Deep Dive into Transformer Monitoring with PI

Vince Polsoni
Alectra Utilities
Agenda

• Alectra
• Maintenance Methodology
• Intelligent Transformer Maintenance
• Innovation
• Leveraging Integrated/Interfaced Systems
• PI AF, Notifications, Analysis, Reporting
Ontario
1,068,587 km²

Alectra Service Territory
- Located just North and West of Toronto, Ontario, Canada
- 1800 km²
- 15 Communities
- 1 million Customers
- 3.1 million Population
- 4750 MW Peak Demand
- $3.6 Billion Total Assets
The Alectra Intelligent Maintenance Plan

The Plan

100% of work (PM) was time based

RCM3 - ISO55000 Compliant
RCM3 - ISO31000 Compliant

'This Work at the Right Time, Done the Right Way, The First time'

Preventive, Predictive
On Condition Task
Failure Finding
Scheduled Restoration
Scheduled Discard
No Scheduled Maintenance

RCM3 (Reliability Centered Maintenance)
CBM (Condition Based Maintenance)

TBM (Time Based Maintenance)
Intelligent Station Maintenance at Alectra

• Leverage integration of PI System and CMMS
• Risk Based - Condition Based Maintenance
• RCM3 methodology incorporated in CMMS
• Situational Awareness - Instant Information 24/7
  • PI Notifications (Real time)
  • Alerts from CMMS System
  • PI System Reports, Dashboards
• Automatic Triggered Maintenance Work Orders
• Analytics in multiple systems
• One source of data
• Keeping it Simple
The Alectra Intelligent Maintenance System

2 Key Components

1. CASCADE CMMS
   • Tracks assets, Maintenance history, Asset Condition and Costs
   • Analytics
   • Trigger maintenance tasks based on condition or events
   • Interfaces with PI System, test equipment and Oil lab data
   • Prioritize maintenance work – Criticality, Health and Risk

2. PI System
   • Data collector, Speed optimized
   • Real-time analysis and notifications
   • Easy reporting tools, easy interfacing, enabler of IIOT
Industrial Development – Industry 1.0 to 4.0

1.0
MECHANISED PRODUCTION
Steam engines

2.0
MASS PRODUCTION
Assembly lines and electricity

3.0
AUTOMATION
IT and electronics

4.0
CONNECTIVITY
‘Smart’ technologies; Cloud computing; Big data; Networked machines and processes

The stages of industrial development
What is RCM3

**Definition of RCM:**
"RCM is a process used to determine what must be done to any physical asset to ensure it continues to do what the user wants it to do (fulfill its functions) in the present operating context."

- Started in the aviation industry as far as 1978.
- Widely adopted by asset-intensive organizations across a variety of industries.
- RCM3 is an enhanced version of RCM2.
- Brings RCM mainstream with the "new" Management Systems ISO 55000 and ISO 31000.
- Risk mitigation is a major focus of RCM3.
- Enhanced methodology and process to make the analysis results more robust and defensible.

### Generations of RCM

1. **1st Generation**
   - Fix it when it breaks
   - Higher availability
   - Lower costs
   - Longer asset life

2. **2nd Generation**
   - Higher availability
   - Lower costs
   - Longer asset life

3. **3rd Generation**
   - Higher availability, reliability and throughput
   - Greater cost-effectiveness
   - Greater safety
   - Better product quality
   - No damage to the environment
   - Longer asset life

4. **4th Generation**
   - Managing physical and economic risks
   - Standardization and adopting standards (i.e. ISO 55000)
   - Globalization
   - Stewardship and social responsibility
   - Renewable strategies
   - Defect elimination
   - Innovation
RCM3 - Understanding Failure Curves

- Premature random failures
- Often after Human Intervention

Source: RCM II by John Moubray, Industrial Press Inc, 1992
RCM3 – On Condition Task
Condition Scoring Using Potential Failure “PF” Curve

Alectra Condition Scoring Matrix

1. New
2. Used
3. Potential Failure
4. Failed – Schedule Repair
5. Failed – Emergency Repair
6. Failed – Repaired Onsite
Embedded Sensors of a Power Transformer at Alectra

