



OCTOBER 25, 2023

A Journey Towards Compression Advanced Asset Performance Management

Talk 1: SoCalGas - A Journey Towards Compressor Predictive Analytics

Talk 2: Process Innovations: Modern AVEVA PI System Implementation with Process Innovations

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Joseph Rose – Project Manager, SoCalGas

Caleb Sargent – VP Operations, Process Innovations





A JOURNEY TOWARDS COMPRESSOR PREDICTIVE ANALYTICS

AVEVA WORLD 2023

Nawar Fattah
Joseph Rose



Agenda



Challenges



How to monitor and optimize Compressor Fleet performance?



Viewing the fleet performance from a high level



Monitoring for ongoing performance decreases



How can we predict failures and prevent them?



Securing our Data



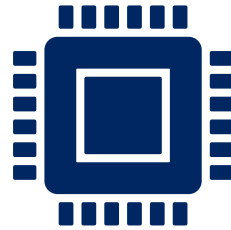
Anomaly detection requires detailed input to train models



The Solution



A compressor performance dashboard that integrates data from multiple sources and provides real-time insights and alerts



A customizable PI System platform that uses PI AF template plug-ins and detailed compressor maps to analyze and visualize data



Service providers that offers expertise and support for dashboard implementation and maintenance

Implementation

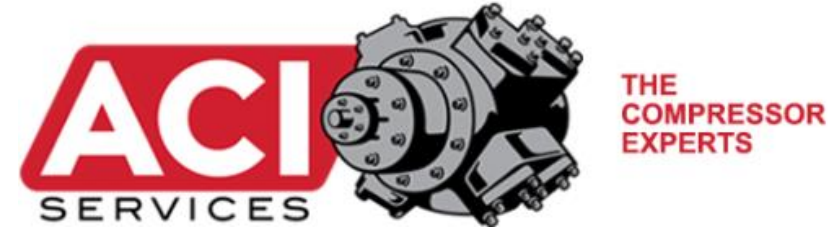


Data Quality: Checks the validity and accuracy of data

Compressor Map: Plots the operating point of a compressor on a map based on its specifications

Efficiency: Calculates the efficiency of a compressor based on its operating conditions

Load Step: Measures the load step response of a compressor



Leading provider of compressor performance software and services

Extensive knowledge and experience in creating and validating compressor maps

Custom compressor maps to suit different types of compressors and applications

Compressor Fleet Dashboard (PI Vision)



Compressor Services: Gather compressor maps/curves, verify and ensure data points and accuracy, & categorize failure types and causes.

Integrity Management: Gather KPI's and propose projects for increased efficiency, reduced emissions, & report potential failure conditions.

Subject matter experts in rotating & reciprocating machinery evaluate equipment performance and optimization



