EQT Midstream's Journey to Reliability Centered Maintenance

Data Driven Operations & Maintenance

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Overview of Presentation

- EQT Corporation Overview

- Operation & Maintenance Objectives

- Business Case

- Case Studies

- Lookback for Success

- Next Steps

EQT Corporation - Two Integrated Business Units

*Natural Gas Exploration, Development, and Transportation*

– Headquartered in Pittsburgh, PA

– In Business for more than 130 Years

– Operations Across Appalachian Region & Texas

– More than 1,800 Employees

– Innovative Techniques & Strategies Employed Across Two Distinct Business Units

  - **EQT Production-Natural Gas Exploration, Drilling, & Development**

  - **EQT Midstream-Natural Gas Gathering, Transportation, & Storage**
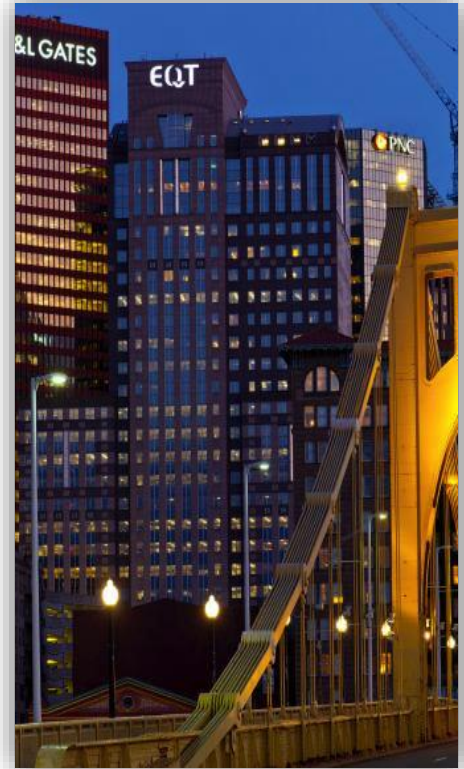
EQT Midstream

Role in the Natural Gas Value Chain

– **Marcellus Gathering Capacity**

  • ~2MMSCFD

– **Gas Gathering Assets**

  • Reciprocating Compressors/Engines
  • Pipelines
  • Measurement

– **Transmission & Storage**

  • Reciprocating & Centrifugal Compressors
  • Large Pipelines
  • Storage Facilities
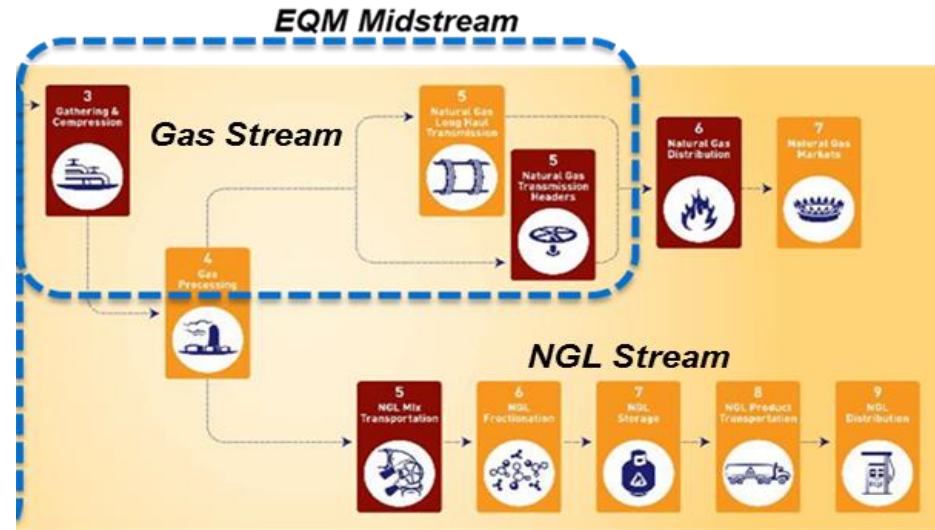
Midstream Goals & Focus

Operational Objectives

- ## Provide Natural Gas Gathering & Transportation Services
  - Health & Safety #1 Priority
  - Customer Service Focus
  - High System Availability & Capacity
  - Provide Value for Customers & Shareholders