Over 100 sensors/monitoring points on a typical station power transformer

- OLTC Temp, Pressure and Controls
- Self Drying Breathers
- Geomagnetic Induced Current
- Oil Level
- Tank Oil Temperature & Pressure
- Winding Temperature
- Bushing Monitoring
- Protection Health
- Cooling Fans & Pumps
- Dissolved Gas Analysis
- Oil Pumps
- Transformer Protection
- OLTC Oil Filtration
- MVA, MW, KV and Amps
- Geomagnetic Induced Current
- Over 100 sensors/monitoring points on a typical station power transformer
Sensors / Equipment Monitoring – Building block for successful Intelligent Maintenance (CBM)

- Transformer Self Drying Breather
- Bushing Monitoring Systems
- Substation Thermal Camera
- Tap Changer Oil Filtration
Sensors / Equipment Monitoring – Key building block for successful Intelligent Maintenance (CBM)

7 Gas Dissolved Gas Analysis Monitoring Unit

Temperature & Pressure

Transformer Monitoring Relay

Protection Relay

Hydrogen Gas Monitor

7 Gas Dissolved Gas Analysis
Fibre Optic - Temperature Sensor Monitoring

Monitors temperature of terminations, locations where InfraRed scanning is not safe or possible.
Alectra Intelligent Maintenance System Setup

Station Equipment Sensors
Analog & Status Data

SCADA

Firewall

PI Interface

PI System

Firewall

Algorithm Rules Engine

PI Reports
Dashboards
(Real-time)

CARE

CMMS

Test Results
Condition Data

CMMS WorkOrder

Internet

OMS

Outage Mgmt System

CIS

PI AF Table Query

PI Notifications
(Real-time)

CMMS Alerts
(delayed)

HTML

Customer Info System

OSIsoft®

PIWorld

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Sensor Data used to Trigger Transformer Maintenance Tasks

- **Transformer:**
  - Dissolved Gas and Moisture (Oil Condition)
  - Loading, Oil Temperature, Oil Level, Transformer Tank Pressure
  - Transformer Cooling Status and Cooling Failure
  - Tap Positions (monthly max and min and if passed through neutral)
  - Tap Changer Oil temperature vs main Tank Oil Temperature
  - Bushing Monitoring Power Factor & Capacitance
  - Geomagnetically Induced Currents (GIC)
How Alectra configures Intelligent Transformer CBM using PI System and CMMS

- **Online Monitor**
  - Define Analogue and Digital State points to send to SCADA
- **WIMAX, Fiber, Radio**
  - Data sent to SCADA via available Communication Network
- **SCADA**
  - SCADA Points Created
- **PI System**
  - PI Tags Created
  - Mapped to SCADA Points
  - PI AF Attributes created in Element Template
  - PI Analysis Created
  - PI Notification Created
- **CASCADE**
  - Cascade READS Created
  - Cascade Mte Triggers Created
  - Cascade Alerts Created
  - Cascade MxProcedure Created
  - MxProcedure / Trigger Applied to Equipment
- **CASCADE CARE**
  - CARE Point Mapping to PI Tags
  - CARE RPacks (Algorithms) Configured
  - CARE RPacks mapped to Cascade READ
  - Cascade Triggers Alerts from CARE RPack
  - Cascade Triggers MxOrders from CARE RPack
- **CASCADE**
  - Condition Based Maintenance
Communication Infrastructure

• Fibre – redundant systems throughout utility territory
  • Leased and owned
• WiMax (Remote stations) to Hubs (Stations) then Fibre to servers throughout utility
• Radio System to Hubs (Stations)
Transformer Monitoring

• Utilize a SEL 2414 Relay
• Inputs:
  • Hydrogen Monitor
    • High, High High, Monitor status (Form C Contact)
  • Winding and Oil temperatures from gauges
  • Oil level
  • Pressure Relief Status, Rapid Pressure (Oil movement – Protection Trip)
  • RTD – building temperature (3 wire 100ohm range)
  • Fan controls, amps
    • Know running current. If within operating window ‘Normal” if outside operating range “Cooling Failure Alarm”
    • Once a week for a 15 min interval fans are exercised automatically.
Example: 7 Gas Transformer Oil Monitor

