Predicting Over-Pressure in Gas Pipelines

Bryan Hennessy & Sergio Hernandez, PG&E
Andrew Pong & Jerry Vin, DST Controls
Gas Pressure Regulator Stations

- Step down pressure for customers downstream similar to an electric transformer
- We operate hundreds
- Risk of over-pressurizing downstream system if failure occurs
Predict Regulator Failures

- 16% of Over Pressure (OP)/near hit events show potential for early saves.

- We have 500 distribution regulator stations with downstream regulator pressures sensors, and another 2,000 coming online in the next 5 years. We have to depend on automated monitoring.

| OP/Near Hit Events per year with Instrumentation | 62 |
| OP/Near hits per year that can be seen by eye more than 2 hours before the SCADA alarm | 10 (16%) |
Alert Envelope Early Catch

SCADA HH Alarm

Pressure Envelope Alarm
14 Hours Earlier
Finding New Potential Issues
System Components
Alerts Before HH Alarm (18 days, 12 days, and 7 days)
## Algorithm Selection

<table>
<thead>
<tr>
<th>consideration</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customized model parameters per station</td>
<td>Typically lower false alarm rate</td>
<td>Each model is trained and maintained independently, so there is a high initial and support cost</td>
</tr>
<tr>
<td>General model parameters for all stations</td>
<td>Can be run on our whole system with little input and minimal cost</td>
<td>Higher false alarm rate with costs to review and to possibly send additional field crews</td>
</tr>
<tr>
<td>Existing Commercial Products</td>
<td>Mature software with lots of features</td>
<td>Locked into a platform. One vendor had non standard hardware requirements</td>
</tr>
<tr>
<td>Open source</td>
<td>Not dependent on vendor to support</td>
<td>Less out of the box features</td>
</tr>
<tr>
<td>Existing Commercial Algorithms</td>
<td>Well known algorithm with proven success in other industries</td>
<td>Designed to look for single snap shots in time across many correlated variables. Doesn’t consider time series shape. Pilot results were not finding the abnormal time series signatures. The results were similar to High and Low flat alarm settings in this application.</td>
</tr>
</tbody>
</table>
Pressure Downstream of Regulator Stations

Plot 0

56
55
54
53
52
51
50
49
48
47
46
5/3/2017 12:00:00 AM
7.00 days
5/10/2017 12:00:00 AM

Plot 0

56
55
54
53
52
51
50
49
48
47
46
5/3/2017 12:00:00 AM
153.00 days
10/3/2017 12:00:00 AM
Anomaly or Normal Operations?

Downstream pressure [46 – 56 psig]

~ 140 days
Transmission Regulator station SSA_PT0009 in Sacramento

Downstream pressure [235-256] PSIG

~8 days

160 days

Distribution Regulator Station CC_SAL_S38 in Salinas

Downstream pressure [51-55] PSIG

~8 days

120 days
See Pattern Across System

Salinas

Hollister

Sacramento

Merced
Distribution Regulator Station in Sunnyvale

- After inspection, pattern disappears
- Pattern due to an internal component in regulator station
- Nothing unusual noted in the maintenance record

Pressure Regulator in Sunnyvale
Before Inspection
• Station was chosen from current pressure trend
• No lock-up due to Sulfur build-up was expected before trip

During Inspection
• Regulator did not lock-up so it had to be rebuilt
Is this pattern important?

- Sawtooth pattern was present in overpressure events that were caused by sulfur build-up
- Unfortunately, not all stations had instrumentation installed at time of incident
Transmission Regulator Station in Sacramento SSA_PT0009

Sawtooth Pattern

Near Hit Event
OSIsoft – Python Connector “OSIsoftPy”

Data Retrieval Features

Read PI points
   Current, interpolated, plot, recorded, summary, and end values

Write PI Points

Monitor PI points for updates

Reading from AF attributes
OSIsoftPy Architecture

- Python issues https requests to PI Web API
- Single command requests many PI Points
- Written as a library
- Warning: Kerberos authentication
  - Microsoft Active Directory requires PI Web API server config as a Service Principal Name

Code Sample

```python
# Import library
import osisoftpy

# Authenticate
webapi = osisoftpy.webapi('https://dev.dstcontrols.com/piwebapi/)

# Get points
point_list = webapi.points(query='name:SINU*')
point_list2 = webapi.points(query='name:CDT*')
for individual_point in point_list2:
    point_list.append(individual_point)

# Read latest value
for individual_point in point_list:
    valueobj = individual_point.current()
    print('Latest value of {} is {} at time {}
    {}'.format(individual_point.name, valueobj.value, valueobj.timestamp))
```
Predicting Over-Pressure in Gas Pipelines