- ## Strategy
  - Operate & Maintain Assets Efficiently & Cost Effectively
  - Apply Innovative Technologies to All Facets of Operations
  - Maintain High Expectations of Quality & Integrity

- ## Plan & Implementation
  - High Reliability – Compressors & Pipelines
  - Data & Analysis for Operational Awareness & Excellence
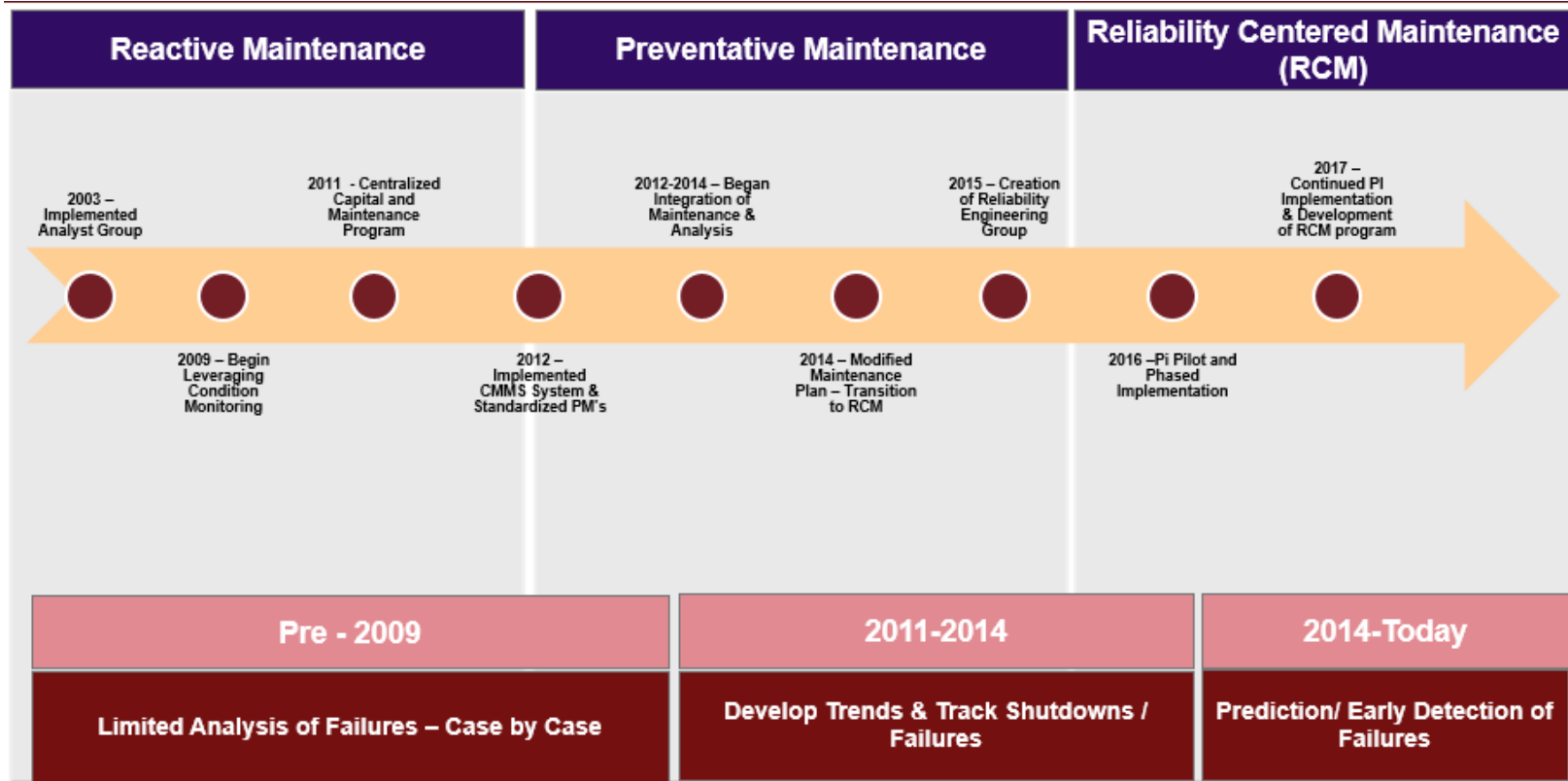 - Transition to Reliability Centered Maintenance

