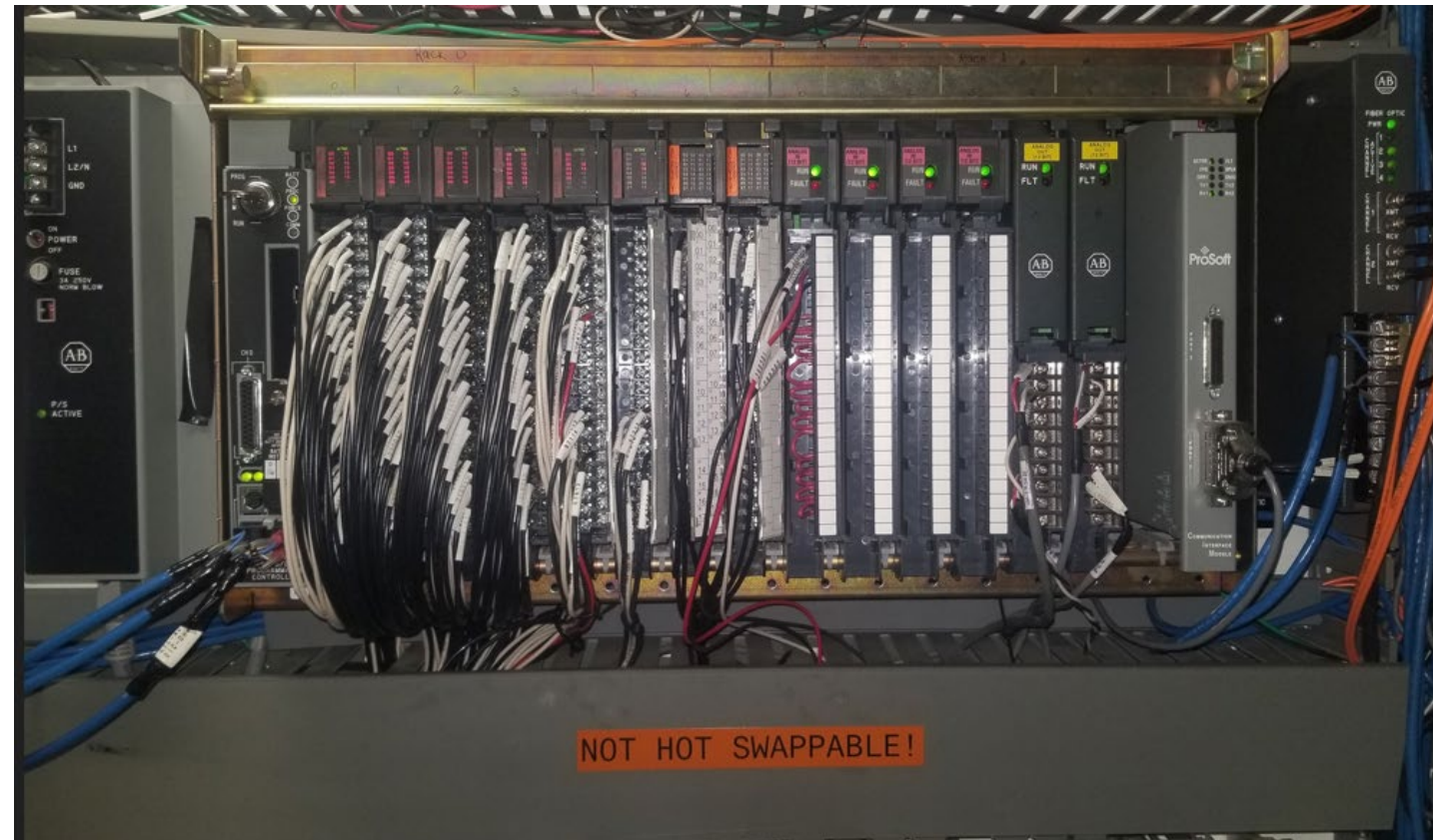
Compressor controls were relay based



The controls were varied



Newer units used Allen-Bradley PLC 5s or Control Logix



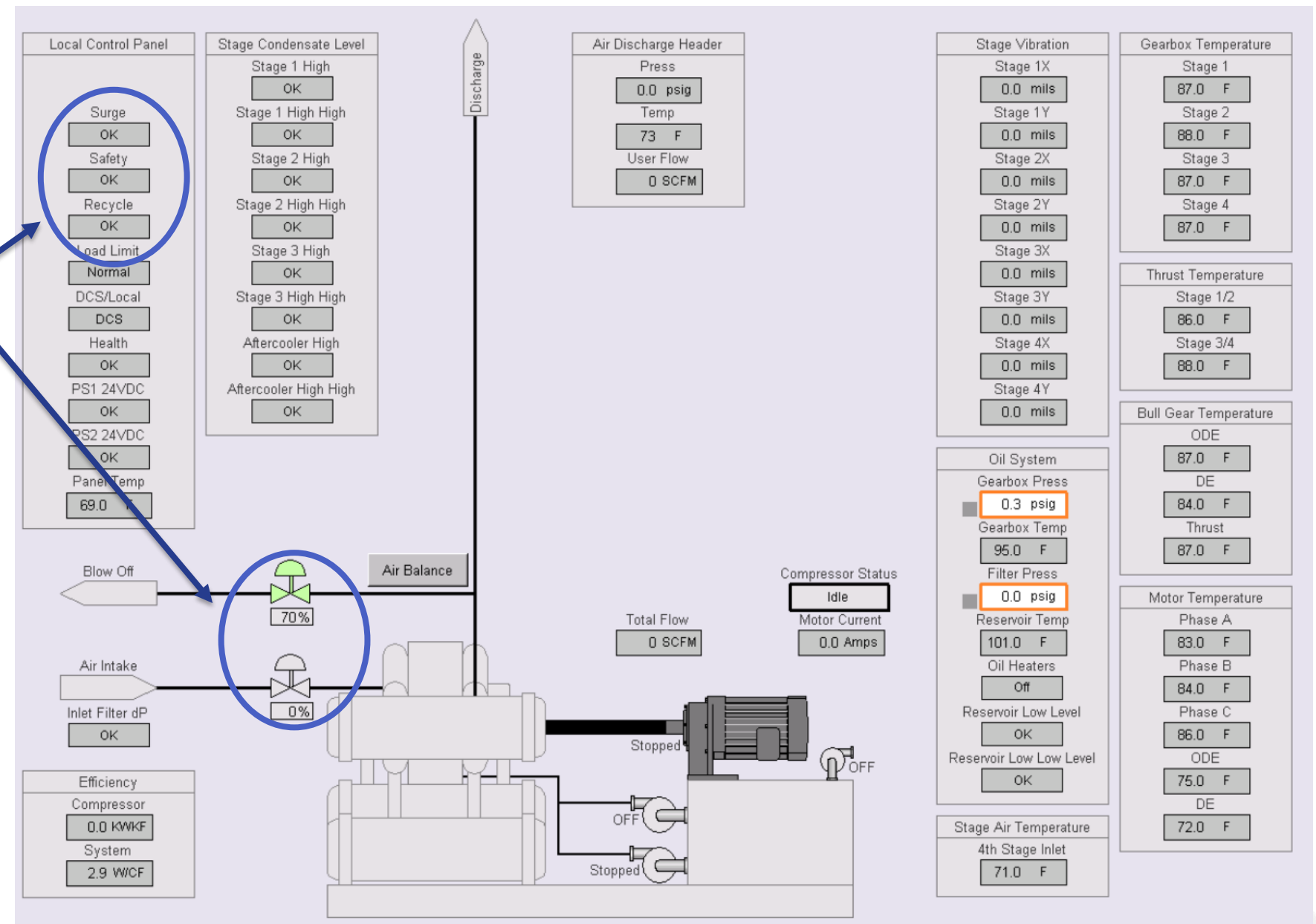
But the individual compressor surge protection and over all header control were handled by Air Misers from Compressor Controls Corporation



Latency in data

- Operations faced process upsets and downtime due to:

- Lack of compressor trip recording data in a central location.
- CCC's "Black Box" intellectual logic, which limited visibility and troubleshooting.
- Time lag between initiating event occurrence and when it gets to a central data warehouse Avena OSI PI



The Challenge

The Legacy System is a “Black Box” ...

- ALPEK needed help...
- How to keep the compressors running at peak performance during hot summer months and maintain steady pressure in the main air header.
 - CCC’s “Black Box” intellectual logic, which limited visibility and troubleshooting.
 - Requires specialized training to understand how the parameters are set in the Air Misers.
 - Requires heavy reliance on the vendor for support.
- How to reduce long downtime due to process upsets due to lack of high accuracy timestamped compressor trip data.
- The required solution needed to:
 - Offer the same functionality as CCC.
 - Provide fully transparent and accessible logic for better troubleshooting and reliability.

Standardize the control platform for each compressor

Working with Robert E. Mason (REM)
Alpek Polyester's Emerson Impact Partner...

Designed and built a standard control panel that would work with any compressor on site.

It included:

- A redundant MQ controller and classic M-series I/O for basic compressor control
- An AMS 6500 ATG vibration machine protection rack
- SOE cards to record trip information from the ATG rack and from critical equipment like the high voltage starter.
(events are timestamped at DeltaV controller time resolution)
- A VIM2 card to data mine from the ATG rack to present the data to the operator at near real time speed.



Standardize the control platform for each compressor



But what about the air header control?





The Solution

Agenda

Jose Arguello

The Solution: SmartProcess™ Compressor Control by DeltaV

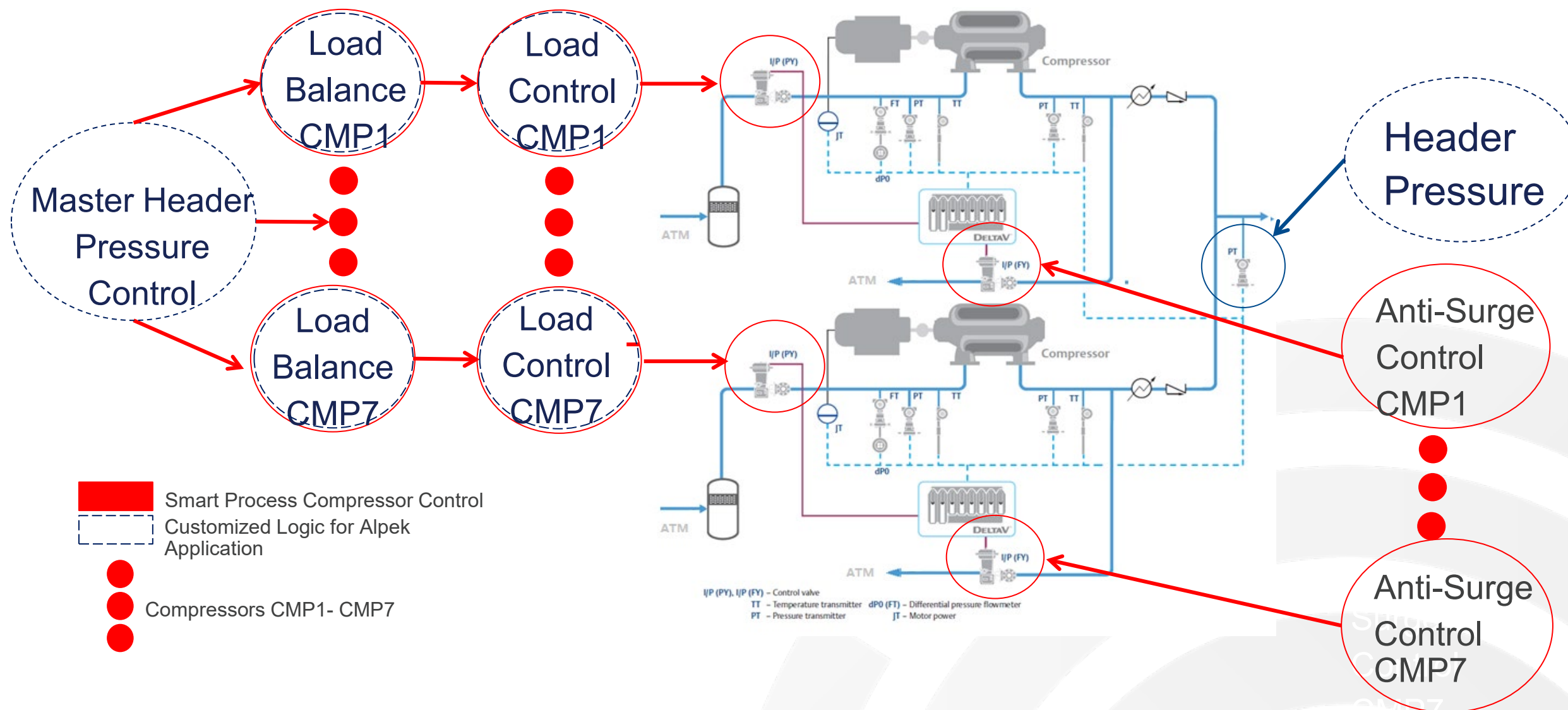
The Solution

SmartProcess™ Compressor Control by DeltaV

- ALPEK decided to replace the CCC controls with Emerson's SmartProcess™ Compressor Solution running on a standard DeltaV MQ controller.
- A four-phase program was initiated in October 2021 to migrate the controls of seven centrifugal air compressors operating in parallel.
- The goal was to transition from the legacy CCC control to the new Emerson solution.
- The first air compressor migration was commissioned in March 2022, utilizing:
 - Emerson's SmartProcess™ Compressor Solution
 - Emerson's EnTech Toolkit
 - AMS 6500 ATG vibration monitoring and protection