Product: Morgan Schaffer Calisto 9
• Analyses 7 gases plus water content
• Monitored Consumables: Carrier gas, Calibration gas  
  • PI Report and Notifications on consumables (weeks remaining and pressure)
• Gas data interfaced to TOA4  
  • Script run at 3pm daily to upload gas values and have oil analyzed
• Synchronized with CMMS twice a day
• PI Notifications if gases exceed IEEE standard thresholds
• CMMS triggers alerts and auto generates work order if DGA or Moisture condition codes show oil is in poor condition
• Data stored in PI as tags and stored in AF structure
Integrated Expert Systems – Intelligent Transformer Oil Monitoring
Transformer Dissolved Gas Analysis Monitor Report
PI Notification - Transformer DGA Levels Exceeding Thresholds

**Hi,**

As of 4/21/2018 9:32:23 PM Eastern Daylight Time (GMT-04:00:00) Gas values have reached one or more IEEE thresholds:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Current Value</th>
<th>Low Alert (2)</th>
<th>Increase Alert (2)</th>
<th>Increase Warning (3)</th>
<th>Increase Alarm (4)</th>
<th>Rate Alert (2)</th>
<th>Rate Warning (3)</th>
<th>Rate Alarm (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen (H2)</td>
<td>2</td>
<td>NA</td>
<td>101</td>
<td>701</td>
<td>1801</td>
<td>0.33</td>
<td>3.33</td>
<td>6.66</td>
</tr>
<tr>
<td>Oxygen (O2)</td>
<td>21300</td>
<td>NA</td>
<td>8000</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Methane (CH4)</td>
<td>5.2</td>
<td>NA</td>
<td>121</td>
<td>401</td>
<td>1001</td>
<td>0.4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Carbon Dioxide (CO2)</td>
<td>635</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>222</td>
<td>NA</td>
<td>351</td>
<td>571</td>
<td>1401</td>
<td>1.2</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Ethylene (C2H4)</td>
<td>3.6</td>
<td>NA</td>
<td>51</td>
<td>101</td>
<td>201</td>
<td>0.17</td>
<td>1.67</td>
<td>3.33</td>
</tr>
<tr>
<td>Ethane (C2H6)</td>
<td>0.4</td>
<td>NA</td>
<td>66</td>
<td>101</td>
<td>151</td>
<td>0.22</td>
<td>2.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Acetylene</td>
<td>0.2</td>
<td>NA</td>
<td>3</td>
<td>15</td>
<td>30</td>
<td>0.12</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>NA</td>
<td>25</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Reinsaturation</td>
<td>0</td>
<td>NA</td>
<td>30</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>CO2/CO</td>
<td>2.86036</td>
<td>3</td>
<td>10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Thanks,
Operations Technology
Real-Time Transformer Oil Analysis
Intelligent Maintenance Example
Dissolved Gas Analysis in Transformer

Transformer Problem Identified
• (Health and Risk Increase)
• PI Notification, CMMS Alert
• Auto Generated CM Work Order
22 out of 22 TS Transformers' sample data have been uploaded at 01/12/2017 3:00:48 PM by TOA4 Daily Upload.
Transformer Hydrogen Gas Alarm Report

- PI System Notification – Real-Time
- CMMS System
  - Alert & Work Order Notification

Equipment information
Location: MS405-Brock
Type: TXMS
Equip #: 980
Serial #: B3250061
Manufacturer: Tranelectrix Tech Inc

Alert generated by
CARE TXMS HYDROGEN MONITOR is at 100% of threshold (Current Value of Failed = Threshold Value of Failed).
You can acknowledge this alert in Cascade.
Detailed Transformer Report

Station Load: 37.475 MVA, 36.576 MW
Transformer Load: 19.342 MVA, 18.442 MW

Heat Trend

Cooling Fans
Stage 1: On, Stage 2: On

Oil Pumps
Stage 1: NO DATA, Stage 2: NO DATA

Main Tank Oil Breather: Normal
Main Tank Oil Level: Normal

Load [MVA]: 16.342 MVA, 37.475 MVA, 18.442 MVA
Load [MW]: 132.05, 151.45

CHR Values
Criticality: 2.9
Health: 132.05
Risk: 151.45

Tapchanger Position
Tapchanger Temperature: 7.1°C
Tapchanger Oil Filter
Number of Open Work Orders: 4
Example: Transformer Bushing Monitor