Maximize Throughput & Asset Efficiency

Optimize Asset Reliability & Availability
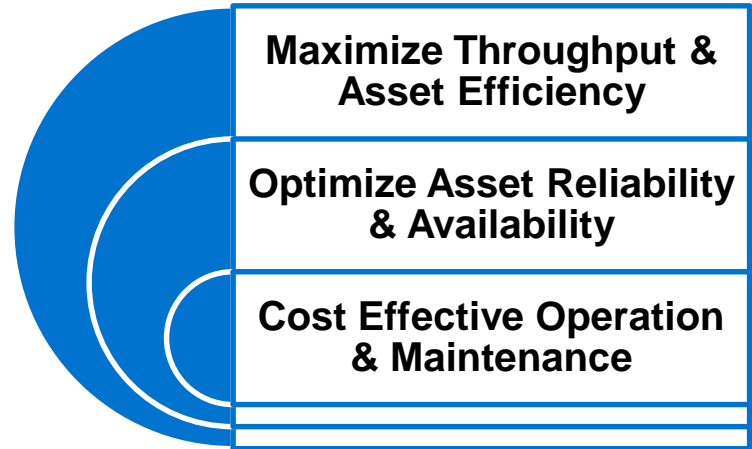
Cost Effective Operation & Maintenance

Operation & Maintenance Objectives

Evolution of Maintenance & Reliability Program

Reactive Maintenance	Preventative Maintenance	Reliability Centered Maintenance (RCM)

Above the timeline:
- 2003 – Implemented Analyst Group
- 2011 - Centralized Capital and Maintenance Program
- 2012-2014 – Began Integration of Maintenance & Analysis
- 2015 – Creation of Reliability Engineering Group
- 2017 – Continued PI Implementation & Development of RCM program

Below the timeline:
- 2009 – Begin Leveraging Condition Monitoring
- 2012 – Implemented CMMS System & Standardized PM's
- 2014 – Modified Maintenance Plan – Transition to RCM
- 2016 –Pi Pilot and Phased Implementation

Pre - 2009	2011-2014	2014-Today
Limited Analysis of Failures – Case by Case	Develop Trends & Track Shutdowns / Failures	Prediction/ Early Detection of Failures

Business Challenge

Leverage Data to Transform O&M

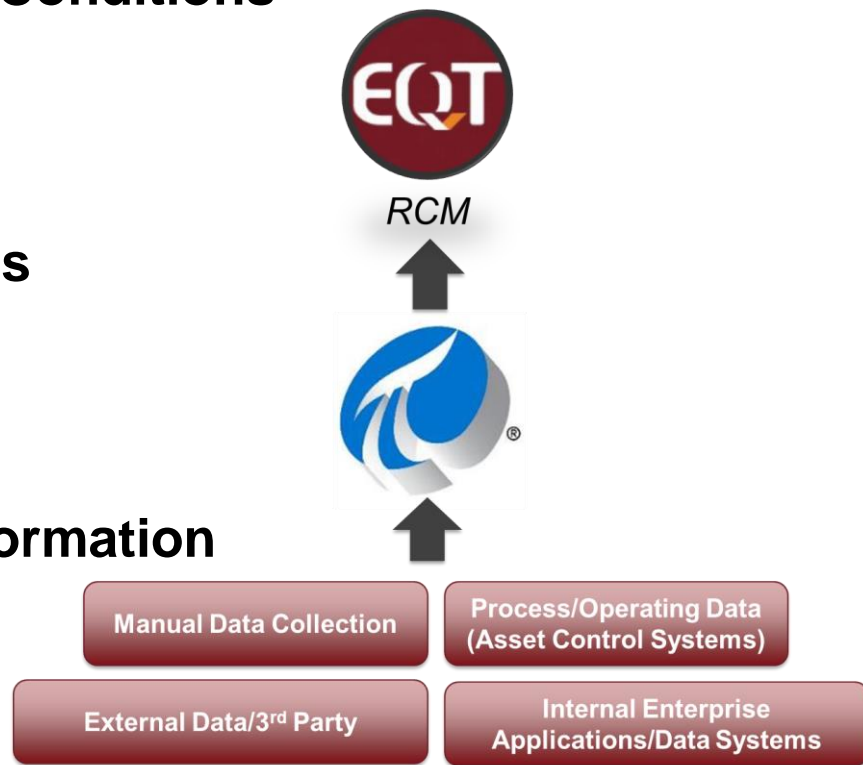## 1. Understand Equipment & Process Conditions
- Engine & Compressor Performance
- Maintenance Needs
- Leading Indicators & Failure Prevention