The Solution

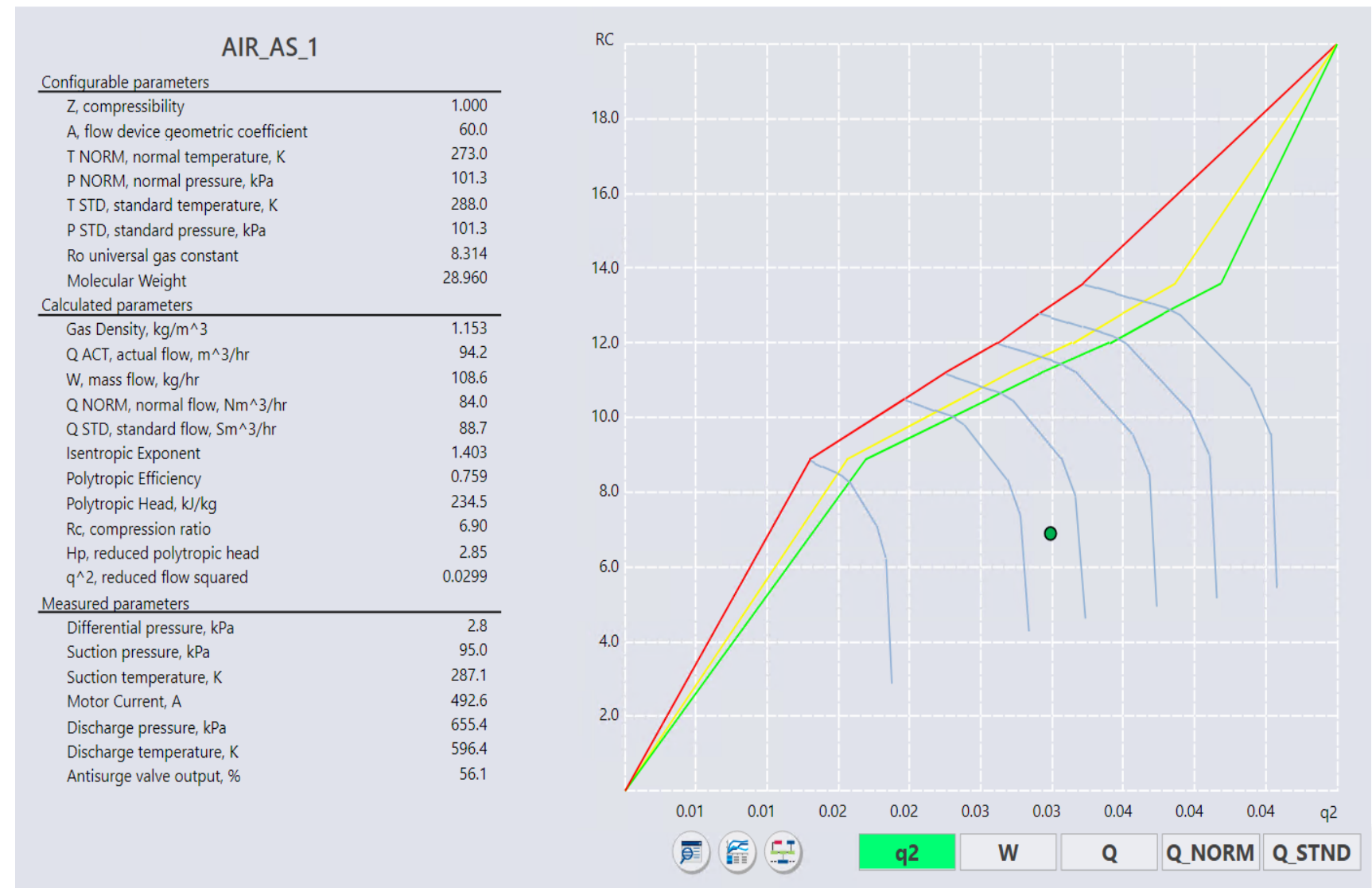
SmartProcess™ Compressor Control by DeltaV Solution Diagram



The Solution

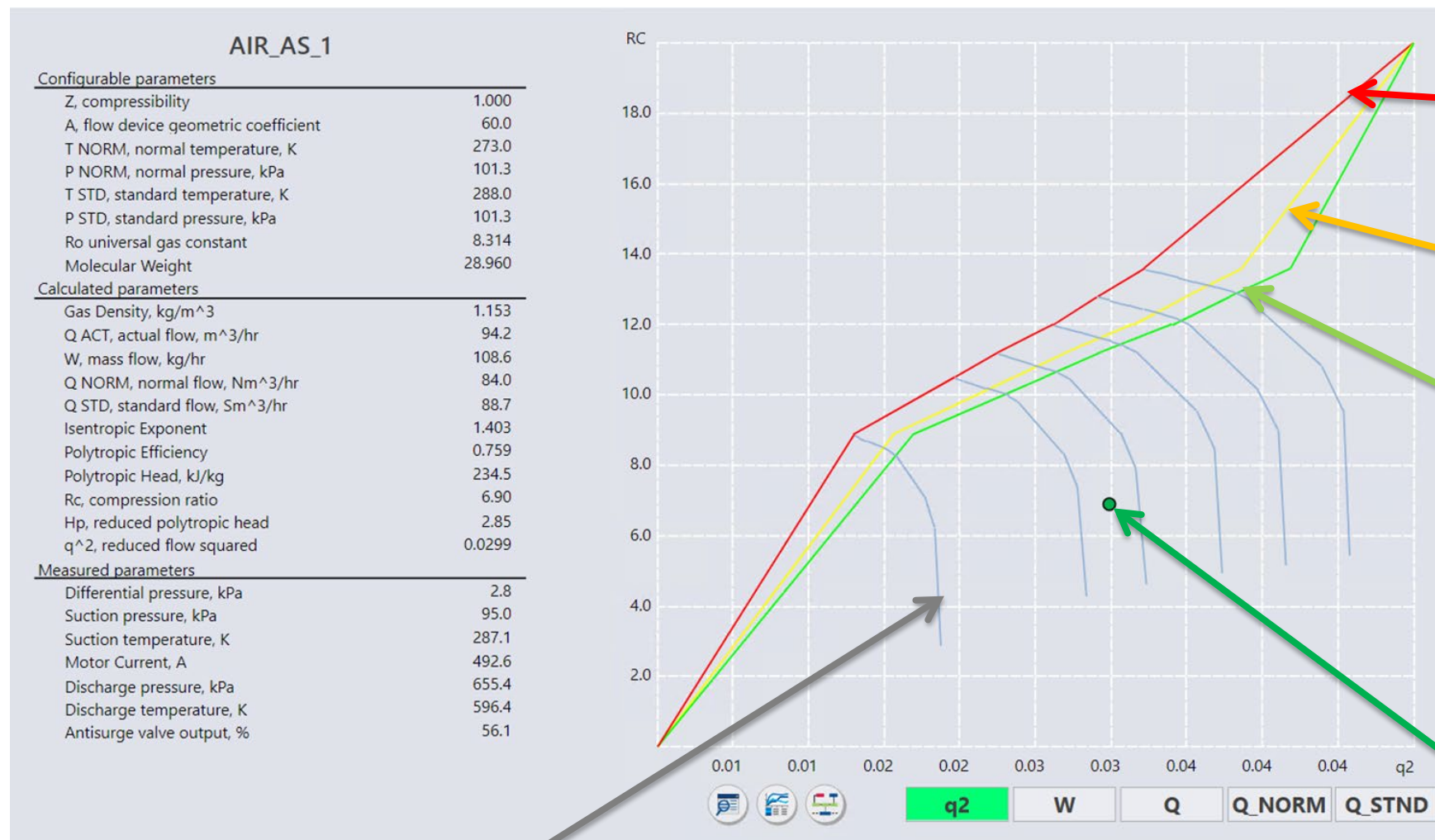
SmartProcess™ Compressor Control by DeltaV

- Automated load/unload/ESD
- Limiting Loops
- Load Control
 - Fallback
 - LoadShare
- Header Pressure Control
 - Load Balance
- Anti-Surge Control
 - Operating Point Calculation
 - Dynamic Compressor Mapping



The Solution

SmartProcess™ Compressor Control by DeltaV



Compressor
Surge Line (Valve
After Surge)

SOS (Safety
Open Step)

Control Line (OP
Setpoint)

OP (Operation
Point)

Compressor Performance Line

Agenda

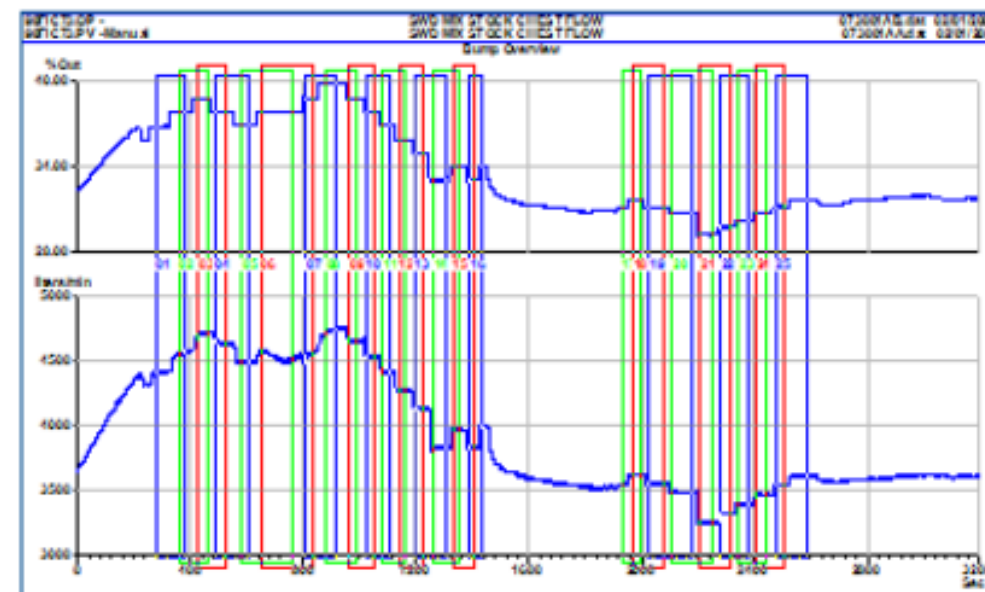
Juha Lehtinen

The Solution: Surge Testing and Tuning

The Solution

Entech Toolkit

- Collect
 - OPC Communication



- Analyse

- Tuner

Tuning Parameters

Loop Overview

Area: VPM2Blend Chest
 Tag: 90FK73.PV [SWD MIX STOCK CHEST FLOW]
 Pv: 0 to 9000 liters/min, Op: 0 to 100 %Out
 Process: Flow, Stock
 Response: 1st Order
 Parameters: Kp=1.56 %Span/%Out, Td=2.17 Sec, Tau1=2.89 Sec
 Actuator: Valve, Pneumatic, Class: 1 (Poor)
 Controller: Foxboro IA System [D on Pv]
 Classical PID (D on Pv), [Units=%Out/%Span], [Ctrl Int.=0.1 Sec]