Product: Doble IDD/Doble Prime

- Each unit can monitor up to 12 bushings
- Connected to SCADA via DNP3
- Local connection and web page reporting
- Raw data from IDD into PI System
- Leverage PI Reporting and PI Notifications
Integrated Expert Systems – Bushing Monitoring
Transforming our World
Bushing Monitoring – 1 set Secondary Windings
Bushing Monitoring – 2 sets Secondary Windings
PI AF – Transformer Management

• PI AF Templates
• PI AF Transformer Attributes
• PI Analysis
• PI Notifications
  • Configuration – Analysis
  • Configuration - Notification
  • Email
• PI Table
  • Data extracted from CMMS and OMS systems
PI Asset Framework – Transformer Attributes
Analysis Template – Tap Changer Oil Level
Notification Rule – Tap Changer Oil Level
PI Notification Email Message Template
Tap Changer Low Oil
PI Notification – Low Tap Changer Oil

Update:

VTS4:VTS4:T2 Tap Changer Oil Level changed to **LOW** at 3/22/2018 12:42:18 PM Eastern Daylight Time (GMT-04:00:00).

Thank you,
Station Sustainment Department
Alectra Utilities
Video Example Table – Transformer and Tap Changer Oil Test Results from CMMS
SCADA – PI System – CMMS working as One

PI Report

(High Water Alarm)

PI Notification

(from SCADA event)

CMMS Work Order Alert

(from CMMS)

CMMS Work Order

(automatically generated)

PI Report

(High Water Alarm Cleared)
PI Notifications – Transformer Conditions

- Transformer Differential
- Transformer Main Tank Breather
- Tap Changer Low Oil
- Tap Changer Oil Filtration Alarm
- Dissolved Gas IEEE Threshold Exceeded
- Dissolved Gas, Moisture and Fluid Quality Condition Code >2
- Calisto 9 Oil Monitor General Alarm

- Transformer Online / Offline
  - Primary Switch Operation
  - Secondary Txmr Breaker Operation
- Transformer Oil Temp/Cooling
- Transformer Bushing Alarm
- Oil Containment Alarm
- Hydrogen Alarm
- Transformer High Winding Temp
SubStation Interconnection – Load Transfer Report

Hi,

MS309:Painswick:T1 Transformer is experiencing a high MVA ratio of 81%.

Current Load is 4.58MVA
Current Applied Rate is 20MVA

<table>
<thead>
<tr>
<th></th>
<th>Base Rate</th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>NA</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Rating</td>
<td>20MVA</td>
<td>26.6 MVA</td>
<td>33.3 MVA</td>
</tr>
</tbody>
</table>

Thanks,
Operations Technology
Geomagnetic Induced Current Report
Feeder Availability Report - Risk

Update:

One or more thresholds have been exceeded by **BARRIE M5 BREAKER** at 3/2/2017 4:30:25 PM Eastern Standard Time (GMT-05:00:00):

<table>
<thead>
<tr>
<th></th>
<th>Number of Incidents</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last 30 Days</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Last 60 Days</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Last 90 Days</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>YTD</td>
<td>2</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Number of Customers fed by this Feeder is **1354**

For more information please see [Hydro One TS Feeders Operations on DPDs](#).
PI Notification – Transformer De-Energized / Energized

Location: VTS2:Torstar:T2
Time: 4/15/2018 10:17:03 PM Eastern Daylight Time (GMT-04:00:00)

Update:
VTS2:Torstar:T2 Transformer has been energized/de-energized at 4/15/2018 10:17:03 PM Eastern Daylight Time (GMT-04:00:00) with loading of 12.63725 MVA.

Primary Switch Status: Closed
Secondary Breaker 1 Status: 21T2A Status: Closed
Secondary Breaker 2 Status: 21T2B Status: Closed

Thank you,
Station Sustainment Department
Aleectra Utilities
PI Notification – Transformer Cooling System On / Off

Update:

Cooling Fans Status changed to On at 4/5/2018 5:16:34 PM Eastern Daylight Time (GMT-04:00:00).