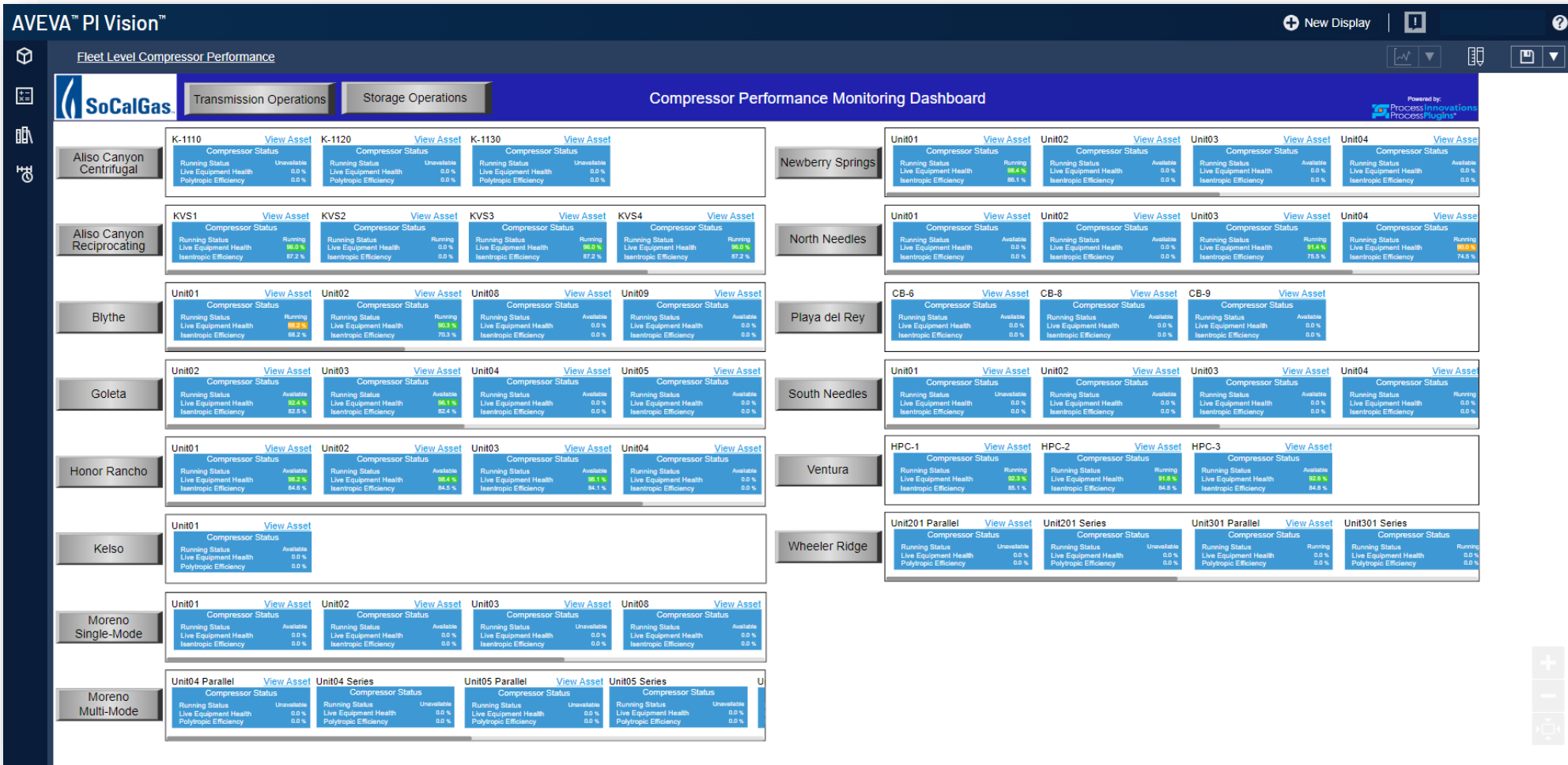
AVEVA PI System

AVEVA PI Vision

AVEVA PI AF

AVEVA PI Event Frames

Dashboard



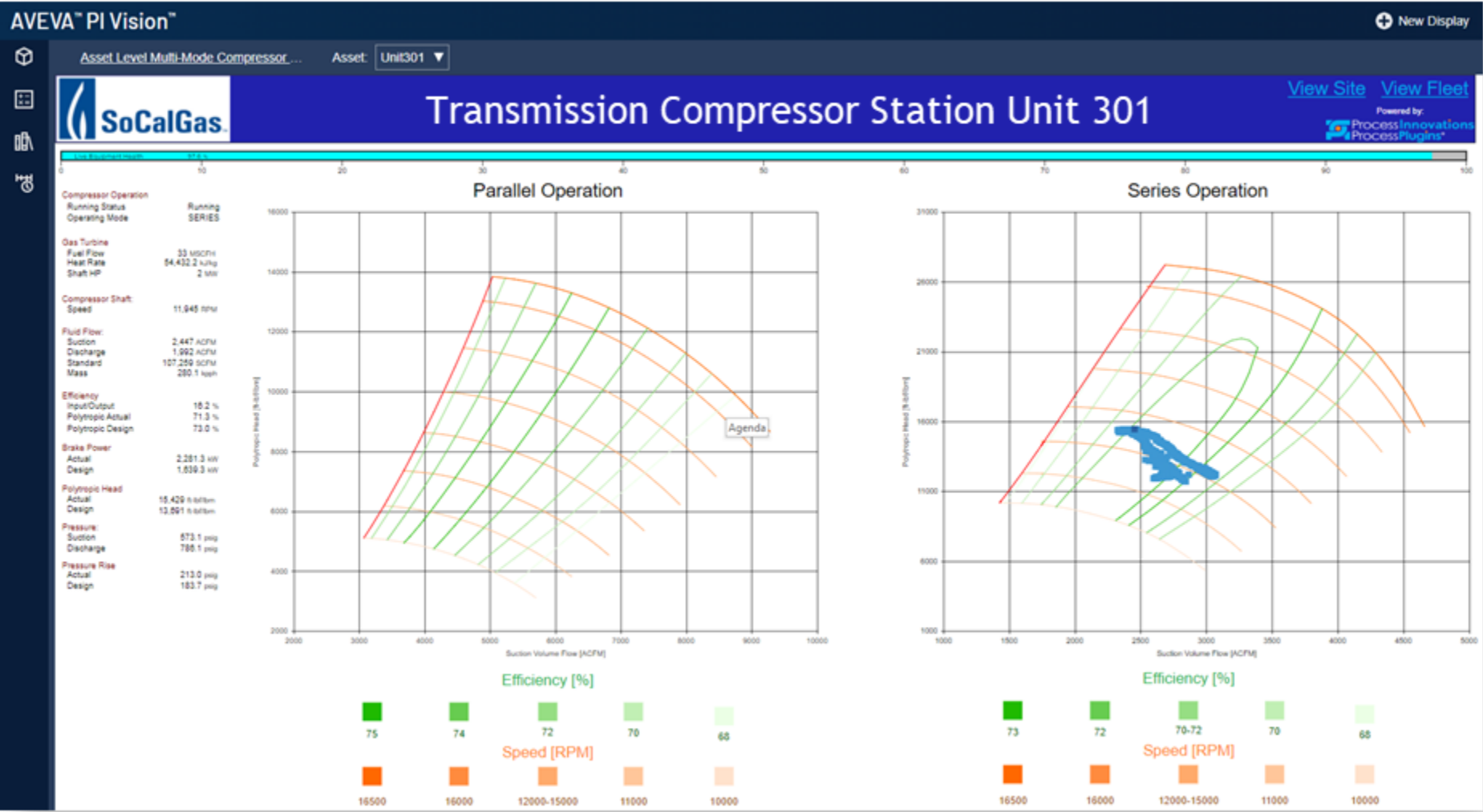
- » High Level Metrics:
- Operating Status
 - Series/Parallel Flow
 - KPI's:
 - Isentropic & Polytropic efficiency
 - Availability
 - Health Score

Site-level



Facility visibility with detailed driver and compressor information

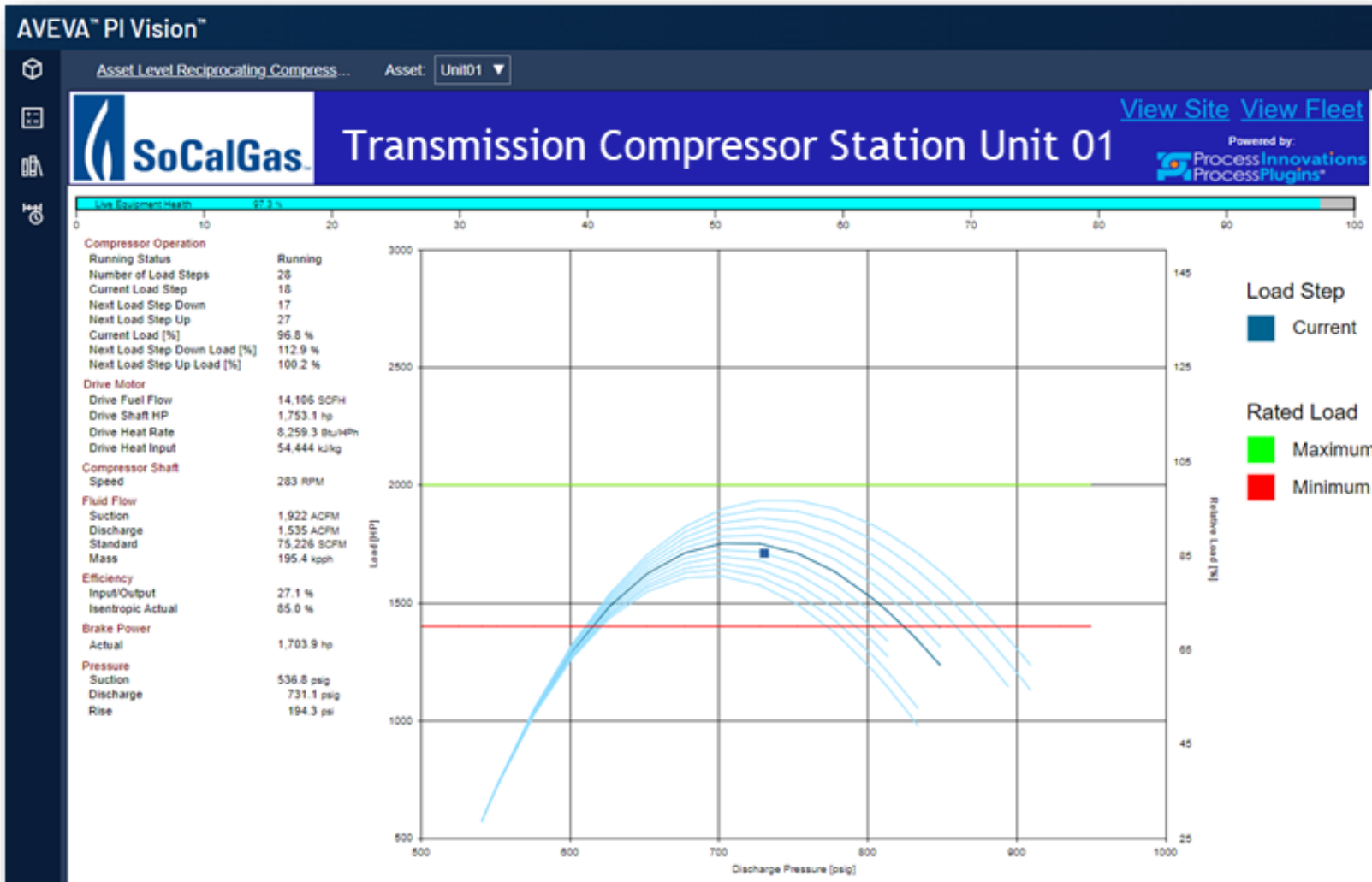
Asset-level (Centrifugal)