PG&E is trying to reduce gas over pressure events

<table>
<thead>
<tr>
<th>CHALLENGE</th>
<th>SOLUTION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure is a serious issue in gas pipelines</td>
<td>Can detect a potential overpressure incident days before using machine learning</td>
<td>Move from react and respond to predictive and proactive response</td>
</tr>
</tbody>
</table>
| • Understanding normal vs abnormal behavior from pressure regulators | • PI Web API with DST Python connector  
• Learning algorithm from EigenPatterns  
• PI vision and Microsoft Dynamics UI | • Notified hours or days before SCADA system alarms  
• %5 of alarms caught in advance  
• One additional alarm per day per hundred stations monitored |
Thank You

Merci
Спасибо
Danke
Gracias
감사합니다
ありがとう
Grazie
Obrigado
Improving Data Quality, Inventory & Material Movement Management, & Refinery Yield with Sigmapine Embedded PI AF

Tyler Cohen – Yield Accounting Engineer
About Hunt Refining Company

Hunt Refining Company is a privately held petroleum refiner headquartered in Tuscaloosa, Alabama. The company markets asphalt, transportation fuels, light oils and other refinery products predominantly in the southeastern United States.

Refineries:
- Tuscaloosa, AL
- Sandersville, MS
Leverage of SigmAFine (Embedded PI AF) to improve:

- Data Quality
- Data/System integration
- Integrated Movement Management
- Plant Production & Yield Accounting
- Inventory Balancing
- Refinery Performance
Sigmafine Model Enables Foundational Areas

- Process Data Quality – meter level
- Inventory Balancing
- Production accounting
- Refinery material balances
- Individual process units material balances
- Detection of measurement errors
- Non-measured flows calculation
- Material losses accounting
**RESULTS**

Accurate information about how the refinery is performing.

- Monitor meters, units, processes & overall refinery performance on a daily basis.
- Improved Reporting

**SOLUTION**

The seamless integration was accomplished by the use of AF and Pimsoft Integration Framework, which integrates and transforms data from Hunt’s systems.

- AF as a centralized business logic layer
- AF-based Pimsoft’s Integration Framework
- Sigmafine mass balance modules

**CHALLENGE**

Different systems having their own version of the “truth”

- Difficult to compare and validate overlapped information
- Systems working independently with no synergy to optimize the operation of the refinery

The main objective was to measure overall refinery performance on a more frequent basis and to improve reporting capabilities and data access to validate individual unit and meter performance.
Improving Yield and Refinery Performance Using AF

• Tyler Cohen
• tcohen@huntrefining.com
• Speaker’s Title
• Hunt Refining
Questions

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PI Asset Framework enables business users to create value through analytics capabilities: the power to succeed and the right to fail, very quickly, without irreversible consequences.

David Chatel - Project Manager – Chevron Oronite
Conference Theme & Keywords

- Digital Transformation
- Energy Management
- Event Frames
- Real-time
- Time Series
- Analytics
- Energy Management
- Regulatory Compliance
- Security
- Open System
- Asset Health
- Sensor-based
- IoT
- Partner
- Connectivity
- Enterprise Agreement
- High Speed
- Process
- Scalability
- Community
- Quality
- Integrators
- Process
- Operational Efficiency
- Safety
- PI System
- Millions of Streams
- Visualization
- Connected Services
- Future Data
- Asset Framework
- Enterprise
- Business Impact
- Connected Services
- Ecosystem
- CBM
- Big Data
The OSI PI System has been a Chevron standard solution for more than 15 years with proven success stories.

Chevron Downstream & Chemicals stream engaged a Manufacturing Data Foundation project.

In 2017, Chevron Oronite Gonfreville Plant (France) was selected to run a PI Proof of Concept

- Gonfreville plant benefits of robust SCADA system but with quite limited analytics capabilities
- Each Oronite manufacturing plant has its own SCADA system without process data aggregation layer

Execute this proof of concept in a Sprint / Agile approach while letting users practice products
**OBJECTIVES**

- **CONSUME PROCESS DATA FROM THE BUSINESS NETWORK**
- **CAPTURE REALTIME DATA FROM HISTORIANS**
- **ALIGNMENT WITH CHEVRON IT STANDARDS**
- **LEVERAGE PI ANALYTICS CAPABILITIES**
- **MINIMUM, IMPACT ON PCN / IT LANDSCAPES**
- **COMPLIANCE WITH PURDUE MODEL**

**ENABLE GLOBAL PROCESSES IMPROVEMENT AND RELIABILITY**

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CHEVRON ORONITE GLOBAL MANUFACTURING ORGANIZATION

DAYS
BATCH PROCESSING
HETEROGENOUS SCADA
## Gonfreville Plant Layout

**Tags 42 K**

**Pilot Tags in Scope: 1,5 K**

- **Unit 1** (East Components)
- **Unit 2** (East Components)
- **Unit 3** (West Components)
- **Unit 4** (South Components)
- **Unit 5** (Alkylation Unit)