DGA Oil Temperature is **28.9 °C**
Main Tank Oil Temperature is **30.899906185303 °C**
Secondary Winding X Temperature is **46.1 °C**
Secondary Winding Y Temperature is **43.6 °C**
Ambient Temperature is **1**

Transformer Load is **89,829.9 MVA**

Thank you,
Station Sustainment Department
Alestra Utilities
PI Notification - Transformer Cooling Failure

From: PI-Notifications@powerstream.ca [mailto:PI-Notifications@powerstream.ca]
Sent: April-20-18 5:01 PM
To:
Subject: MS309:Painswick:T1 Cooling Failure Status Change

Hi,

Cooling Failure Status changed to **Failed** at 4/20/2018 5:00:48 PM Eastern Daylight Time (GMT-04:00:00)

**Additional information:**
- Fan current is **0A**
- Oil Level is **Normal**
- Oil Temperature is **27°C**
- Winding Temperature is **25°C**
- Transformer Load is **4.44MVA**

Thanks,
Operations Technology
PI Notification – Tap Changer Oil Filtration Alarm

Update:

MTS3:D.H. Cockburn:T2 Tap Changer Oil Filter status changed to **Alarm** at 4/16/2018 1:09:22 AM Eastern Daylight Time (GMT-04:00:00).

Thank you,
Station Sustainment Department
Alectra Utilities
Maintenance Performance Reports
Maintenance Program and Backlog Performance (by Mtce Task)
Current Year Transformer 3 Winding Doble Test Maintenance Program Completion Report
Current Year Transformer Tap Changer Maintenance Completion Report
Transformer - Annual Oil Samples
Station Maintenance Program Performance
(by Equipment Type)

Historical
• Generated
• Closed

YTD Completed
Forecasted

Open WO Status

WO to be Completed

Estimated Effort

Open WO Status

Percent Completed

Backlog

Source: CMMS

02/10/2017 8:59:51 PM
02/11/2017 7:59:51 PM
30d
Now
Corrective Maintenance Performance
Visualizing Real-Time Asset Health – CMMS and PI System

**Risk**

**Function of Criticality and Risk**

- CMMS
  - Maintenance Program Performance
- CMMS and PI / SCADA Data
  - Equipment Condition (DGA, Moisture, Fluid Quality, Insulation, Capacitance, Bushings, etc.)
  - Failures, Equipment Status
  - Number of Customers per Feeder / Transformer / Station
  - Number of Open Work Orders
  - Age

**Health**

- No of Transformers at Station (1, 2 or more)
- Transfer Capability
- Oil Containment
- Key Customers
- Proximity of Station to Water
- Total No of Customers per Station

**Criticality**

- Criticality
- No of Transformers at Station (1, 2 or more)
- Transfer Capability
- Oil Containment
- Key Customers
- Proximity of Station to Water
- Total No of Customers per Station
# Transformer - Criticality, Health and Risk

## North MS Transformer CHR

<table>
<thead>
<tr>
<th>Barrie</th>
<th>TX #</th>
<th>Criticality</th>
<th>Health</th>
<th>YTD Average</th>
<th>Risk</th>
<th>YTD Average</th>
<th>No. of Open Work Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS301: Anna North</td>
<td>TI</td>
<td>1.35</td>
<td>117.50</td>
<td>111.80</td>
<td>158.63</td>
<td>150.94</td>
<td>2</td>
</tr>
<tr>
<td>MS302: Saubers</td>
<td>TI</td>
<td>1.00</td>
<td>28.95</td>
<td>28.85</td>
<td>28.95</td>
<td>28.85</td>
<td>1</td>
</tr>
<tr>
<td>MS303: Fennell South</td>
<td>TI</td>
<td>1.00</td>
<td>48.95</td>
<td>48.85</td>
<td>48.95</td>
<td>48.85</td>
<td>2</td>
</tr>
<tr>
<td>MS305: Holly</td>
<td>TI</td>
<td>1.00</td>
<td>48.95</td>
<td>48.85</td>
<td>48.95</td>
<td>48.85</td>
<td>1</td>
</tr>
<tr>
<td>MS307: Humma</td>
<td>TI</td>
<td>1.25</td>
<td>42.35</td>
<td>41.92</td>
<td>52.94</td>
<td>52.40</td>
<td>0</td>
</tr>
<tr>
<td>MS309: Park Place</td>
<td>TI</td>
<td>1.00</td>
<td>77.50</td>
<td>77.50</td>
<td>77.50</td>
<td>77.50</td>
<td>0</td>
</tr>
</tbody>
</table>