- » Detailed Metrics:
 - Detailed Metrics and analysis for a Centrifugal compressor with two operation modes.
- » Key features include:
 - Displaying the current operating point of the compressor on its map
 - Historical trend of the compressor's efficiency, temperature, pressure.
 - Indications of Surging or Choking of Turbines



Asset-level (Reciprocating)



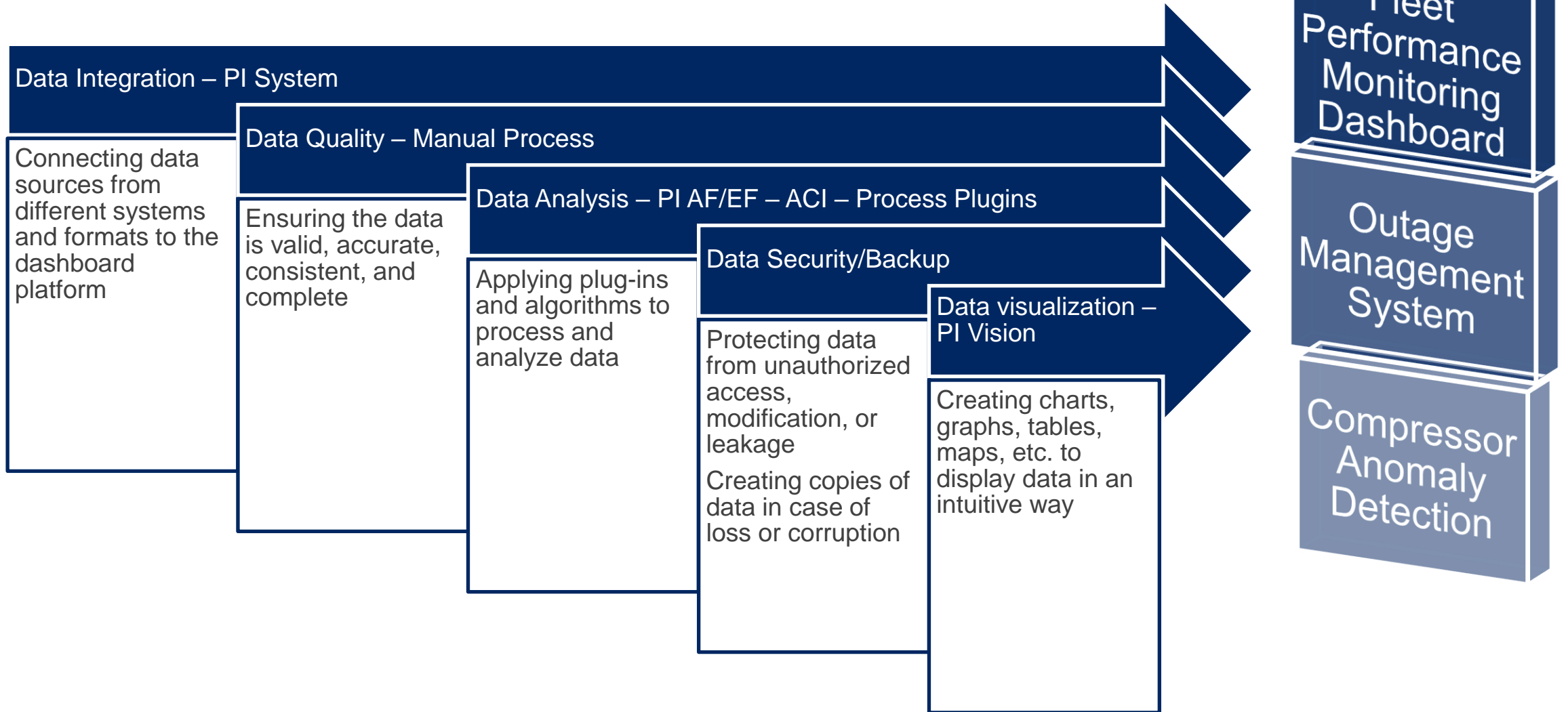
» Detailed Metrics:

- Detailed Metrics and analysis for a reciprocating compressor

» Key features include:

- Load Step analysis
- Pressure Differential
- Loading Efficiency
- Indication if data is within Range of ACI Services Model limits

Process Flow Elements

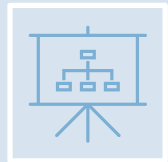


Lessons Learned



One centralized PI data system is preferable to multiple disparate data sources

- * Simplifies data integration, quality, and security.
- * Helps ensure data consistency & completeness.



Detailed history of all compressor failures, causes and solutions is essential for failure prediction and prevention

- * Failure history provides valuable data for training machine learning models.
- * Helps users understand the root causes and effects of failures and how to avoid them.



Less unique types of compressors

- * Makes implementation much quicker and easier
- * Reduce the complexity and diversity of data analysis and visualization
- * Increase the accuracy and reliability of data models and results

Next Steps



Utilize PI Information to build an Outage Management System to track compressor issues and tie them to anomaly detection.