- **Blending Unit** (Supply Chain)
- **Wonderware** (in scope)
- **Wonderware** (out of scope)
- **Legacy Scada** (out of scope)
PILOT ORGANIZATION

GONFREVILLE PLANT TEAMS
- IT / PCN (TECHNOLOGY & INTEGRATION)
- BUSINESS EXPERTISE
  - PROCESS ENGINEERING
  - MFG OPERATIONS
    - SECTOR 3
    - SECTOR 4
    - RELIABILITY

CHEVRON GLOBAL GROUPS
- CHEVRON ENERGY TECHNOLOGY COMPANY PROCESS AUTOMATION UNIT (PI subject ownership)
- IT CHEVRON (Infrastructure)
- DOWNSTREAM IT OPS (DATABASE MGMT)

EXTERNAL PARTNERS
- VENDOR (OSISOFT)
- EXTERNAL CONSULTING (PI System)

CHEVRON GLOBAL GROUPS
- CHEVRON ENERGY TECHNOLOGY COMPANY PROCESS AUTOMATION UNIT (PI subject ownership)
- IT CHEVRON (Infrastructure)
- DOWNSTREAM IT OPS (DATABASE MGMT)
On the same host we use:

- ICU OPC (PI Client interface)
- Wonderware FS Gateway (OPC DA Server)
• Technical integration went very well and smoothly with zero impact on PCN / IT infrastructure and application landscapes.
• Chevron Process Automation Unit high expertise on PI made products implementation quite efficient.
• 11 K tags were loaded from our Wonderware platform instead of the initial 1,5K with fewer effort (thanks to PI Builder)
• We met our major milestone which was the held of a workshop
• Efforts : Business (180 hours) – IT Ops / PCN – (40 hours) – PM (350 hours)
AF Tags & Hierarchy Buildout

Wonderware comes with data visualization tools (Trend, Query and Workbook), familiar to business users, that enable crawling within a logical hierarchy to retrieve time series values. Each tag is associated to a hierarchical node.

1. First goal was to export tags “flat” list for registration in PI Data Archive(s) and population with PI ICU (OPC)
2. Second objective was to recreate this entire hierarchy in Asset Framework and, by extension, in PI Coresight
3. Third goal was to create element templates with appropriate attributes
4. Third objective was to map tags with hierarchical structure

Data export and load phases were successfully achieved using:
- Wonderware client tools
- Extensive use of PI Builder
- Some Excel formulas make data consistency easier
- SQL queries and VBA to export and modelize hierarchy

ELAPSE TIME: 2 WEEKS
AF ELEMENTS TEMPLATES

Wonderware is an object-oriented SCADA development and deployment platform.

It uses templates of objects that can be derived to create a new element / assets like in PI AF. Each template can come with multiple attributes.

This best practice makes the creation of new equipment / attributes consistently managed.

Every individual Wonderware templates
1. Has been exported
2. Has been created in PI Explorer using PI Builder

Ultimately, mapping between templates and hierarchical node has been exported as well.

ELAPSE TIME : 1 WEEK
AF ELEMENTS & TEMPLATES MAPPING

One of the objectives was NOT to create all tags in PI AF. Every template comes with the tag address named in a generic way:

\%Server\%\%Element\%\%Attribute\%

Last step consisted in mapping every PI AF element with the corresponding PI AF template which was achieved as well with PI Builder.

ELAPSE TIME: 1 WEEK
PUMP USE CASE (ANALYSIS)

**Requirement**
- Reliability engineers have identified a key pump in a particular Manufacturing unit
- This pump operates well but is unique and is a key component in the process
- Engineers wish to be notified of an abnormal situation **before reaching a critical state**. This situation is the combination of:
  1. The pump flow rate must exceed a configurable value
  2. This excessive situation must persist during a configurable amount of time
  3. Once those conditions are met a notification email will be sent to a list of recipients

**Process Data**
- A PI Point exists in PI AF and hosts Wonderware Historian pump flow rate tag
- A configuration item is required to store minimum flow rate limit
- A configuration item is required to store minimum duration (excess persistence)
- A new PI Point will be used to store analysis calculation results

**Conditions**
- Pump has to be in an active state

**ELAPSE TIME : 2 DAYS**
### Pump Use Case (Analysis)

**Logical Built**
1. An expression was built to detect excess cumulated time and store duration (expressed in seconds) in a dedicated PI Point
2. An Event Frame triggers a notification to a list of recipients, only once after having exceeded the configurable duration

**PI Element – Attributes Content**

- **Configuration Items used to store thresholds (flow rate ratio and minimum duration)**
- **PI Points that hosts realtime replicated tags from Wonderware Historian**

- **PI Point created to store analysis result**
Key PI Points are stored into variables to ease evaluation and recall in other sub expression.