2. Integration of Multiple Data Sources
- Site Level/Automated Data Collection
- External Data
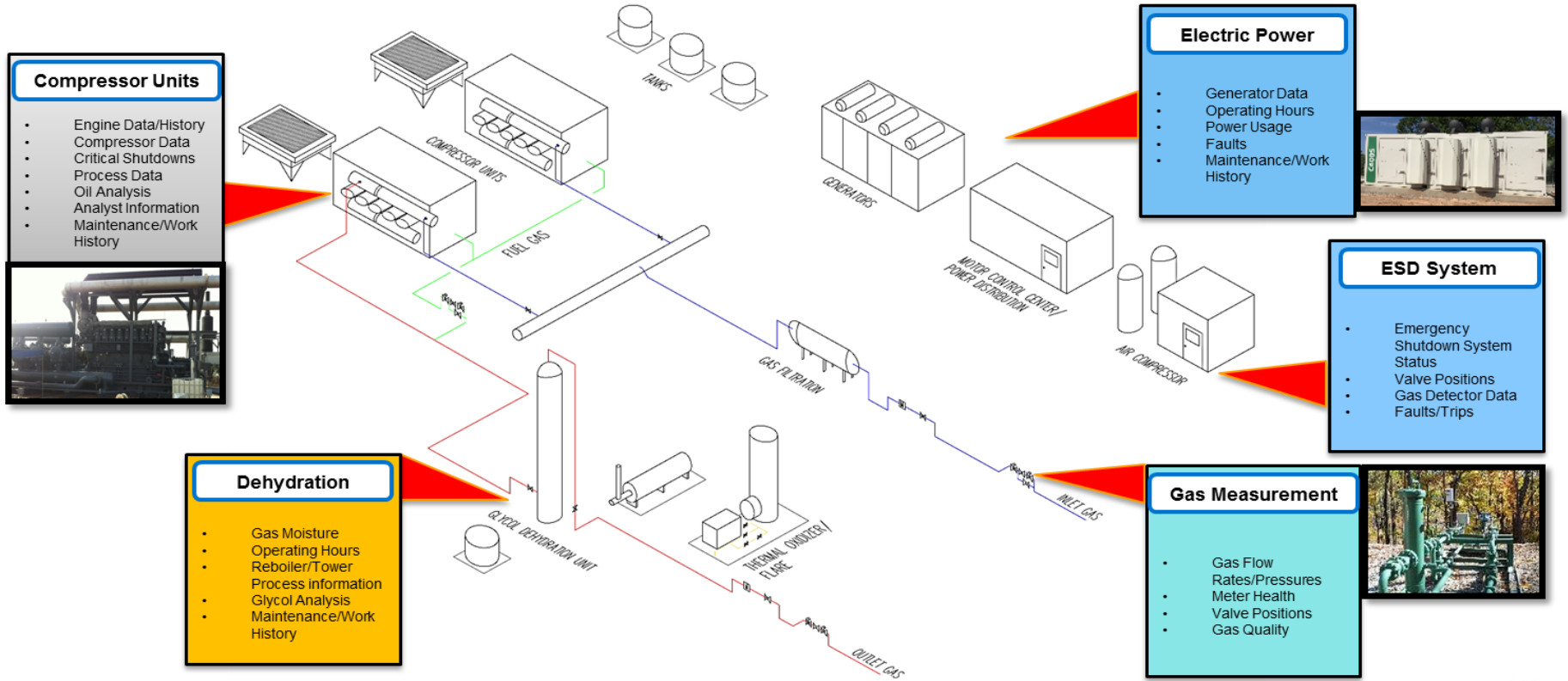- Manually Collected Data

3. Transform Data into Actionable Information
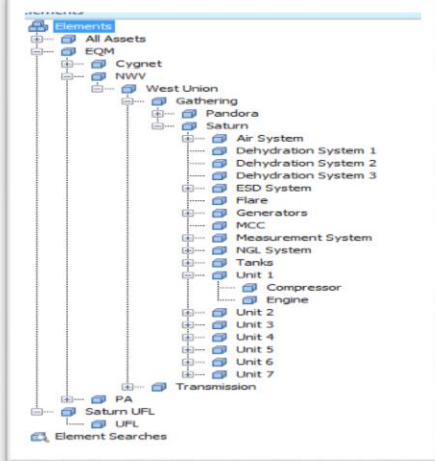- KPI's/Performance Metrics
- Benchmarking
- Time Synchronization