Developing Compressor Specific Predictive Analytics

Outage Management System

Outage Management System

Process Innovations
ProcessPlugins®

Outages

Outages

Outage Events [Create Event Outage](#) [Reset Filters](#)

Start Range: Select Start Range... End Range: Select End Range... Status: 5 selected (New Open Draft) Location: All Unit: All System: All

Subsystem: All Failure Mode: All

Outage ID ↑	Status	Location / Unit / System	Affected Subsystem	Date / Time	Failure Mode
3	Draft Close	Blythe MU1 System1	New Sub Template	S: 5/22/2023 10:01:15 AM E: 5/31/2023 2:00:00 AM	Unloader valve seizes, fail to open / close

Rows per page: 10 1 -1 of 1

- Outages automatically generated based on Event Frames.
- Ability to create events manually if Event Frame not generated.
- Template database allows quick repeatability of assets.
- This enables advanced learning by building a successful data repository for Compressor Failures

Outage Management System (cont.)

Failure Modes

[Create New](#)

ID	Description	Effects
2	Unloader valve seizes, fail to open / close	Unable to vary compressor output capacity
3	Rider bands wear out	Excessive leakage from piston and cylinder wall, can break the piston rod, overheating, leak gas vented out Leads to compressor shutdown
4	Rod packings worn	Excessive leakage from packer, overheating, leak gas vented out Leads to compressor shutdown

- Failure Mode database based on industry known failures.
- Ability to edit Outage events to failure modes and affected systems. This enables the ability for Machine Learning of failures based on types of failure.
- The Outage Management System formalizes the equipment failure database that maintains history, file attachments, and information including notes and recommendations.

Edit Outage Event

Location
Blythe

Unit
MU1

System
System1

Start Time
5/22/2023 10:01:15 AM

System End Time
5/31/2023 2:00:00 AM

Status
Draft [Reject](#) [Close](#)

Affected Subsystem
System1/New Sub Template ▾

FailureMode
Unloader valve seizes, fail to op ▾

End Time (Manual)
mm/dd/yyyy --:-- -- 📅

Priority
High ▾

Assignee
Test Dev ▾

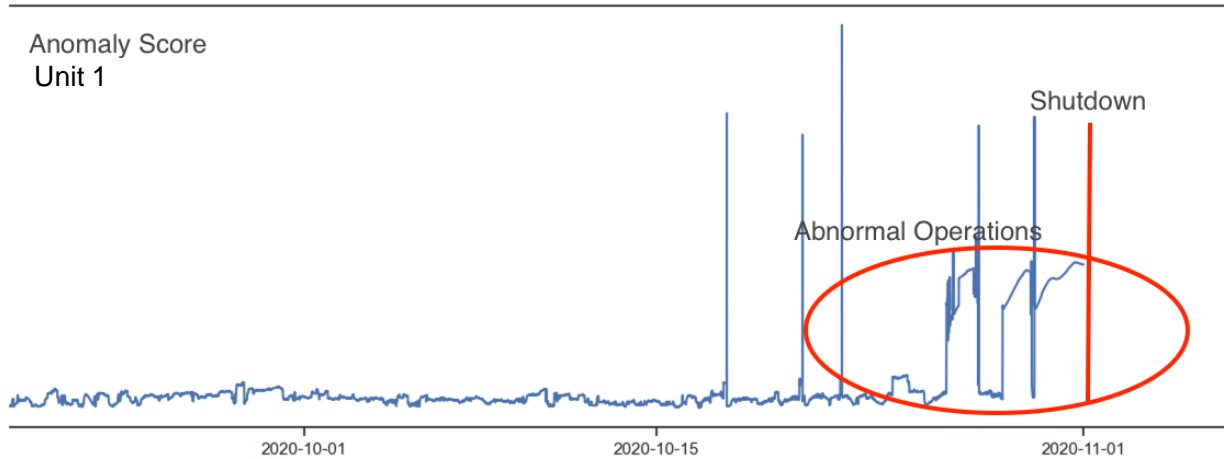
Notes
q323

Recommendation

Affected Parts

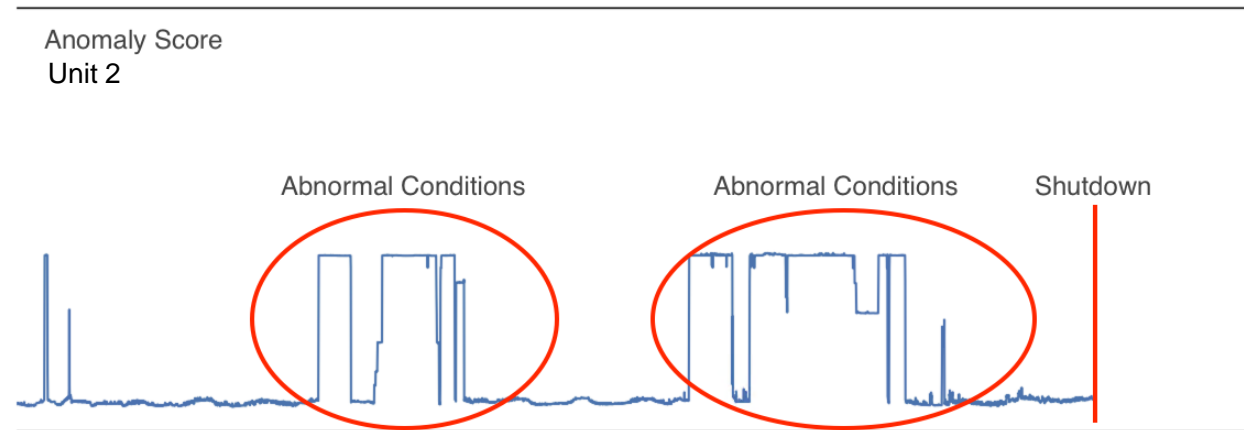
[Save](#) [Back to List](#)

Compressor Predictive Analytics



- After two weeks of consistent operations, anomalies start to show up.
- Anti-rotation pin severed and sent main bearing rotating with shaft.

- Abnormal conditions start due to lowering of compression
- Loss of compression due to piston rod - complete break from crosshead.



OCTOBER 25, 2023

Modern AVEVA™ PI System™ Implementation with Process Innovations

The Process Plugins Solutions

Presented By: Caleb Sargent

AVEVA

Behind the Project

- About Process Innovations and ACI Services
- Review Process Plugins Data Processing
 - ACI eRCM Model Integration
 - Asset Framework Templates
 - Analyses
 - Notifications
 - Event Frames

Process Innovations and ACI Services

AVEVA



Leading provider of software and consulting for advanced data analytics, visualization, and integration for the AVEVA PI System.

- Focus to maximize the performance of assets through providing cost effective, APM integrated solutions to Oil and Gas, and Power Generation companies.



Certified Operations System Integrator supporting over 100 companies as their PI System trusted advisor.



The leader in the reciprocating compressors industry for providing engineered solutions and developing advanced, compressor performance models.