### Notes
- The chart displays criticality, health, YTD average, risk, and YTD average for various transformers in the North MS region.
- Each transformer is evaluated on their overall criticality, health status, and risk level, with corresponding YTD averages.
- The number of open work orders for each transformer is also indicated.
Various Operations / Equipment Reports - Alectra

- Transformer Availability
- Transformer Oil Temperature
- Transformer DGA
- Transformer Hydrogen
- Transformer Hydrogen and Moisture
- Transformer Health & Risk
- Transformer Cooling
- Geomagnetic Induced Current
- Transformer Loading

- Transformer Mtce Completion
- Transformer Mtce Forecast
- Transformer Oil Containment
- Transformer Monitoring Equipment
- Transformer Pressure Relief Vent & Gas Accumulation
- Transmission System Supply
230kV Transmission Supply Status Report
Station Performance Metrics (Example)

Performance Indicators (Performance Equations)

Multi States

Analytics (Performance Equations)
Station Availability (Risk) Report

Overall Station Performance

<table>
<thead>
<tr>
<th></th>
<th>TS Stations</th>
<th>MS Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Station Risk Index</td>
<td>97.73 %</td>
<td>97.64 %</td>
</tr>
<tr>
<td>Overall Transformer Availability</td>
<td>95.45 %</td>
<td>96.88 %</td>
</tr>
<tr>
<td>Overall Bus Availability</td>
<td>100.00 %</td>
<td>98.11 %</td>
</tr>
<tr>
<td>Feeder Breakers &quot;Closed&quot;</td>
<td>100.00 %</td>
<td>97.64 %</td>
</tr>
</tbody>
</table>

TS Station Performance

MS Station Performance

Legend

Station Performance Values

- < 50 %
- 0-75 %
- 25-50 %
- 75-100 %
Transformer Fleet Availability
## Station Transformer Oil Temperature/Cooling Report

### Lazenby 2

<table>
<thead>
<tr>
<th>Power</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>41.80 MVA</td>
<td>44.10 MVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil Temp Status</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temp</td>
<td>25.17 °C</td>
</tr>
<tr>
<td>Fans 1/2</td>
<td>On/On</td>
</tr>
</tbody>
</table>

### J.V. Fry

<table>
<thead>
<tr>
<th>Power</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>33.95 MVA</td>
<td>34.48 MVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil Temp Status</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temp</td>
<td>25.17 °C</td>
</tr>
<tr>
<td>Fans Group 1/2</td>
<td>On/Off</td>
</tr>
</tbody>
</table>

### A.M. Walker

<table>
<thead>
<tr>
<th>Power</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26.55 MVA</td>
<td>23.57 MVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil Temp Status</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temp</td>
<td>28.30 °C</td>
</tr>
<tr>
<td>Fans Stage 1/2</td>
<td>On/Off</td>
</tr>
</tbody>
</table>

### D.H. Cockburn

<table>
<thead>
<tr>
<th>Power</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48.55 MVA</td>
<td>0.00 MVA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oil Temp Status</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temp</td>
<td>31.10 °C</td>
</tr>
<tr>
<td>Fans Group 1-4</td>
<td>1 2 3 4</td>
</tr>
</tbody>
</table>

---

**Note:** The graphs and data provided are indicative of the transformer's operation and temperature readings.
Transformer Oil Temperature Report
Event Frame Report - Substation Transformer 110% Overloading Events

110% MS Transformer Overloading Events (Last 2 months)

- AMS 5: T1: 6 events
- MS 405: Holly T1: 5 events
- MS 508: Park Place T1: 15 events

Total Overloading Events:
- Total: 25 events
PI-ESRI Reports

- PI Integrator for ESRI ArcGIS
- ArcGIS Online

- Users of ESRI reports:
  - System Planning
  - Engineering
  - Operations

- Other reports:
  - Outages with Weather Radar and Wind
  - Transformer Health
  - Transformer Loading
  - Transformer Oil Temperature

Transformer Loading

Number of Customers per Station

Station Load with Weather radar

Workers on Site
Notable Transformer Saves – Alectra Intelligent Maintenance
Save - 230kV-27.6kV 75/125 MVA
Integrated Expert Systems – Alectra Intelligent Transformer Maintenance