Tuning Rule: Suggested: PI (P-Z Cancellation) Click Accept button to allow calculation of Controller Settings

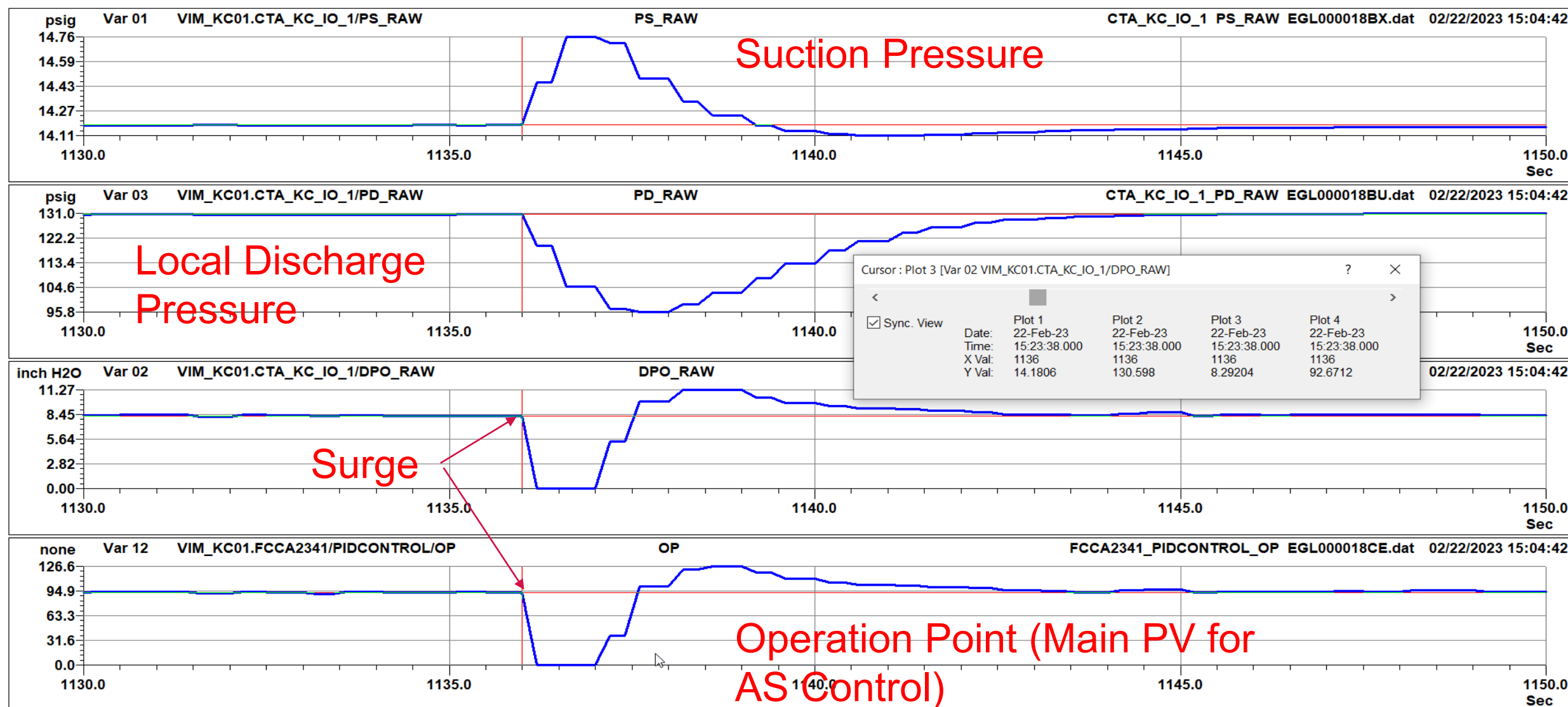
Lambda: 8.6673

Approx. Load Corner Period: 68.102

Controller Settings		Lambda Range	
Tuning Rule	PI (P-Z Cancellation)	Minimum Lambda Limit is 2.1714 Sec.	
Input Filter	<0.01445 Min	Due to the process deadline, the Aggressive Lambda Value is 3.496 Sec.	
Proportional	583.7 %Band	Suggested Lambda Value is 8.6673 Sec.	
Integral	0.04815 Min/Rep		
Derivative	None Min		
Ctrlr Filter	None Sec		

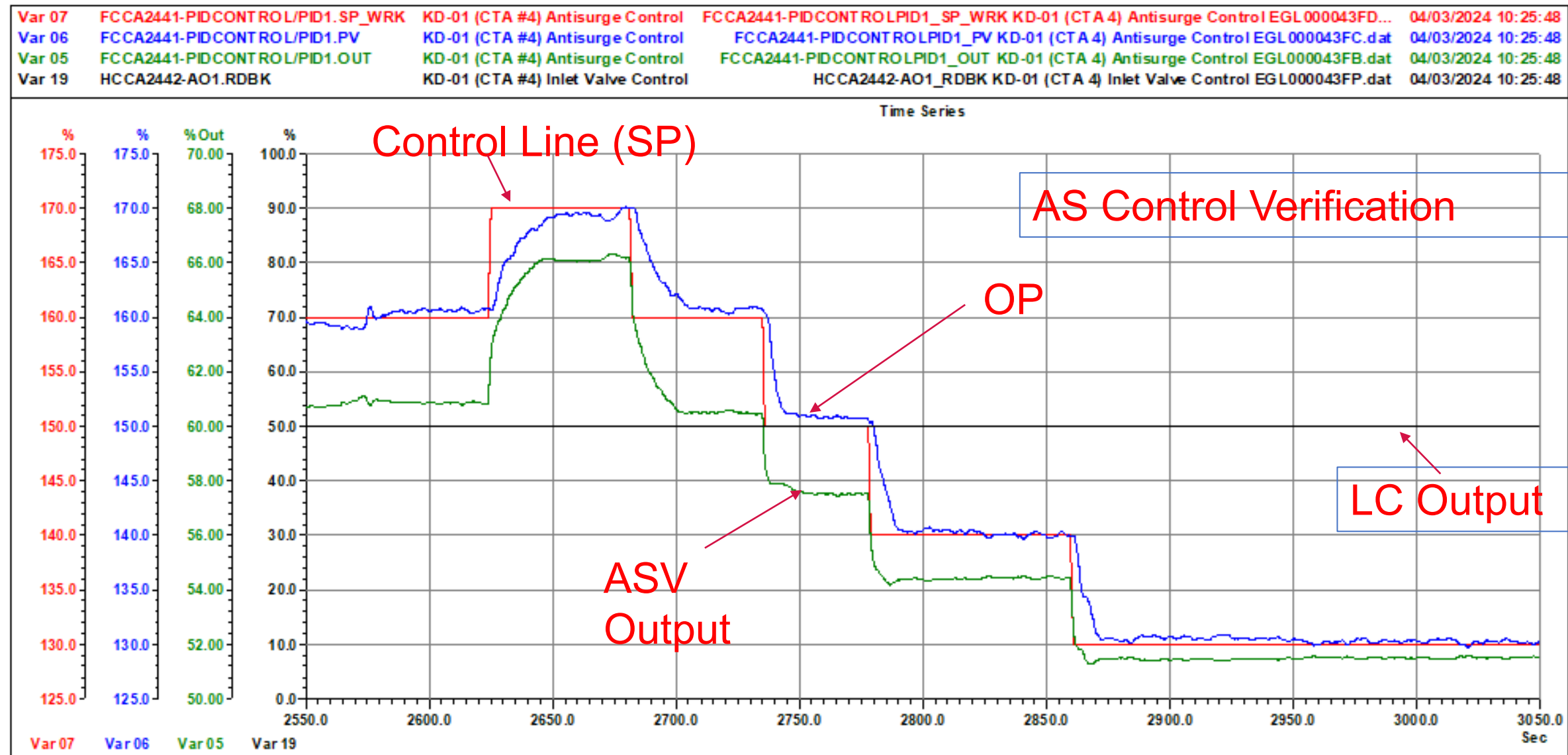
The Solution

Surge Testing and Tuning (EnTech ToolKit Collect)



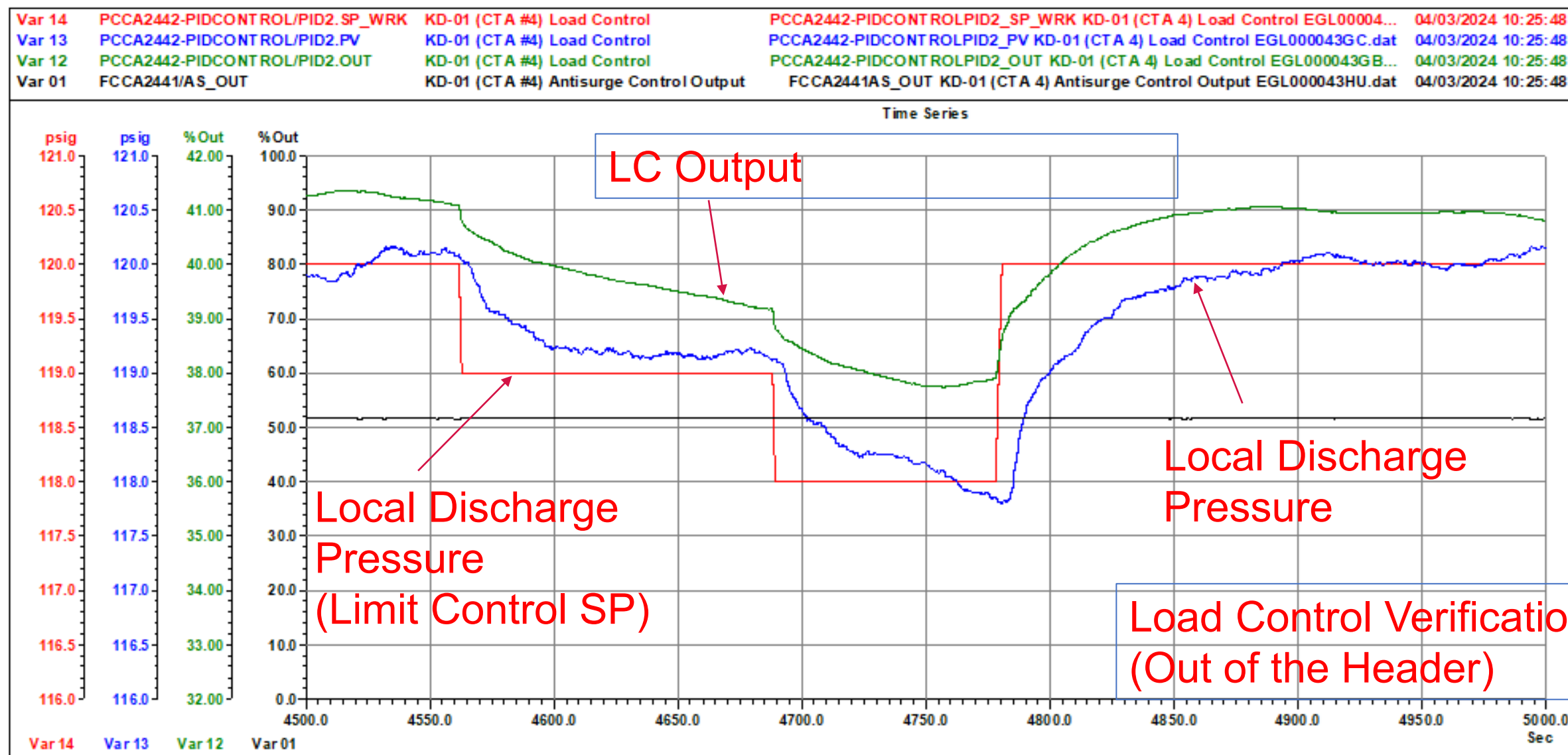
The Solution

Surge Testing and Tuning (EnTech ToolKit Analyse)