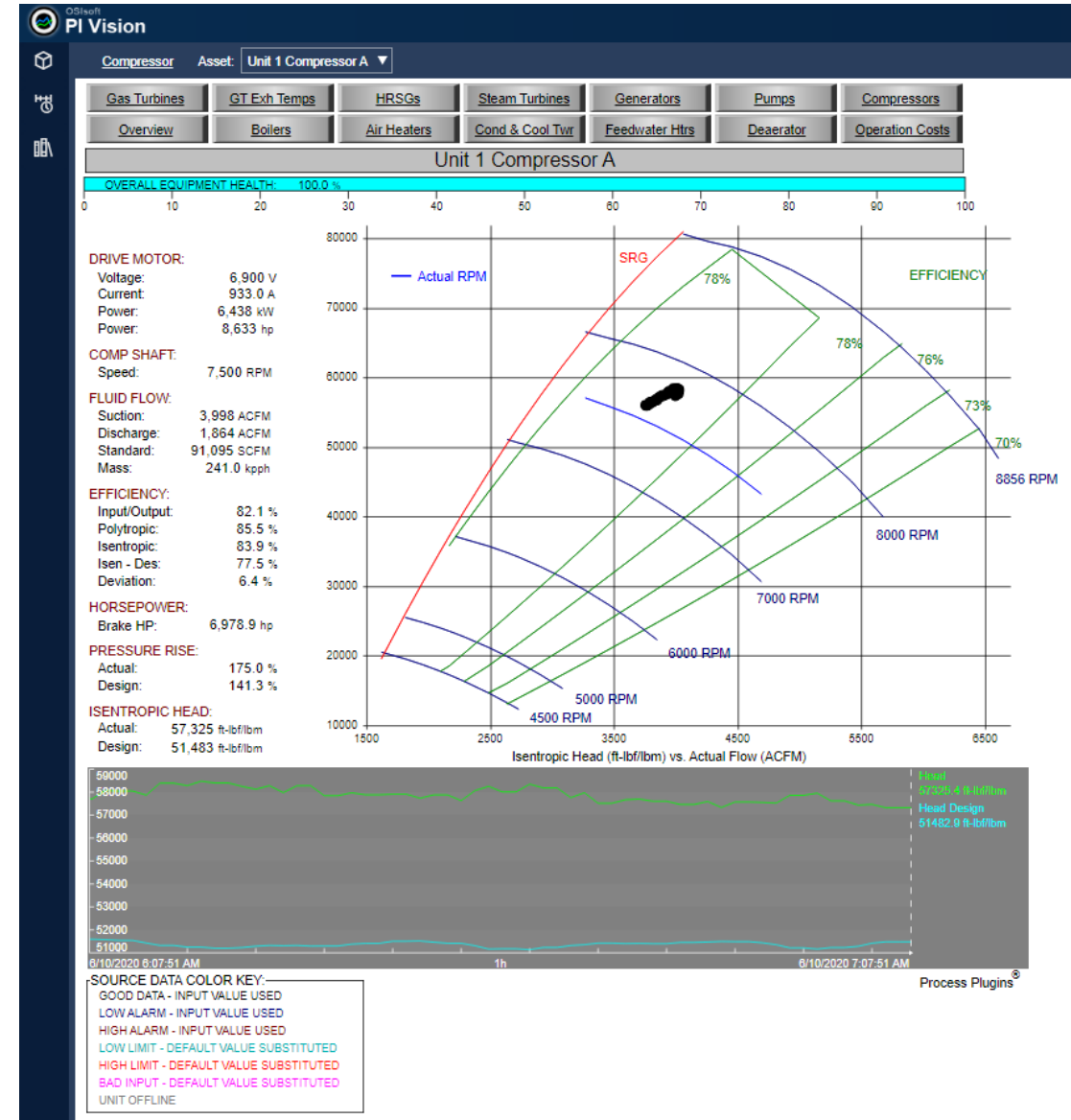
- ACI's eRCM is the backbone of many commercial and OEM software packages.
- eRCM is integrated into edge computing devices, PLCs, hydraulic pipeline simulation software, real-time monitoring systems, and Big Data Analytical systems.