EQT

RCM

Manual Data Collection

Process/Operating Data (Asset Control Systems)

External Data/3rd Party

Internal Enterprise Applications/Data Systems

Compressor Station Overview

Multiple Data Sources – One Point of Access with The PI System®

Compressor Units
- Engine Data/History
- Compressor Data
- Critical Shutdowns
- Process Data
- Oil Analysis
- Analyst Information
- Maintenance/Work History

Electric Power
- Generator Data
- Operating Hours
- Power Usage
- Faults
- Maintenance/Work History

ESD System
- Emergency Shutdown System Status
- Valve Positions
- Gas Detector Data
- Faults/Trips

Dehydration
- Gas Moisture
- Operating Hours
- Reboiler/Tower Process information
- Glycol Analysis
- Maintenance/Work History

Gas Measurement
- Gas Flow Rates/Pressures
- Meter Health
- Valve Positions
- Gas Quality

TANKS
COMPRESSOR UNITS
FUEL GAS
GENERATORS
MOTOR CONTROL CENTER/ POWER DISTRIBUTION
AIR COMPRESSOR
GAS FILTRATION
GLYCOL DEHYDRATION UNIT
THERMAL OXIDIZER/ FLARE
INLET GAS
OUTLET GAS

EQT Midstream PI System® Development

*Building the Tools for Reliability*

PI Asset Framework (PI AF)

Develop Hierarchy of Compressor Station Assets

Organization of Data Into Useful Sets

Standardization Across Sites

Templates for Scalability

Translation/Integration With Other Business Systems
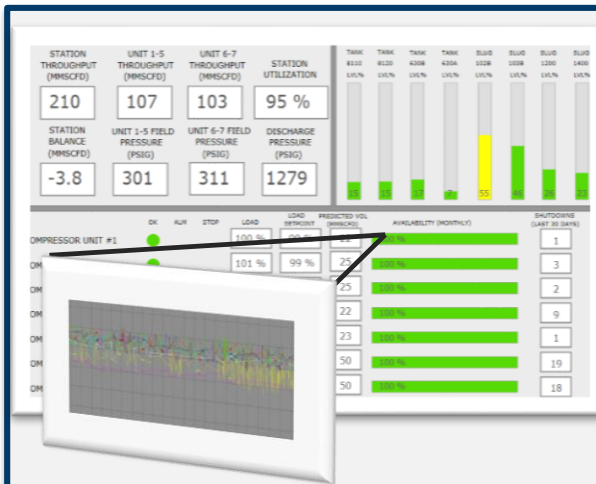
PI Coresight

Dashboards for Operational Monitoring

Multiple Sources of Data Combined Into Single View

Pair Analytics w/Real-Time Values

Single Point Access Across Organization
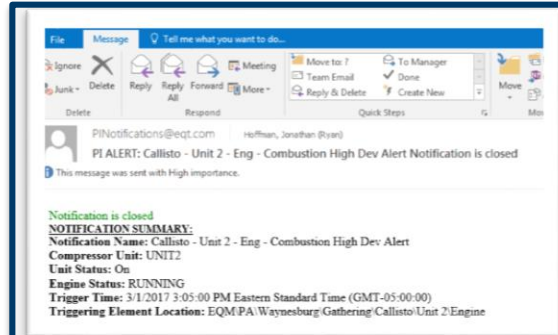
PI Alerts & PI Notification

24/7 Monitoring & Communication of Anomalies

Failure Detection, Efficiency Monitoring, Work Mgmt.