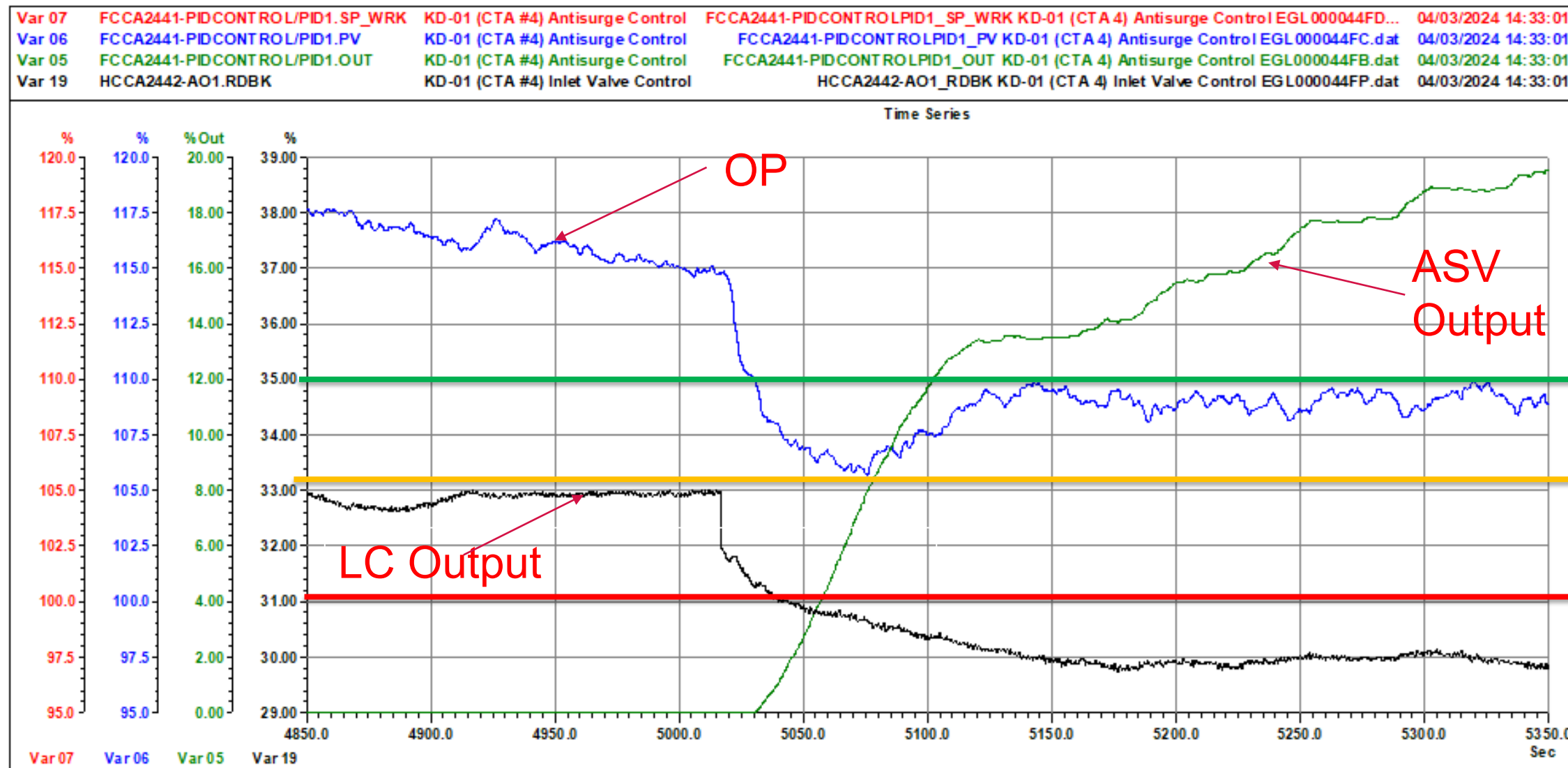
The Solution

Surge Testing and Tuning (EnTech ToolKit Analyse)



The Solution

Surge Testing and Tuning (EnTech ToolKit Analyse)



AS Regulatory Control (In the Header)

Agenda

Jose Arguello

The Solution: Load Control

Jose Arguello

The Solution: Load Balance

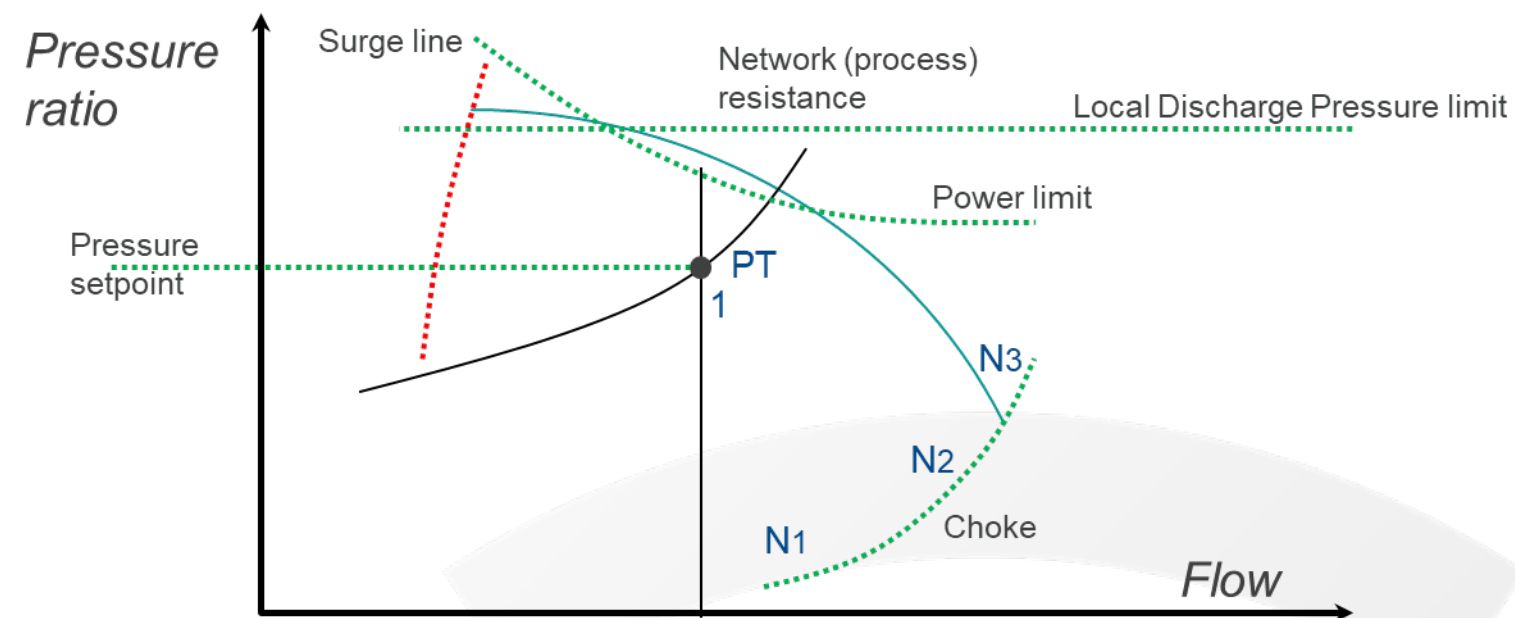
Jose Arguello

The Solution: Master Header Pressure Control

The Solution

Load Control

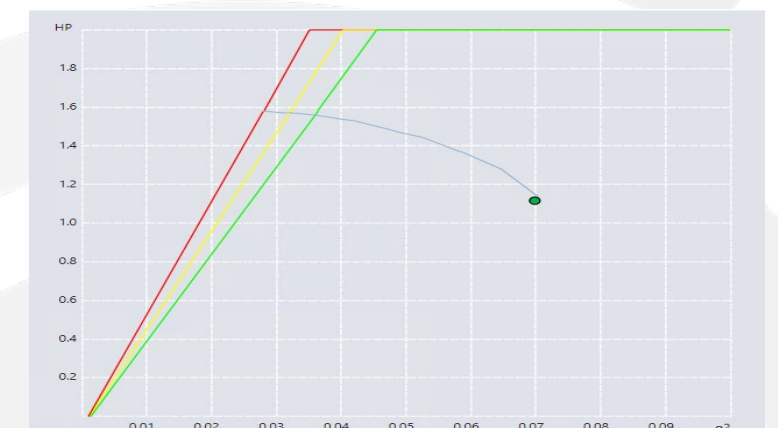
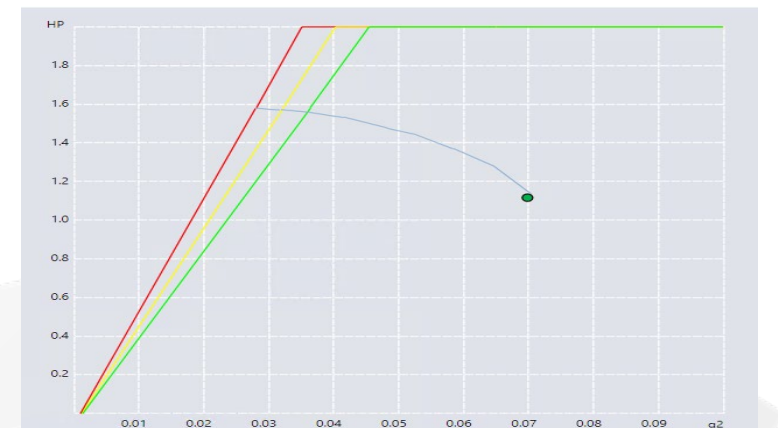
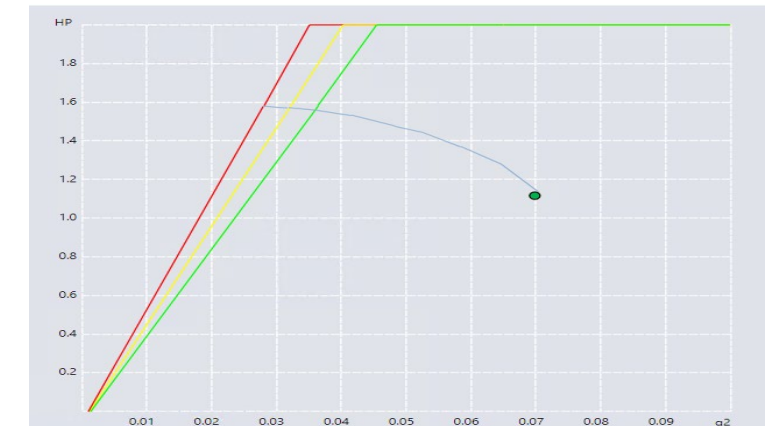
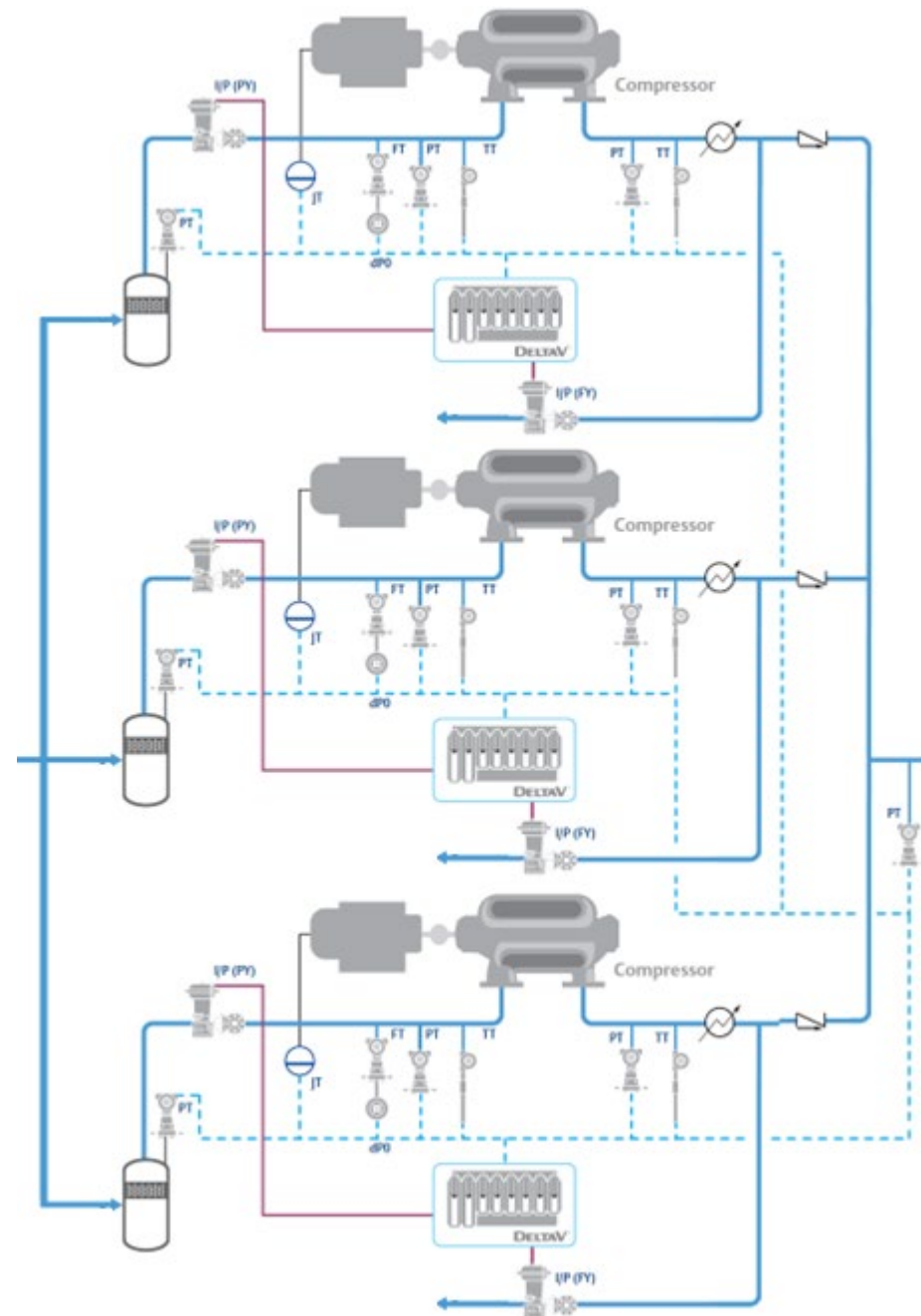
- Main PI control loop.
- On Fallback Mode each compressor main PI Control loop switches to control local Discharge Pressure.
- On LoadSharing Mode each compressor main PI control is bypassed and reads the output from Master Header Pressure Control.
- Limiting Loops (Local Discharge Pressure, Motor Power, Header Pressure).
- Automated load/unload/ESD sequences.
- Linearized Load Control.