Process Plugins PI System/PI AF Accelerators



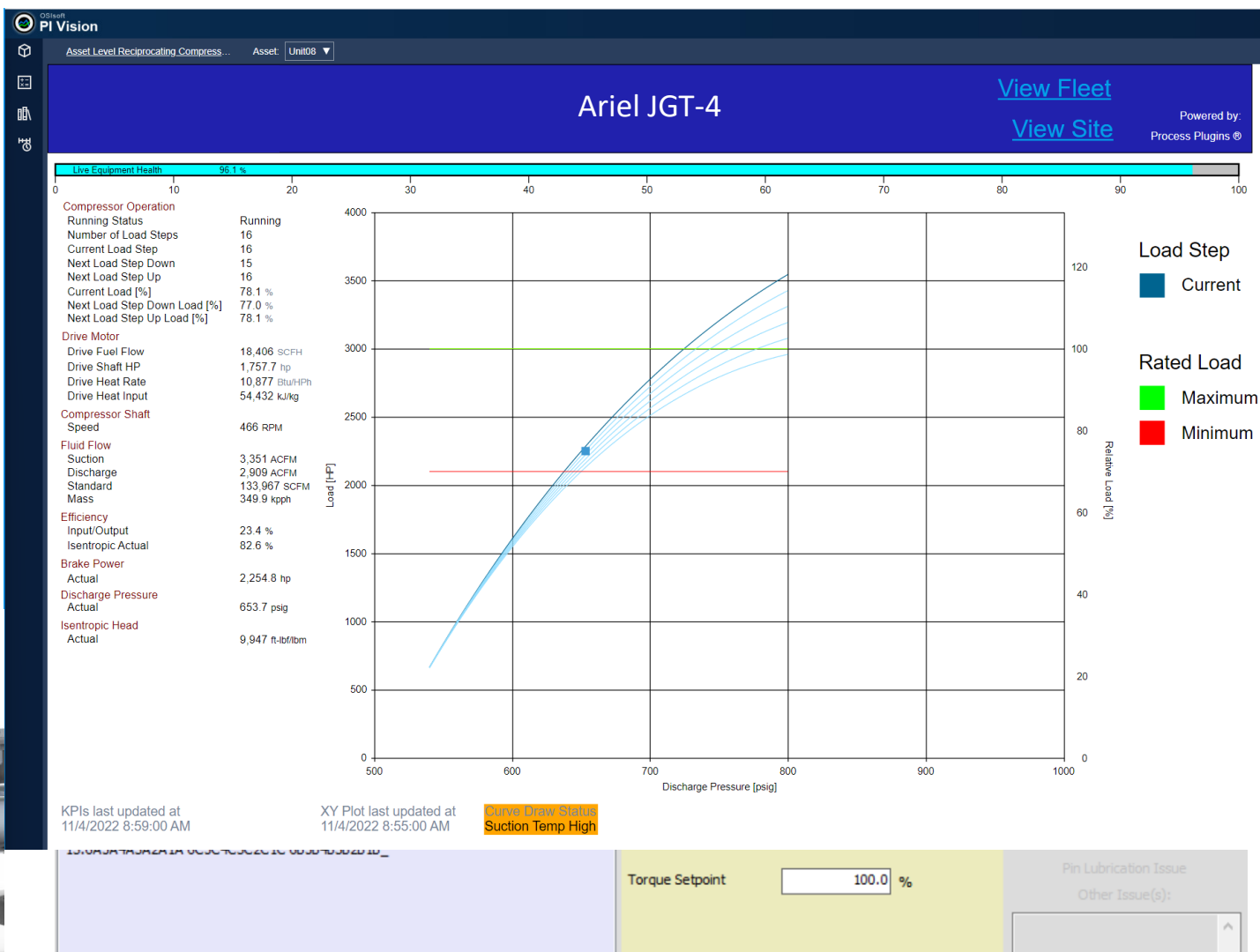
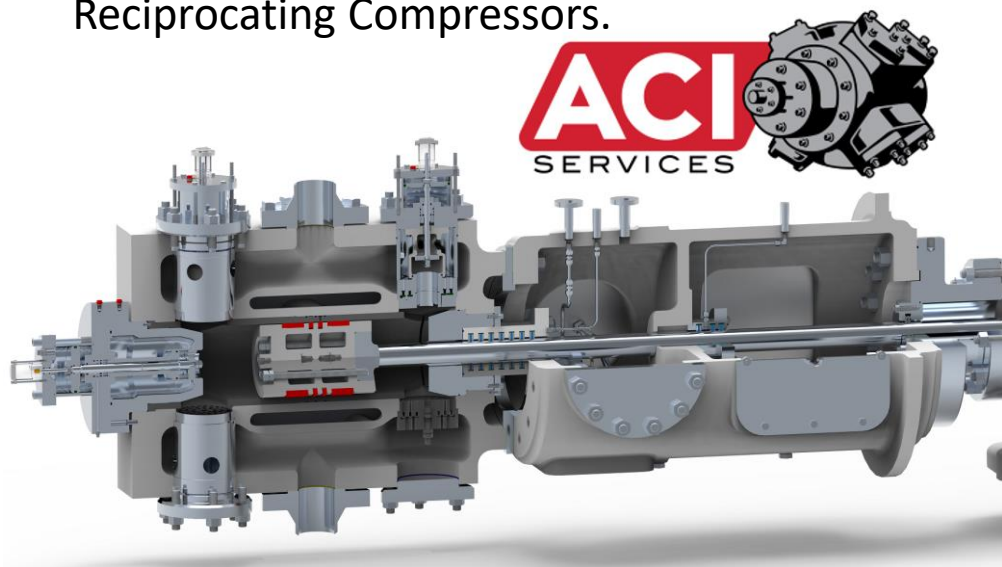
Rapid TTV with PI AF Plugins

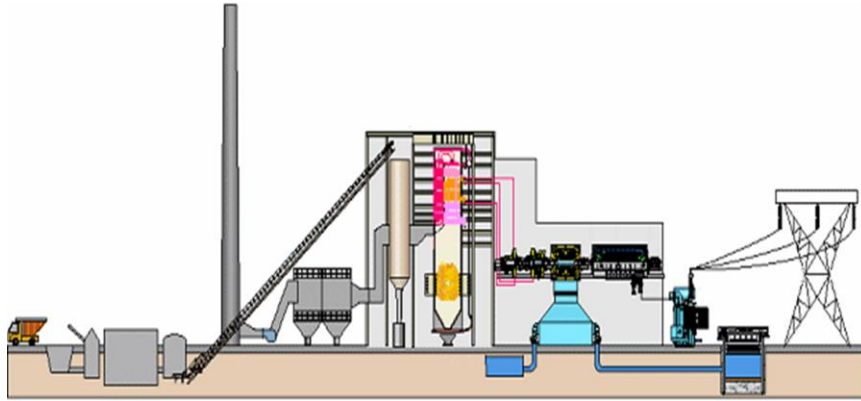
- Solutions are tightly integrated with the Modern AVEVA PI stack, leveraging Asset Framework (AF) for templates, analyses, and event frames
- Calculations and visualizations enable quick analysis of complex systems
- Equations from ASME Standards and engineering best practices are embedded in enterprise software vs spreadsheets



ACI Services eRCM Models

- Accurate, tunable compressor models that reflect OEM safety specifications.
- Models are easily used by Engineers, Operators, Automation & Controls, Gas Control, Data Analytics, and Management.
- ACI's eRCM™ Technology is integrated into Process Plugins APM Solution for Reciprocating Compressors.





Parameter	Value
Compressor Brake Power	2802.8 hp
Compressor Discharge Pressure	765.11 psig
Compressor Discharge Temperature	117.19 °F
Compressor Discharge Volume Flow	2747.9 SCFM
Compressor Head	11361.8 ft/ftm
Compressor Inlet Efficiency	26.101 %
Compressor Isentropic Efficiency	76.756 %
Compressor Load	2802.8 hp
Compressor Suction Mass Flow	285.47 kpph
Compressor Suction Pressure	601.82 psig
Compressor Suction Standard Volume...	1.468E+05 SCFM
Compressor Suction Temperature	60.963 °F
Compressor Suction Volume Flow	3096.9 ACFM
Current Relative Load	88.111 %
Current Load Step	1
Curve Draw Status	Suction Temp Low

ProcessPlugins™

Overall Turbine Health: 93%

Generation

- Generation Actual: 1773 MW
- Capacity Expected: 160.8 MW
- * Base Loaded: YES
- * Generation Corrected: 1892 MW
- ** Generation Corrected: 1952 MW

Fuel

- Fuel Gas Temperature: 1000 °F
- Fuel Gas Pressure: 4000 psia
- Fuel Gas HHV: 23,128.9 Btu/ftm

Exhaust

- Minimum Temperature: 1104.0 °F
- Maximum Temperature: 1154.0 °F
- Average Temperature: 1120.0 °F
- Temperature Spread: 50.0 °F
- ** Molar Pct O₂: 13.35 %
- ** Molar Pct H₂O: 1005 %