Improve Operational Awareness

Eliminate "Digging" for Issues

Case Studies

Identification & Diagnosis of "Bad Actors"

Using PI Analytics & Notifications to Identify & Diagnose Recurring Issues

Case Study: Engine Load Control - Improve Equipment Availability & Reliability

Notification Name	Occurances in Last 24 Hours	Occurances in Last Week	Occurances in Last Month	Occurances YTD	Date of Last Occurance	Level
Saturn - Unit 3 - Eng - Speed High Delta Alert	7	64	169	410	10/3/2016 7:26	Level 1
Saturn - Unit 3 - Eng - High Fuel Position % Alert	0	8	11	11	10/1/2016 14:03	Level 1
Saturn - Unit 3 - Comp - Throw High Disch Temp Theo v Actual Alert	0	6	14	275	10/1/2016 21:15	Level 2
Saturn - Unit 3 - Comp - Shutdown Alert	0	4	10	51	9/29/2016 20:15	Level 1
Saturn - Unit 3 - Comp - Low Speed Alert	0	2	4	17	10/1/2016 11:25	Level 3
Saturn - Unit 3 - Eng - Load % Alert	0	1	1	6	9/29/2016 19:08	Level 2

Background

- Frequent Deviations Indicate Underlying Issues
- Identifying & Detecting Correlation of Deviations Improves Effectiveness of Diagnostics
- Prior to the PI System® – Limited Visibility into Assets

Solution

- Leverage PI Analytics to Monitor Critical Parameters
- Develop PI Notifications to Alert & Track Deviations
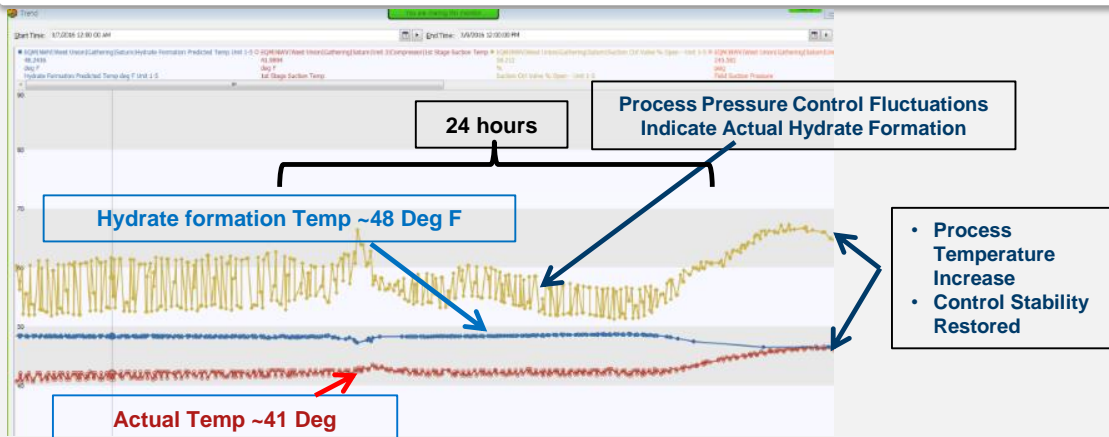- Reliability Review of "Bad Actors"

Results

- Reduced Identification & Troubleshooting Time
- Reduce Repeat Shutdowns
- Eliminate Parts Consumption – Replace to Troubleshoot

Analysis of Trends & Operational Issues

Using PI Analytics & PI Notifications to Detect & Prevent Process Upsets

Case Study: Reduce Process Interruptions & Optimize Assets

24 hours

Process Pressure Control Fluctuations Indicate Actual Hydrate Formation

Hydrate formation Temp ~48 Deg F

- Process Temperature Increase
- Control Stability Restored

Actual Temp ~41 Deg

Background

- EQT Midstream Transports "Wellhead" Gas with High Concentration of C3+ Hydrocarbons
- Hydrates Can Form in "Heavy" or "Wet" Gas Applications
- Hydrates Can Interrupt/Block Gas Flow in Piping & Equipment
- Eliminate or Affect Hydrate Formation Line Via:
  1. Introduction of Inhibitor/Methanol
  2. Change Process to Avoid Hydrate Formation Area

Solution

- Leverage PI Analytics to Predict Hydrate Formation Temperature
- Use PI Notifications to Monitor Process/Hydrate Formation Temperature
- Alert Key Personnel to Potential Hydrate Formation
- Modify Process Accordingly to Avoid Interruptions/Upsets

Results

- Modify Operations in Response to Notifications
- Reduce Operating Pressures to Avoid Hydrate Formation
- Reduced Capacity Vs. Complete Outage
- Minimize Dependency on Hydrate Inhibitor
  - Reduce Costs & Consumption
  - Eliminate Secondary Impacts of Inhibitor