SCADA

Online Monitor

Data

Oil

Portable Lab

Data

Oil

Delta-X Research

TOA4

CMMS

OSIsoft

PI System

SAN FRANCISCO 2018

OSIsoftUC

PIWorld

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Comparison of Sister Units - DGA Trends

(Good Transformer)

(Failing Transformer)
Increased Gassing - 2 Significant Events

Event 1
Oct 20, 2012
Gas levels increased as load increased

Event 2
April 19, 2013
Gas levels increased as load increased
Transformer Problem Identified (Health and Risk Increase)
PI Notification, CMMS Alert and Auto Generated CM Work Order
(Alert Generated if TOA4 DGA code is >2)
Findings and Cost Avoidance

- It was found that one of the "T" connectors was not crimped during manufacturing to the copper lead.
- Transformer was just over 5 years old.
- Problem was identified just after warranty period ended.

Cost Avoidance:
- Onsite Repair: $100,000 (Potential Failure)
- Over $3 million if unit failed catastrophically or with serious internal damage to windings or core.
Save - 10MVA 44kV-13.8 kV Transformer

PI Notification
- High Winding Temperature
- High Hydrogen Alarm

Installed a Hydrogen Gas Monitoring Unit and connected to SCADA (PI and CMMS)

Cost Avoidance: $500,000 averted
- Repair Cost: $130,000
- No customer outages
- Transformer taken out of service before failure, repaired and replaced with spare
Increased Visibility – Transformer Maintenance Programs

- Dramatic Increase in Visibility and Awareness of Asset Condition and Program Performance
- 24/7 Equipment Reliability (Availability/Uptime)
- Decrease Emergency Maintenance Tasks
- Increase Corrective Maintenance Tasks (no missed deficiencies)
- Decrease in Preventive / Predictive Maintenance Tasks
- Detective Maintenance (Failure Finding from RCM3)
HUGE SAVINGS - Intelligent Maintenance

• Failure Avoidance Costs – RCM3 → CBM
  • 2 Notable Catastrophic Transformer Failure Avoidances
    • $3.5 Million Avoided Costs
• Many Reliability Improvements through CBM Identified Potential Failures
  • No missed failures no matter how small
• Safer Working Environment / Safer for Public
• Improved Risk Management
• Better Asset Condition Assessment (Health and Risk)
Benefits of Leveraging PI System for Transformer Management

• Makes it Easy to turn Real-time Data into Information
  • Stores Key Information for Asset Management Decision Making

• Enabler for Risk Based Condition Based Maintenance

• Maintenance Optimizer

• Innovation stimulant

• PI System is Easy to learn

• Keeping it Simple is better
New – Live Video Streaming PI Report
New - ESRI Report in PI Vision Report
Questions

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

State your name & company

Please remember to...

Complete the Online Survey for this session

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COMPANY AND GOAL
Alectra Utilities Inc. is a progressive distribution utility company that focuses on Innovation and Technology to achieve operational efficiencies that contribute to maintenance optimization and reduction of equipment failures.

CHALLENGE
Implement an Intelligent Transformer Maintenance System that improves worker safety, increases asset availability, improves reliability, lowers Operational costs, and provides Operations information to those who do not have access.

• Adopt a new approach to transformer maintenance which lowers maintenance costs while extending life of asset and improving worker safety.

SOLUTION
Used the PI System as a means of enabling Prioritized Risk based Condition Based Maintenance on station transformer fleet. Interface key systems to allow operational data to aid in Optimizing transformer maintenance.

• Configured Intelligent Maintenance system with RCM3 as core maintenance utilizing CMMS and PI Systems to operationalize the system.

• Integrated to CMMS system to enable True Condition Based Maintenance

• Developed PI Notifications to notify on equipment conditions.

RESULTS
Transformer fleet fully monitored. Deficiencies are automatically detected early and prioritized. Cost avoidance is achieved as a benefit. Life Cycle extension is realized.

• Cost Avoidance achieved with every deficiency find.
• Improved System Reliability
• Improved Response Time to Equipment Abnormalities
• Increased Equipment Availability due to early detection of problems.
• Savings in Operating Costs

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Contact Information

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Alectra Utilities Inc.
Thank You

Optional: Click to add a takeaway you wish the audience to leave with.