The Solution

Load Balance

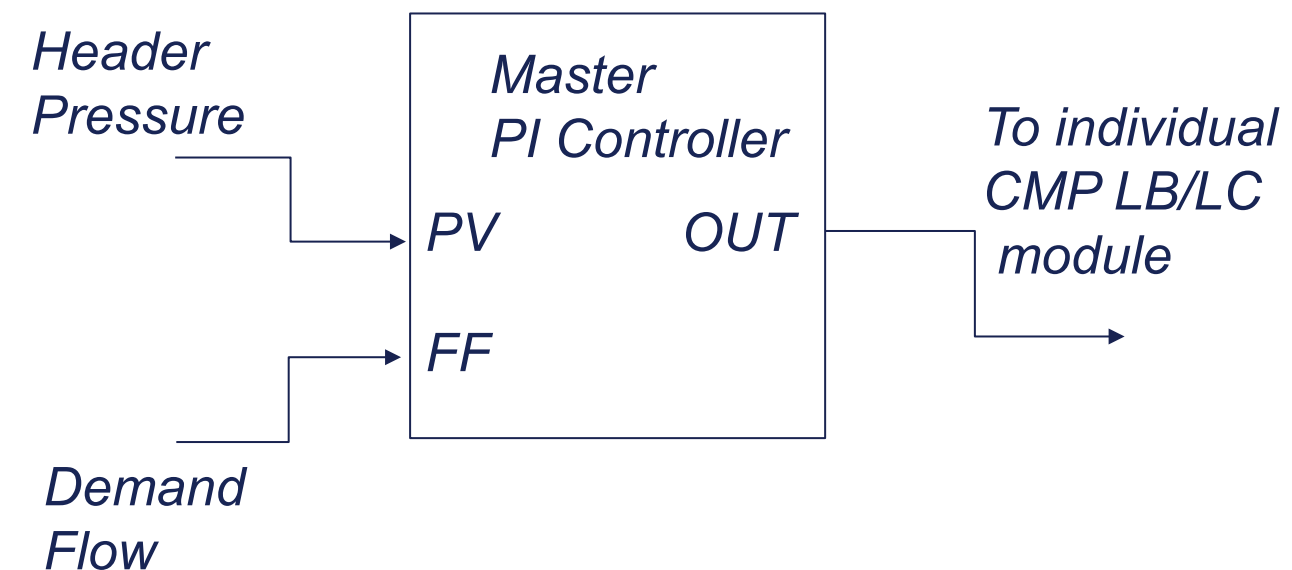
- Calculates Average Control Line from all compressors in Load Share mode and compensates proportionally on each Load Control output to reach same distance to Control Line in Load Share Mode.
- Temporary Low Clamp set on TV/IGV when Master Control drives compressors near control line.



The Solution

Master Header Pressure Control

- Master PI Controller.
- Main Feedback control loop (Header Pressure) is assisted by feedforward control (demand flows).
- Output of Master PI Controller is propagated proportionally to each Compressor's Throttling valve /Inlet Guide Vane on LoadShare Mode.
- Gain Scheduling provided for each Compressor Load Control on LoadShare Mode.
- DeltaV Splitter box functionality with native signaling between Master Control and each Compressor Local Control.