Engineering & Analysis to Maximize Resources

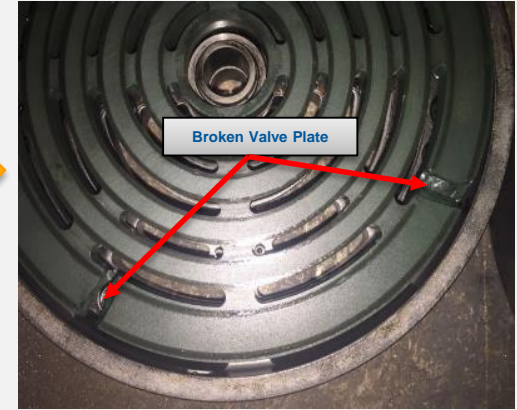*PI Analytics & PI Notifications Reduces Field Data Collection Time*

Case Study: Compressor Valve Condition – Targeted Use of Resources

Background

- Compressor Valves – High Frequency Failure
- Affect Compressor Performance & Efficiency
- Typically Identified by Equipment Analysts on Weekly/Semi-Weekly Field Analysis
- Equipment Analyst Time Valuable & Limited

Solution

- Leverage PI Analytics to Predict Theoretical Gas Discharge Temperature
- High Deviation in Actual Temp. w/Predicted Indicates Potential Valve Issue
- Condition Based Analysis Vs. Time Based

Results

- Reduce Data Collection Time - Equipment Analyst
- Use PI as 1st Tier Approach to Focus Resources
- Repurpose Analyst Time to Other Areas of Condition Monitoring
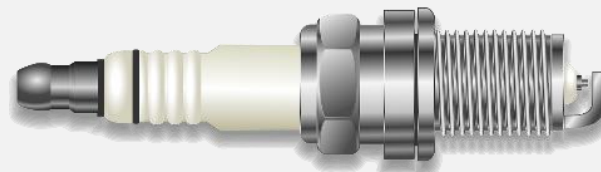- Provide Operations With Tools to Detect Issues Prior to Analyst Visit

Data & Trends for Condition Based Maintenance

PI Trends & PI Analytics to Maximize Component Life & Value

Spark Plugs Replaced
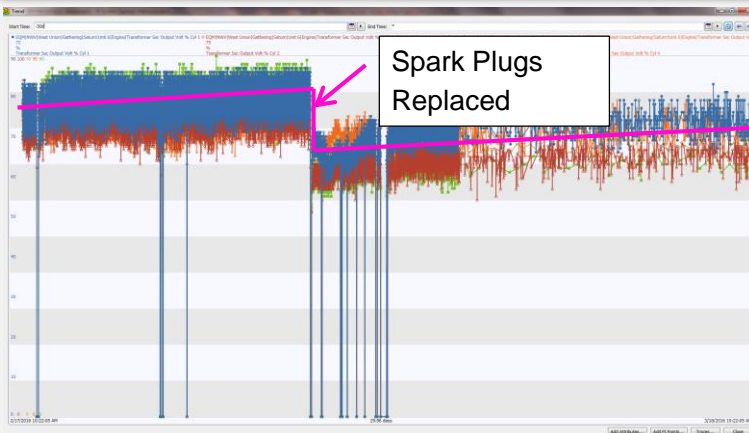
Secondary Ignition Voltage – Plug Condition Indicator

Background

- Spark Plug Life Varies by Application/Site
- Secondary Ignition Voltage – Leading Indicator of Plug Condition
- Voltage Increases Slowly as Plug Decays Over Time
- Plugs Represent Challenge with Utilizing Condition Monitoring & Maintenance

Solution

- Use PI Coresight & Notifications to Trend Increase in Leading Indicator Value
- Integrate PI AF & Maximo to Generate WO at Defined Conditions
- Apply Spark Plug Philosophy to Other, Higher Impact Systems

Results

- Reduce Frequency of Spark Plug Changes
- Eliminate Downtime & Cost of Unnecessary Plug Changes
- PI/Maximo Integration – Develop Tracking System for Reliability Analysis
- Foundation to Begin Assessment of Condition Indicators & Application to Overarching Systems