Turbine Performance

- Fuel Gas Flow: 22270 SCFM
- ** Firing Temperature: 2343.1 °F
- ** Turbine Efficiency - LHV: 40.8 %
- ** Turbine Efficiency - Isentropic: 301.2 %
- ** Air Flow Actual: 846.1 lbs/s
- ** Air Flow Corrected: 866.8 lbs/s
- ** Pressure Ratio: 10.0
- ** Isentropic Efficiency: 84.6%
- ** Turbine Speed Corrected: 35174 RPM
- ** Polytrropic Efficiency: 88.7%
- ** Turbine Speed Corrected: 977 %

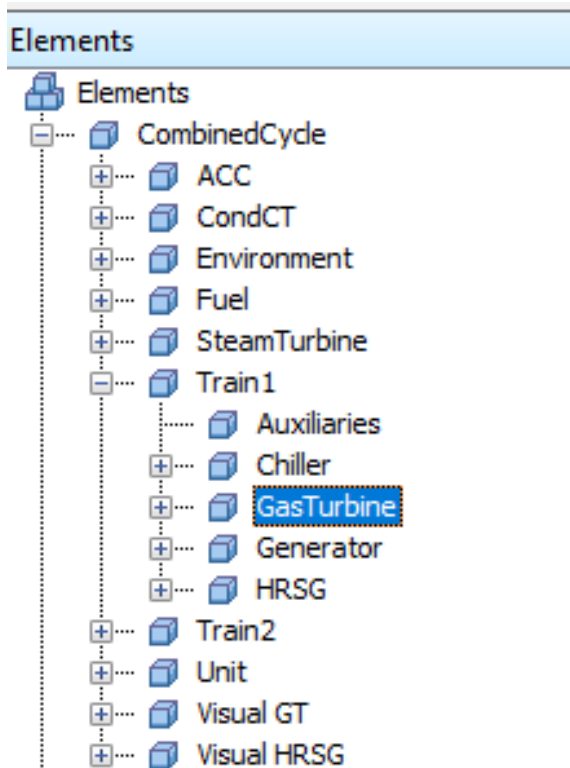
HRSG

- Flue Gas Flow: 3334.4 kpph
- HRSG Efficiency: 790 %
- HRSG Effectiveness: 94.1%
- Pinch Temperature: 4000 °F
- Stack Temperature: 3000 °F
- Flue Gas O₂: 12.5 %
- Flue Gas NO_x: 300 ppm
- Flue Gas CO: 200 ppm

ElementPath	ParameterDescription	Parameter	LowLimit	LowAlarm	Default	Test	HighAlarm	HighLimit	OnSetAvg	TagName01	TagName02	TagName03	TagName04	TagName05
Bedford Falls	Fuel Flow	SCFH	0	0	0	0	1000000	1000000	0	BL-MFL_F...				
Bedford Falls	Fuel Pressure	psia	0	0	3000	3000	1000000	1000000	0	BL-MFL_P...				
Bedford Falls	Fuel Temperature	°F	-470	0	300	3000	10000	10000	0	BL-MFL_T...				
Bedford Falls	Energy Exhaust Output	%	0	0	12	100	100	100	0	BL-MFL_E...				
Bedford Falls	Compressor Operating Mode	enum	0	750	0	1000	1000	10000	0	BL-MFL_B...				
Bedford Falls	ABSOLUTE Pressure (Leave TagName01) Blm...	psia	400	450	0	771	812	1000000	0	BL-MFL_B...				
Bedford Falls	GAGE Pressure (Leave TagName01) Blm...	psig	0	450	0	771	812	1000000	0	BL-MFL_D...				
Bedford Falls	Temperature	°F	-470	-450	0	105.4	1000000	1000000	0	BL-MFL_T...				
Bedford Falls	Mass Flow (Leave Blank if Volume Flow) L...	0	0	0	0	0	1000000	1000000	0	BL-MFL_M...				
Bedford Falls	Volume Flow	ft3/s	0	0	254.118	1000000	1000000	1000000	0	BL-MFL_V...				
Bedford Falls	ABSOLUTE Pressure (Leave TagName01) Blm...	psia	575	575	0	627.5	680	1000000	0	BL-MFL_B...				
Bedford Falls	GAGE Pressure (Leave TagName01) Blm...	psig	0	575	0	627.5	680	1000000	0	BL-MFL_D...				
Bedford Falls	Temperature	°F	-470	-113	0	86	272	10000	0	BL-MFL_T...				
HomeData	Gas Chromatograph CH4 Methane	%	0	0	14.807	94.997	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph CH4 Ethane	%	0	0	4.015	4.015	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph CH4 Propane	%	0	0	0.108	0.108	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph CH4 Isobutane	%	0	0	0.006	0.006	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph Carbon Dioxide	%	0	0	0.884	0.884	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph C3H12 Isobutane	%	0	0	0.005	0.005	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph N2 Nitrogen	%	0	0	0.748	0.748	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph C3H10 Isobutane	%	0	0	0.0219	0.0218	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Gas Chromatograph CH212 Isobutane	%	0	0	0.0054	0.0054	100	100	0	HR-GC_CH...	HR-GC_CH...			
HomeData	Fuel Flow	SCFH	0	0	0	0	1000000	1000000	0	HR-F1-42...				
HomeData	Fuel Pressure	psia	0	0	300	300	1000000	1000000	0	HR-F1-42...				
HomeData	Fuel Temperature	°F	-470	0	300	3000	10000	10000	0	HR-F1-42...				
HomeData	Engine Exhaust Oxygen	%	0	0	12	100	100	100	0	HR-A4_O2...				
HomeData	Speed	enum	0	0	626	675	1000	1000	0	HR-G2-700...				
HomeData	GAGE Pressure (Leave TagName01) Blm...	psig	0	1301	0	2300	3400	1000000	0	HR-F1-600...				
HomeData	Temperature	°F	-470	0	105.4	1000000	1000000	1000000	0	HR-T1-60...				
HomeData	Volume Flow	ft3/s	0	0	254.118	1000000	1000000	1000000	0	HR-T1-60...				
HomeData	GAGE Pressure (Leave TagName01) Blm...	psig	0	475	0	612.5	741	1000000	0	HR-F1-600...				
HomeData	Temperature	°F	-470	-191	0	79	189.5	10000	0	HR-T1-60...	HR-T1-60...	HR-T1-60...		
HomeData	Volume Flow	ft3/s	0	0	254.118	1000000	1000000	1000000	0	HR-T1-60...	HR-T1-60...	HR-T1-60...		
HomeData	GAGE Pressure (Leave TagName01) Blm...	psig	0	475	0	612.5	741	1000000	0	HR-F1-600...				
HomeData	Temperature	°F	-470	-191	0	79	189.5	10000	0	HR-T1-60...				