Results

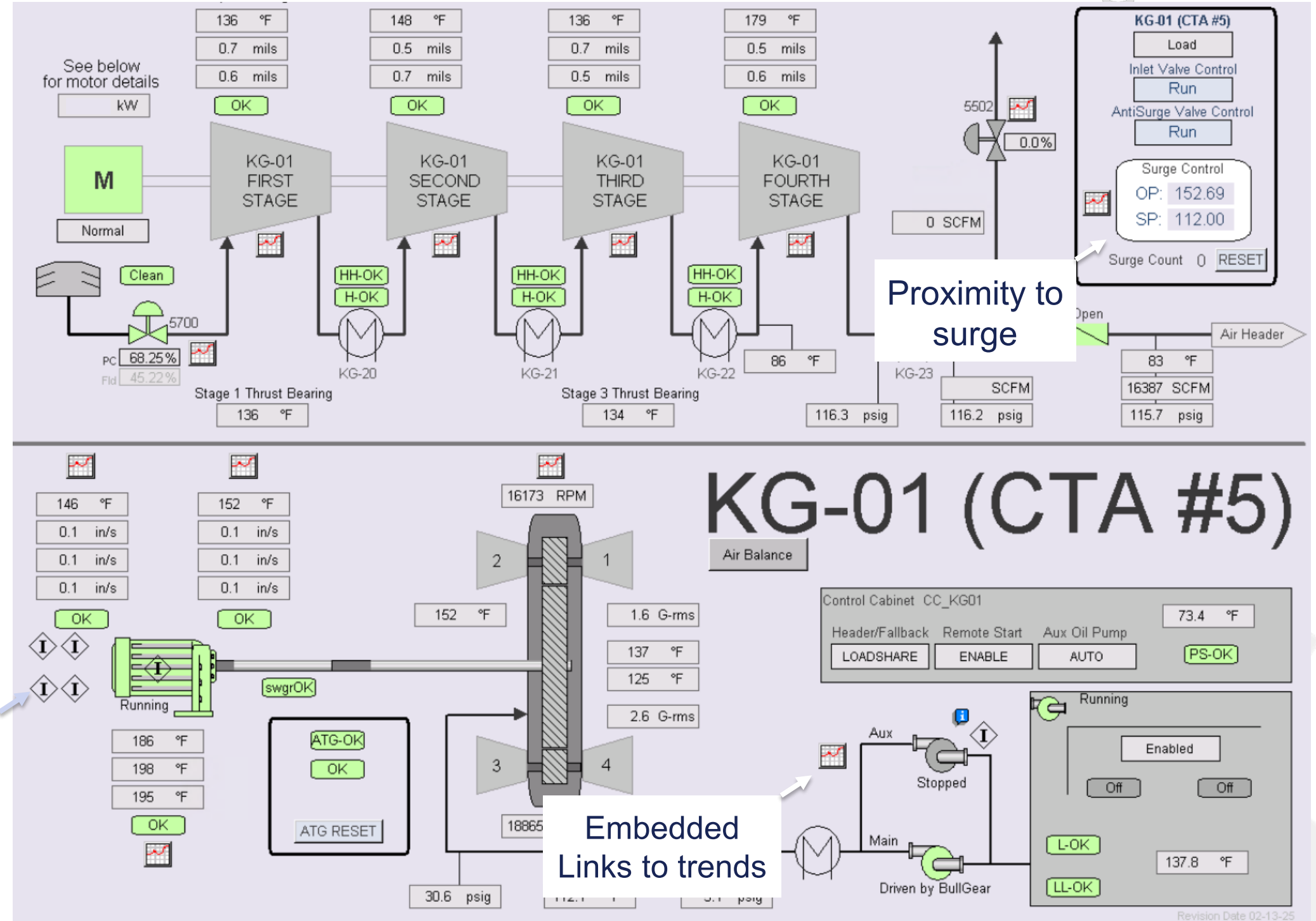
Agenda

Chris Williams

Results

Results

- Better Visibility on current compressor status



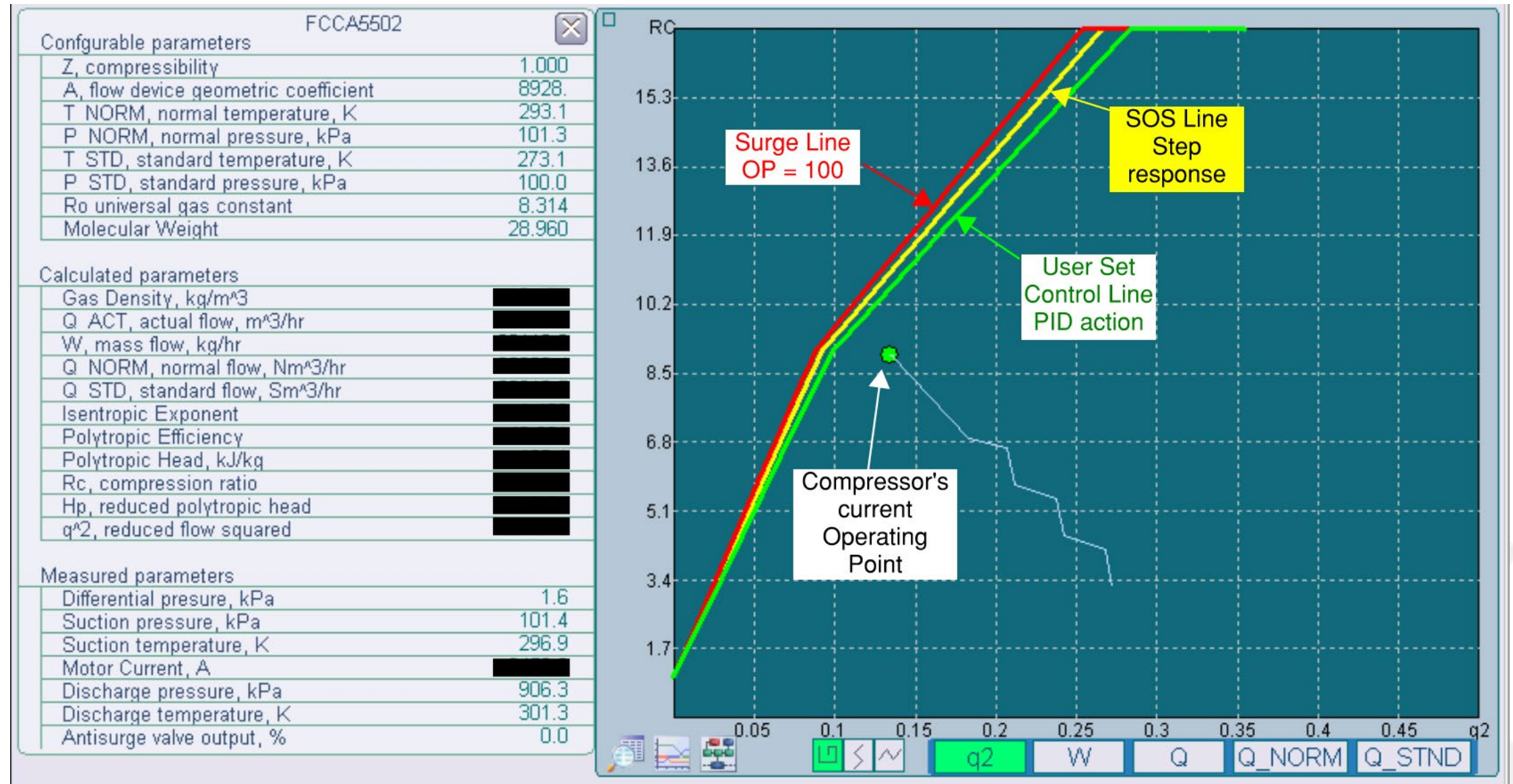
True First Out

Embedded Links to trends

Proximity to surge

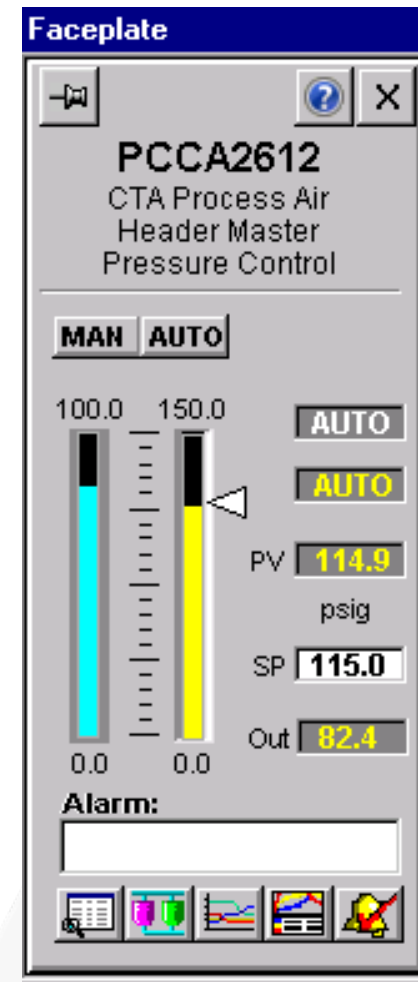
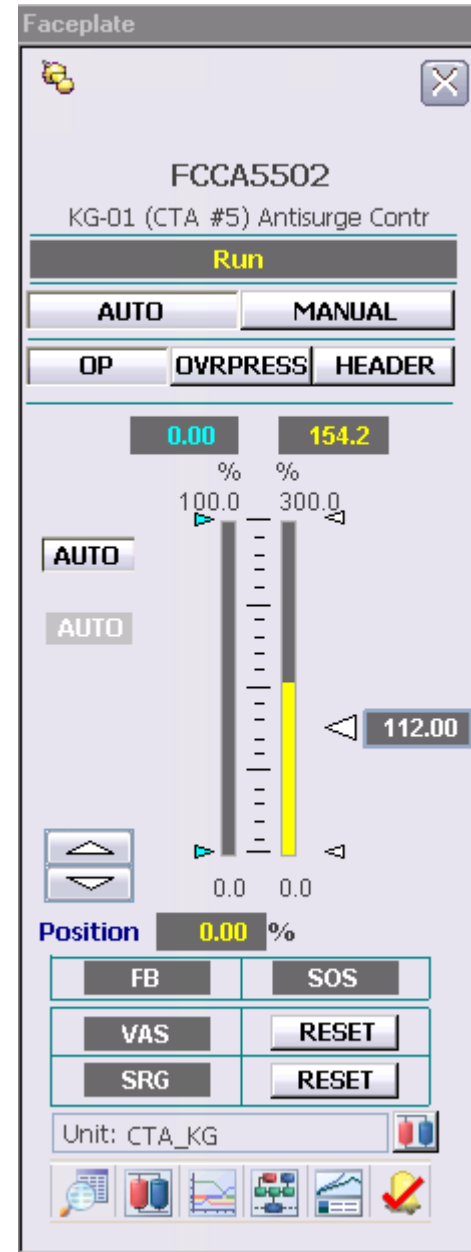
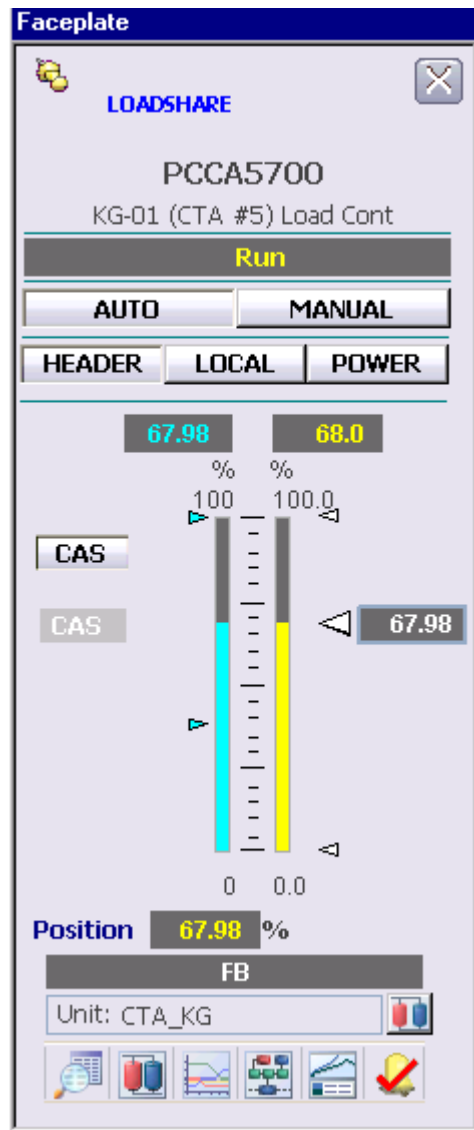
Results

- Better Visibility on current compressor status



Results

- Familiar DeltaV DCS faceplates for the load control valve and for the antisurge controller



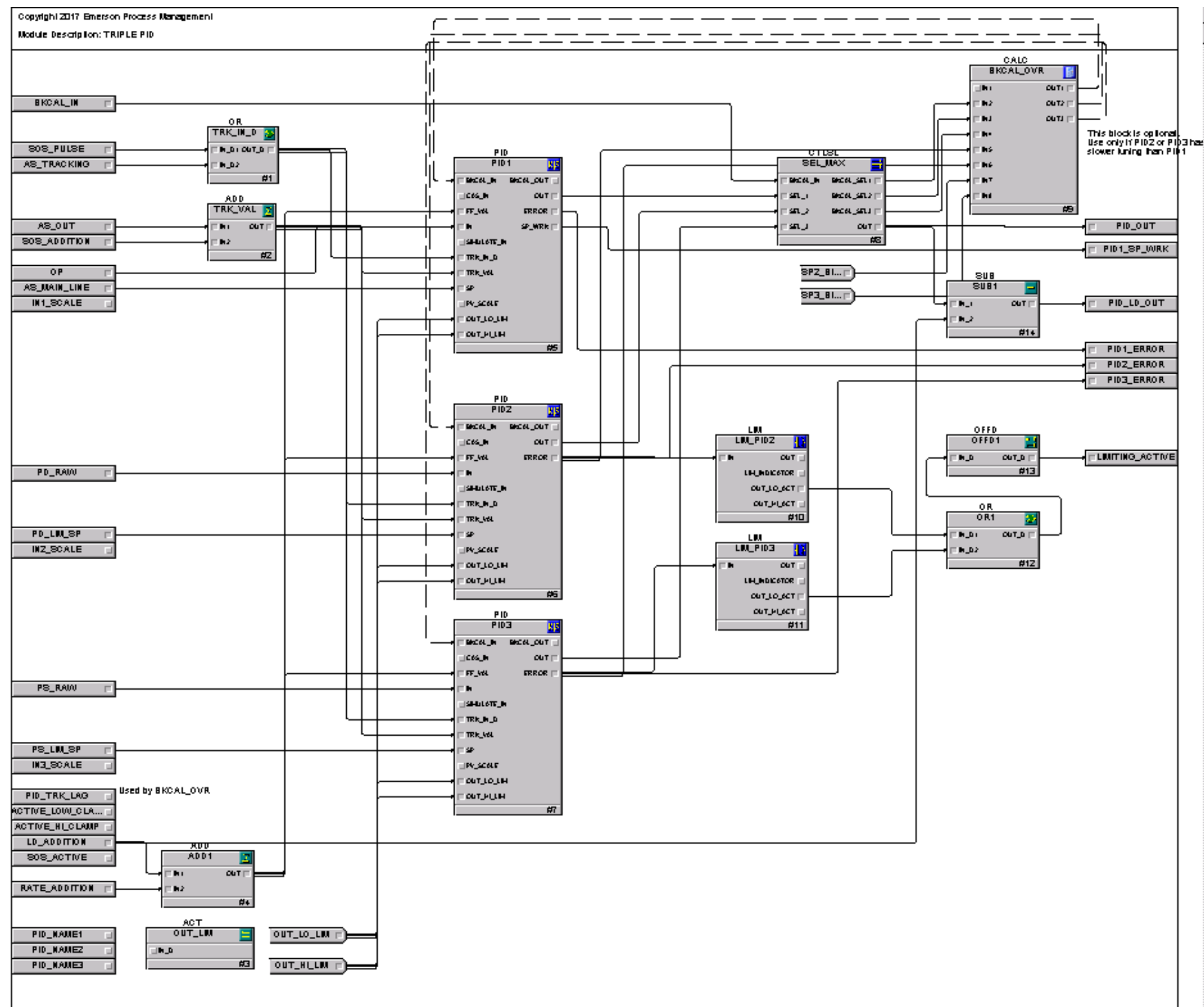
- Standard tuning constants

Detail
PCCA5700
KG-01 (CTA #5) Load Control
PID LD Misc

Tuning Parameter	HEADER	LOCAL	POWER
Gain	0.50	0.50	0.07
Reset	6.0 s	3.3 s	1.5 s
Rate	0.0 s	0.0 s	0.0 s
PV Filter TC	0.5 s	0.0 s	0.5 s
SP Filter TC	0.0 s	0.0 s	0.0 s
SP Rate DN	1.0 EU/s	1.0 EU/s	50 EU/s
SP Rate UP	1.0 EU/s	0.1 EU/s	50 EU/s
I Deadband	0.1	0.0	0
FF Gain	1.00	1.00	1.00