Looking Back & Ahead

Cultural Change: People, Processes, & Technology

A Sustainable PI System Begins With Details

Long Term Vision & Management Support

Support Business Case w/Value

Communicate Strategy

Identify Resources

Utilize the PI System® as Tool for a Culture Shift

Identify Critical Data & Build Foundation

Data to Support Business Case

Focus on Data Quality & Integrity from Beginning

Develop Manageable Scope and Scale Up

Develop PI AF to Support Long Term Strategy & Sustainability

Communication & Feedback

Engage Users in Development

Build Tools & Process with Users in Mind

Feedback Loop for System Improvement & Value

Looking Ahead: EQT Midstream & The PI System®

The Next Steps in the Journey Towards RCM

PI Coresight, Notifications, & Connectors

- Engage Users Across Company with Coresight
- Integrate PI AF with Other Business Systems to Drive Business Intelligence
- O & M Strategy Shift Built on Data & Analysis

Transform Data, Analysis, & Condition Assessment as the Basis for Maintenance & Operation
- Distance from Preventative Approach
- Culture Shift to Data Driven Activities

PI Analytics, Notifications, & Connectors

- Refine and Enhance Existing Analytics & Notifications
- Develop More Advanced Analytics for Improved Predictive Capabilities
- Identify Key Metrics & KPI's & Implement in PI to Drive Performance

Advanced Development & Refinement of EQT Midstream's PI System®
- Advanced Analytics
- Additional Predictive Strategies
- Integration w/Other Systems
- Enhanced Reporting & Visualization Tools

PI AF, Notifications, Coresight, & Data Link

- Utilize Templates in PI AF to Efficiently Deploy System at Additional Facilities
- PI DataLink to Effectively Manage Tags & Differences in Assets
- Continue Development of Internal Knowledge Base of System & Tools

PI System® Installations at Additional Facilities
- More Data = Better Understanding of Equipment & Processes
- Benchmarking & Relationships
- Applications Beyond Compressor Stations

Journey to Reliability Centered Maintenance

Data is the Foundation for Solutions

COMPANY and GOAL

Maximize Customer & Shareholder Value by Optimizing the Maintenance & Operations of EQT Midstream's Natural Gas Gathering & Transportation Systems

EQT Midstream
PARTNERS, LP

CHALLENGE

Reactive maintenance and operational culture resulting in suboptimal operational asset performance

- Many different toolsets

- Inability to share solutions

- SCADA based mentality

- Data quality, governance, and security challenges

SOLUTION

Business Unit Initiative to Implement the PI System® to Collect, Aggregate, Analyze and Visualize Operational Data to Optimize Assets & Processes

- PI AF – Organize & Templates of Compressor Asset Data

- PI Coresight – Dashboards to View Compressor Data & Trends

- Focused on data quality, governance, and security

RESULTS

Have made significant progress towards objective of a reliability centered maintenance organization

- Reduced maintenance

- Avoid 1 to 2 Catastrophic Equipment Failures Per Year

- Reduction in Parts Usage – 1 to 2 Less Replacements Annually Per Type

- 25% -50% Reduction in Troubleshooting Time

Contact Information

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Questions

Please wait for the **microphone** before asking your questions

State your **name & company**

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A cultural Change: People, Process, & Technology

A Sustainable PI System Begins With Details

Data Integrity & Value (PI AF, Data Link, …)
- Scrutinize Data & Sources for Collection
- Focus Effort on Data – Scaling, Ranges, Compression, & Other Attributes
- Avoid Collecting Unnecessary Data Points
- Consider Users

Communication & Sustainability (PI Notifications, Coresight,…)
- Tools & Process to Engage Users
- Feedback System for Improvement
- Useable Tools (Displays, Trends, Notifications) for All User Groups
- Strive for Continuous Improvement of System

Identify Critical Data & Assets (PI Asset Framework)
- Data to Meet Business Case/Objective
- Assets/Data Driving Actions Applicable to Business Challenge Scalability
- AF Provides Ability to Contextualize Data
- Consider Long-Term Goals/Strategy
    - Organization of Data & Assets in AF
    - Unique Identifiers & Naming Conventions for Integration w/Other Systems

Management Support & Charter
- Support Business Case with Value
- Gain Management Support & Buy-In of Other Business Groups
- Clearly Communicate Long-Term Vision & Executable Strategy

- Identify Needs & Focus Resources on Implementation of Strategy
    - PI is a System & Tool
    - Requires Dedicated Focus & Support
    - Continuous Development

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