Expression is assessed every time the pump flow rate changes.

1. Scheduling: Event-Triggered
2. Trigger on: R_01_Valeur_Mesure
4. The result of expression will populate a dedicated output PI Point
is nothing but a simple IF THEN ELSE
IF Pump flow rate exceeds configurable limit
AND discordance AND pump status are both positive
THEN time difference between past and penultima PI Points will be added to the aggregated value
ELSE 0 (will be written as an output to reset the counter)

3. Special functions are used to retrieve
- PI Points values and timestamps
- For the last and penultima pump flow rate
Then the difference between the 2 timestamps is converted into an integer to enable use in formulas
4. The result of expression will populate a dedicated output PI Point

is nothing but a simple IF THEN ELSE

IF Pump flow rate exceeds configurable limit
AND discordance AND pump status are both positive

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3. Special functions are used to retrieve
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   - For the last and penultima pump flow rate

Then the difference between the 2 timestamps is converted into an integer to enable use in formulas
**Centrifuge Use Case (Analysis)**

**Context**
- Centrifuges play a key role in our processes
- Among multiple parameters, vibration rate is a very reliable indicator of asset health
- Data scale is quite reduced (expressed in millimeters) and makes abnormal state hard to see to the naked eye on a classic trend screen…and it will be very often after the facts

**Objective**
- Anticipate progressive negative deviations that are impossible to monitor in real time

**Requirement**
1. Create a common logic to all centrifuges (embedded in an element template)
2. Provide ability to configure vibration threshold on a per asset basis
3. Notify Reliability team after every reach of maximum limit
CENTRIFUGE USE CASE (ANALYSIS)

Analysis came with:
1. The calculation of an hourly vibration average rate
2. Compared with penultima hourly vibration average rate
3. The calculation of difference between the 2 past averages
4. This delta is compared with a threshold configurable by business experts
5. And the sent of a notification when delta exceeds threshold

ELAPSE TIME: 1 DAY
ZINC PHASES DETECTION (EVENT FRAMES)

Context
• AF enables detection of events through the Event Frames feature
• Chevron had few opportunities to exploit this (recent) feature and Oronite wishes to identify easily batch processes
• Current situation is a manual processing of thousands of records pulled out from historian that take

Achievements
• Process engineers documented processes phases and steps in quite a synthetic document
• Efficient preparation work made execution simple

In 2 days business users have been able to create “event frames” to detect successfully all 5 phases of the process

<table>
<thead>
<tr>
<th>3 - DISTILLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WFE</strong></td>
</tr>
<tr>
<td>Stop</td>
</tr>
<tr>
<td>FIC116.R01.Value.Measure=500</td>
</tr>
<tr>
<td>Recycling</td>
</tr>
<tr>
<td>Producing</td>
</tr>
</tbody>
</table>

1 - ACID
1 sequencer
Start and stop conditions easy to identify

2 - NEUTRAL (DEGAZING)
2 asynchronous sub-phases
2 sequencers
Start and stop conditions easy to identify

2 - NEUTRAL (NEUTRAL)
2 sub-phases
2 sequencers
Only one has to be active to confirm process execution

3 - DISTILLATION
3 tanks
Only one has to be active to confirm process execution

4 - FILTRATION
1 sequencer
Start and stop conditions easy to identify
ZINC PHASES DETECTION (SAMPLE OUTPUTS)

**ACID PHASE**

<table>
<thead>
<tr>
<th>Event/Phase</th>
<th>Start Time</th>
<th>End Time</th>
<th>Duration</th>
</tr>
</thead>
</table>

**NEUTRAL PHASE**

<table>
<thead>
<tr>
<th>Event/Phase</th>
<th>Start Time</th>
<th>End Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZINC-5 DISTILLATION PHASE 2018-04-11 18:59:59</td>
<td>13/04/2018 15:15:40.004</td>
<td>13/04/2018 15:15:40.004</td>
<td>86.6 Hours</td>
</tr>
</tbody>
</table>

**FILTRATION PHASE**

<table>
<thead>
<tr>
<th>Event/Phase</th>
<th>Start Time</th>
<th>End Time</th>
<th>Duration</th>
</tr>
</thead>
</table>
TAKEAWAY MESSAGES

1. PI Asset Framework is an ideal platform to apply **Agile methodology principles**.

2. Event Frame feature is by design **easy to use** and reveals data as they've never been seen before and **reduces drastically effort** required to identify batches, durations, etc.

3. Building an efficient analysis has **much greater** chances to succeed **only if** consistent time is dedicated with business users to understand data series, what they mean, conditions, triggers, and expected results.

4. Leverage **extensively** the Backfill/Recalculate feature on Analysis and Event Frames to control analysis consistency against past data before making logic live.
• David Chatel
  • david.chatel@chevron.com
  • IT Project Manager
  • Chevron Oronite
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