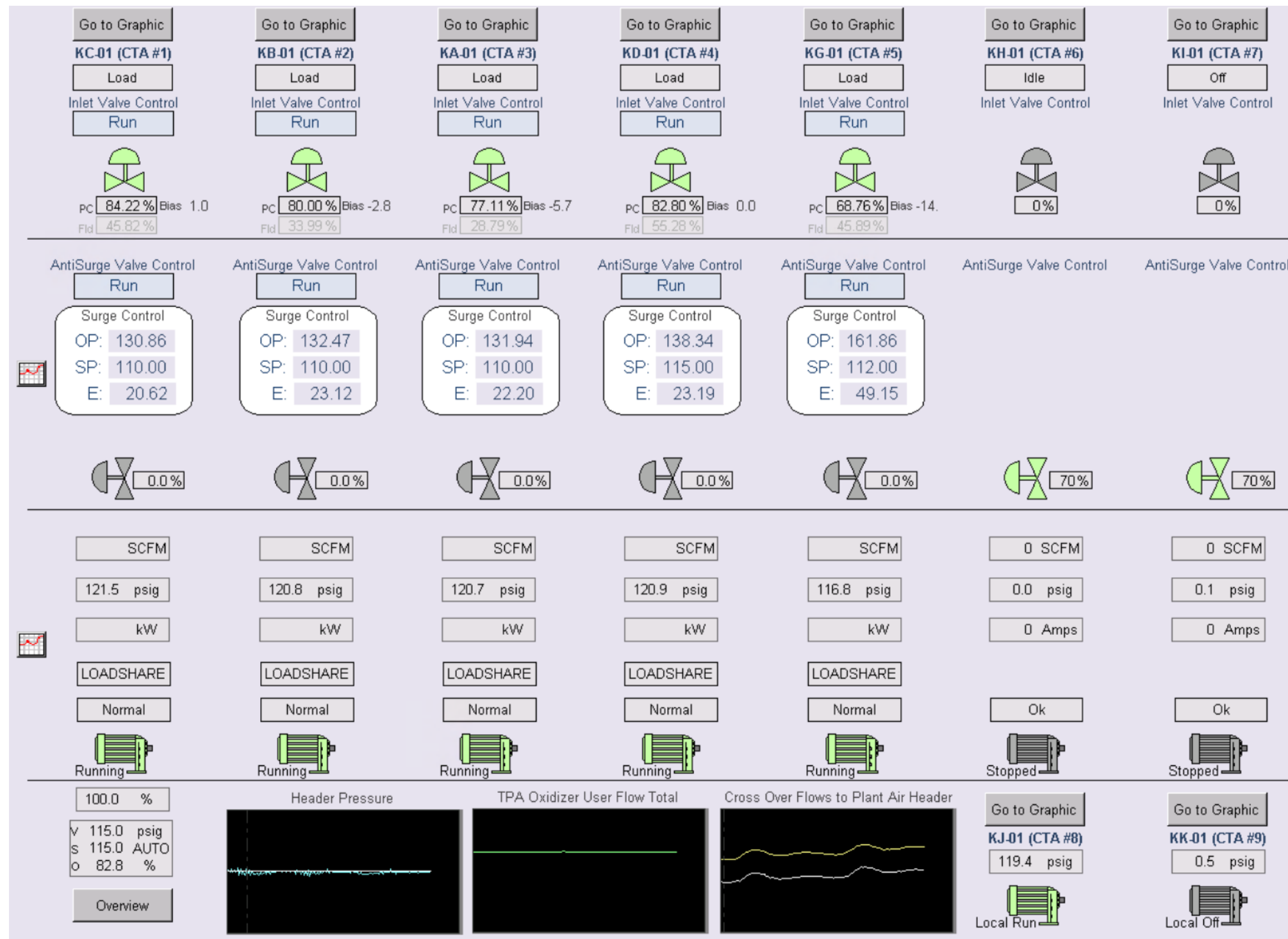
Results

- All code visible if you want to look under the hood both offline and online



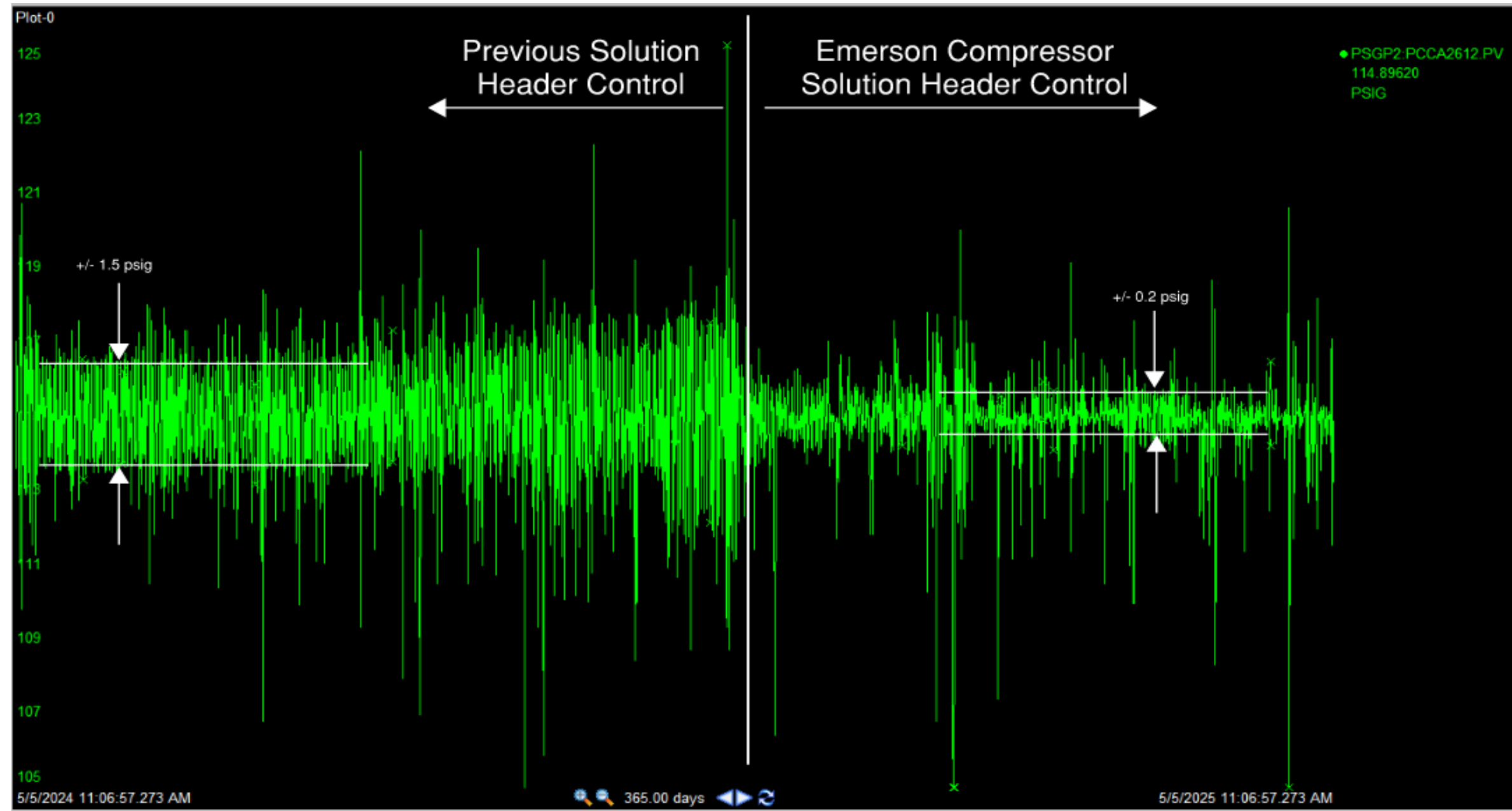
Results

- Since code is accessible, you can build custom graphics so you can see the data you want how you want to see it