Complete AF configuration for all assets monitored

We build the entire structure in your AF server that contains all calculations and links for visualization with PI Vision. Scalable to hundreds or thousands of assets.



The screenshot shows the PI Vision interface for 'Unit01'. The left pane displays the 'Elements' tree, and the right pane shows the 'Attributes' tab. The 'Attributes' table lists various monitored parameters and their values.

Name	Value
Ambient Pressure	Unknown Attribute '
Ambient Temperature	Unknown Attribute '
Asset Name	Unit01
Asset Path	Bedford Falls\Unit01
Asset Utilization PI Vision URL	./#/Displays/139/Rec
Component	StageAll
Compressor Brake Power	2802.8 hp
Compressor Discharge Pressure	765.11 psig
Compressor Discharge Temperature	117.19 °F
Compressor Discharge Volume Flow	2747.9 ACFM
Compressor Drive for PI Vision Tiles	
Compressor for PI Vision Tiles	
Compressor Head	11361 ft-lbf/lbm
Compressor In/Out Efficiency	26.101 %
Compressor Isentropic Efficiency	76.756 %
Compressor Load	2802.8 hp
Compressor Load for PI Vision XY Plot	
Compressor Suction Mass Flow	385.47 kpph
Compressor Suction Pressure	601.62 psig
Compressor Suction Standard Volume...	1.468E+05 SCFM
Compressor Suction Temperature	60.963 °F
Compressor Suction Volume Flow	3096.8 ACFM
Compressor Utilization for PI Vision	
Current Relative Load	88.111 %
Current Load Step	1
Curve Draw Status	Suction Temp Low

Elements

- Station
 - Environment
 - PPI_FilterBP
 - PPI_FilterDB
 - PPI_FilterRH
 - PPIHum_RHtoSH
 - PPIHum_ShttoWB
 - Fuel
 - FuelGas
 - FuelOil
 - Unit 1
 - Unit 2
 - AirHeaters
 - AH1
 - AH2
 - WtdAvg
 - Auxiliary
 - Boiler
 - ColdReheatInlet
 - Combustion
 - Drum
 - FeedwaterInlet
 - PPI_WriteToPIHealth
 - RHDesup1
 - RHSteamOutlet
 - SHDesup1
 - SHDesup2
 - SHSteamOutlet
 - Boiler Feed Pumps
 - BFP 1A
 - BFP 1B
 - BFP 2A
 - BFP 2B
 - CondCT
 - Condenser
 - CoolingTower
 - Hotwell
 - PPI_FilterP
 - PPI_FilterCold
 - PPI_FilterHot
 - PPI_WriteToPI_Q
 - FeedwaterHeaters
 - Cost
 - DA
 - HP1
 - HP2
 - HP3
 - LP1
 - LP2
 - LP3
 - LP4
 - Fuel
 - FuelCoal
 - FuelCoalDesRef
 - FuelGas
 - FuelGasDesRef
 - FuelOil
 - FuelOilDesRef
 - PPI_WriteToPI_FuelCost
 - PPI_WriteToPI_FuelM
 - PPI_WriteToPI_FuelQ
 - PPI_WriteToPINetMW
 - PPI_WriteToPINUHR
 - PPI_WriteToPINUHR_IO
 - PPI_WriteToPINUHRExp
 - Pump_Cond
 - PPI_FilterF
 - PPI_FilterP
 - SteamTurbine
 - Generator
 - HPTurbine
 - IPTurbine

Unit01

General Child Elements Attributes Ports Analyses Notification Rules Version

Name	Backfilling
Outage	✓
Outage Start and End	✓

Name:

Description:

Categories:

Analysis Type: Expression Rollup Ev

Name	5/... [746.06:25:34] 6/...	Duration	Start Time	End Time
Outage2022-05-18 08:14:14		27:1:37:00	5/18/2022 8:14:14 AM	6/14/2022 9:51:14 AM
Outage2022-05-11 15:03:14		33:20:59:00	5/11/2022 3:03:14 PM	6/14/2022 12:02:14 PM
Outage2022-02-22 12:10:31		76:22:19:43	2/22/2022 12:10:31 PM	5/10/2022 11:30:14 AM
Outage2021-09-02 08:45:16		10:22:22:38	9/2/2021 8:45:16 AM	9/13/2021 7:07:54 AM
Outage2021-07-20 22:24:45		42:8:33:31	7/20/2021 10:24:45 PM	9/1/2021 6:58:16 AM
Outage2020-07-27 07:32:40		11:6:05:00	7/27/2020 7:32:40 AM	8/7/2020 1:37:40 PM
Outage2020-07-03 12:39:40		17:1:26:30	7/3/2020 12:39:40 PM	7/20/2020 2:06:10 PM
Outage2020-06-05 02:50:10		5:11:44:59	6/5/2020 2:50:10 AM	6/10/2020 2:35:09 PM
Outage2020-05-29 05:36:40		12:2:58:30	5/29/2020 5:36:40 AM	6/10/2020 8:35:10 AM

Elements

- Event Frames
- Library
- Unit of Measure
- Contacts
- Management

Sample of Process Plugins Modules

- Combustion Gas Turbine Performance Monitor & Plant Heat Rates
- Combustion Gas Turbine Power Curves
- Reciprocating Compressor Performance Monitor
- Centrifugal Compressor Performance Monitor
- Turbine Compressed Air Cooler Condition Monitor
- Pump Condition Monitor
- Water Cooled Condenser CW Pump Optimizer
- Air Cooled Condenser Condition Monitor
- ... and many (20+) more





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Project Manager

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VP Operations

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Questions?

Please wait for the microphone.
State your name and company.



Please remember to

Visit Process Innovations at **Booth 38**
for more information and to discuss
your opportunity.



Thank you!

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AVEVA is a world leader in industrial software, providing engineering and operational solutions across multiple industries, including oil and gas, chemical, pharmaceutical, power and utilities, marine, renewables, and food and beverage. Our agnostic and open architecture helps organizations design, build, operate, maintain and optimize the complete lifecycle of complex industrial assets, from production plants and offshore platforms to manufactured consumer goods.

Over 20,000 enterprises in over 100 countries rely on AVEVA to help them deliver life's essentials: safe and reliable energy, food, medicines, infrastructure and more. By connecting people with trusted information and AI-enriched insights, AVEVA enables teams to engineer efficiently and optimize operations, driving growth and sustainability.

Named as one of the world's most innovative companies, AVEVA supports customers with open solutions and the expertise of more than 6,400 employees, 5,000 partners and 5,700 certified developers. The company is headquartered in Cambridge, UK.

Learn more at www.aveva.com