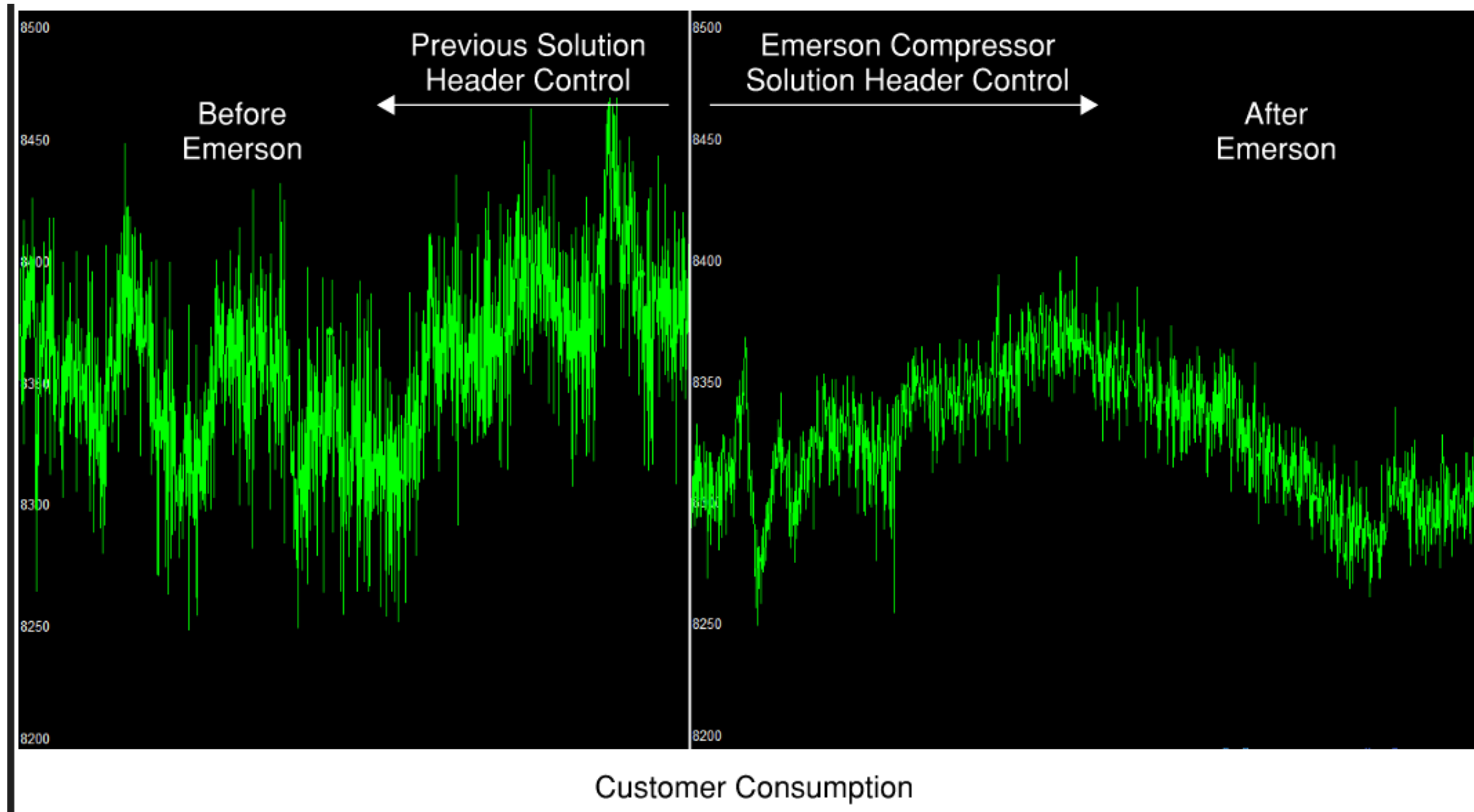
Results

- Reduced header pressure variance



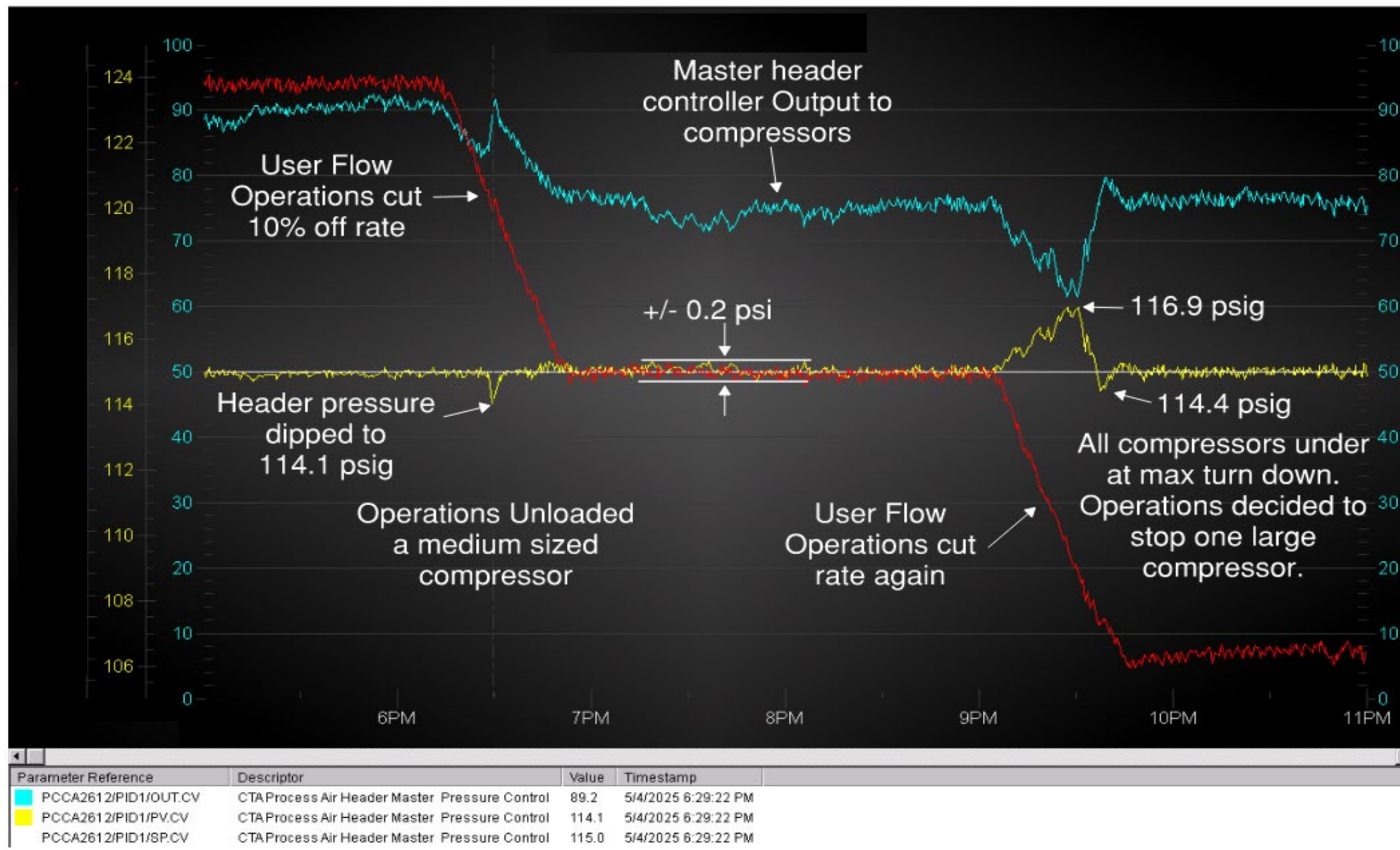
Results

- Improved customer air flow consumption stability



Results

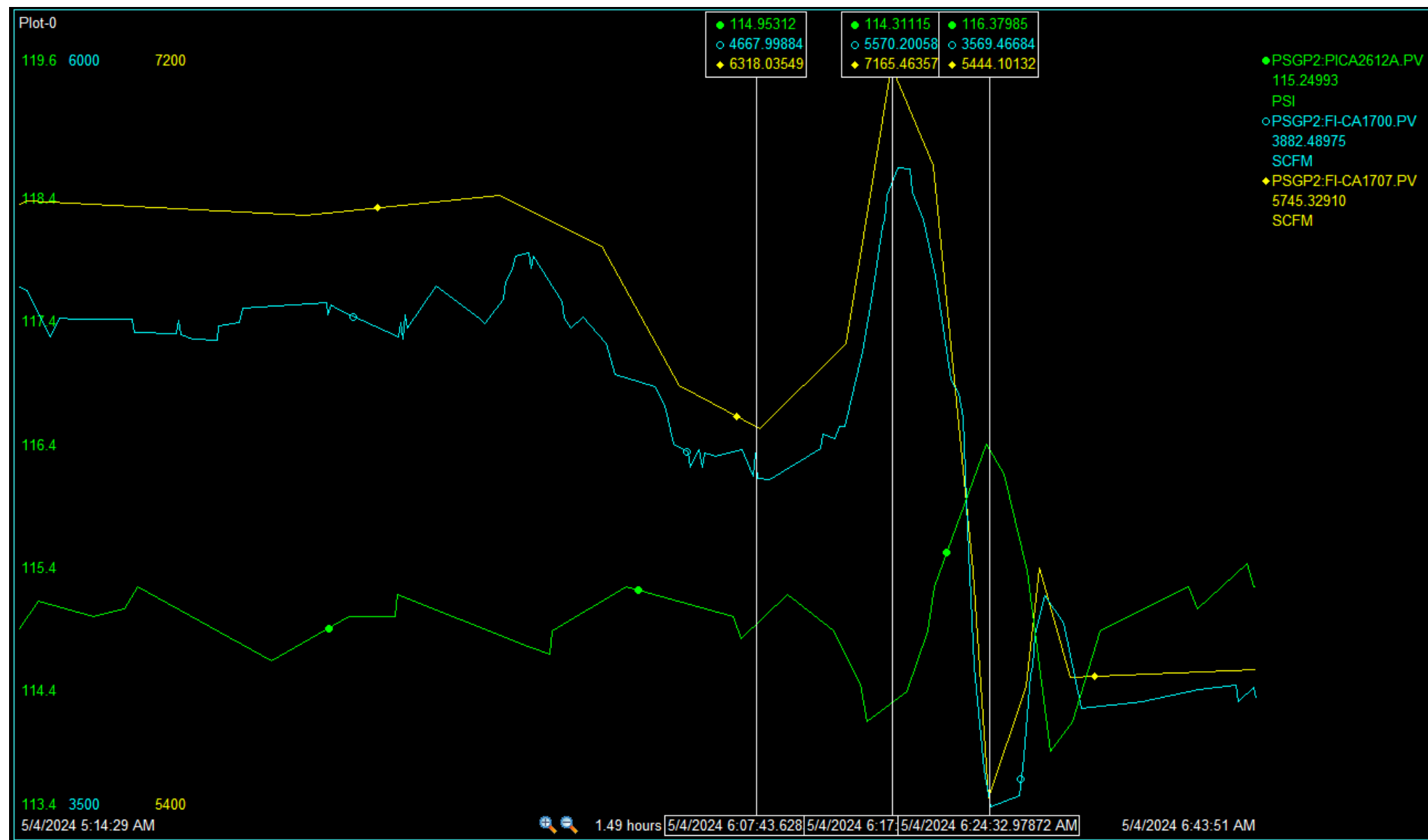
- Good response to customer rate changes



Results

- Header response to plant air user flow change before Emerson Header Control.

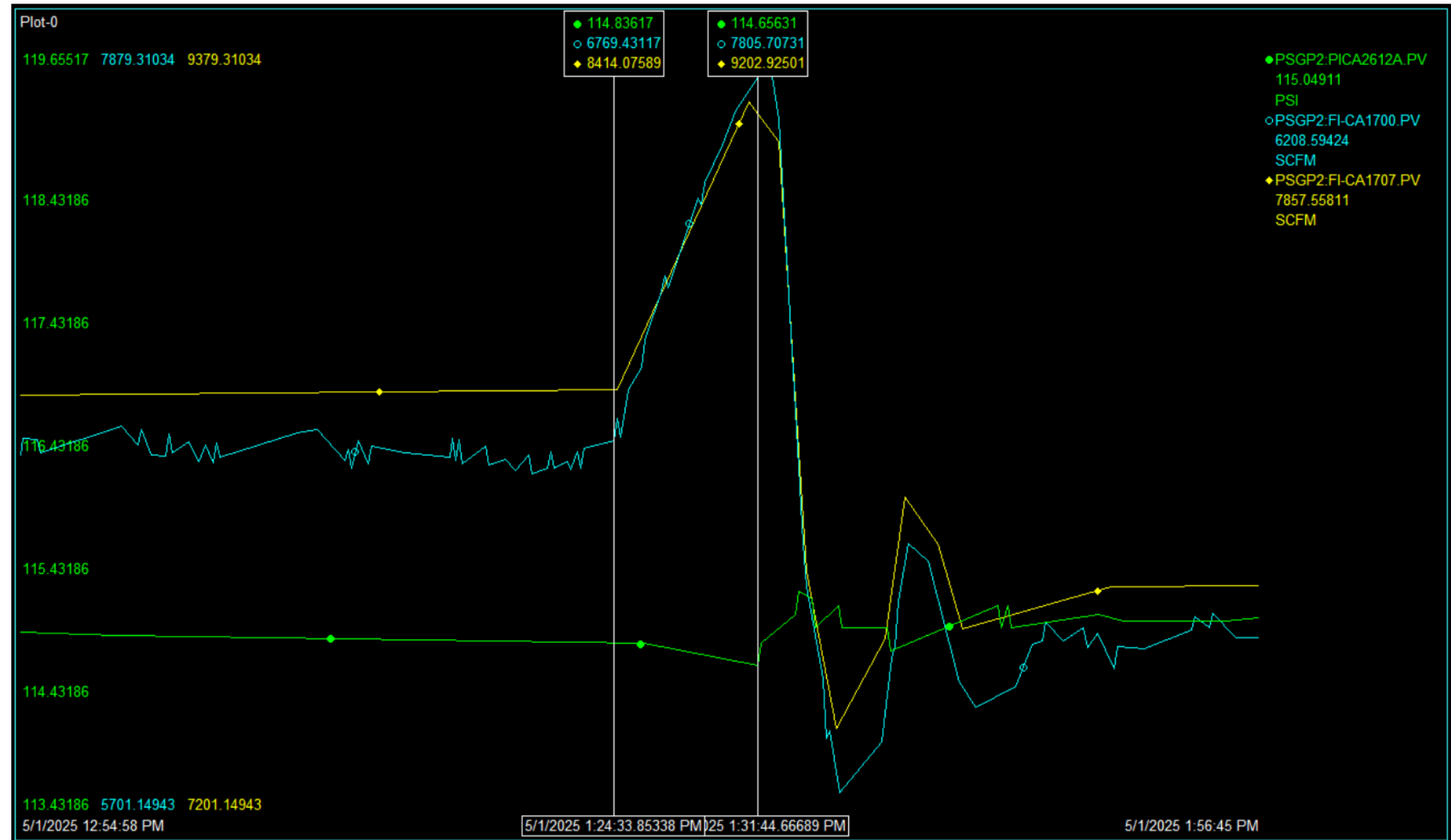
Note the variations in the header pressure in response to the plant air flow changes.



Results

- Header response to plant air user flow change after Emerson Header Control.

Note the much smaller deviation in header pressure (green line)



Results - Summary

- Elimination of the “black box problem” improved Compressor Operation due to access of compressor mapping and new faceplates and access to logic ease troubleshooting burden on plant engineers.
- Tighter antisurge margin allowed a wider operation range.
- Surge testing allowed to precisely map compressor’s surge curves and set the configuration parameters for best safety and efficiency.
- Visibility of each compressor’s performance allowed decisions to be made regarding the unit’s mechanical condition.
- Optimized compressor response by adding linear behavior to the valve characteristic curve.
- Header Pressure variability was reduced due to the faster reaction of the compressors.
- The software is native to Emerson DeltaV, running on the same controller as the basic process control.
- Tight integration with the AMS 6500 ATG vibration protection unit via M-series SOE cards ensures all compressor actions are documented and easily traceable.

Find More Information

SmartProcess™ Compressor Product Data Sheet

Web Link: <http://www.emerson.com/documents/automation/1510338.pdf>

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Thank You