Condition-based Maintenance Across the Enterprise

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AGENDA

- Objective & Evolution of Asset Management
- CBM Drivers
- Why use real-time data
- Implementation example & deployment results
- SDG&E RtCBM Program
- OSIsoft Enabling Technology
  - Business Process
  - Sample Capabilities

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Primary Objective and Related Goals for Asset Management

Maximize asset performance at lowest life-cycle cost

1. Reduce maintenance and corresponding O&M expense
   - *Dispatch skillful technicians for specific problems*
   - *Manage trouble response to minimize cost*
2. Maximize equipment performance
   - *utilization*
   - *reliability*
3. Optimize asset replacement strategy

and

4. Eliminate or reduce catastrophic equipment failures

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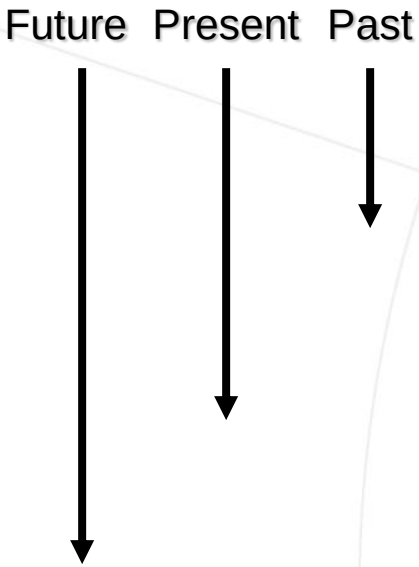
Evolution of Asset Management

1. Traditional asset management approaches
   - *issues*
   - *limitations*
2. Evolution of maintenance practices



- Interval based
  - *Time based*
  - *Counter based*
- Condition based
- Real-time Condition based
- Future Asset Management Practice

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Why Integrate Real-time Data?

- Better automated processes for CBM
- **Operations Benefits** – provides access to the real condition of the asset, better utilize the asset
- **Maintenance Benefits** – facilitates fine tuning of maintenance processes
  - Drill down to what is really driving the condition
  - Determine whether to send someone now or later

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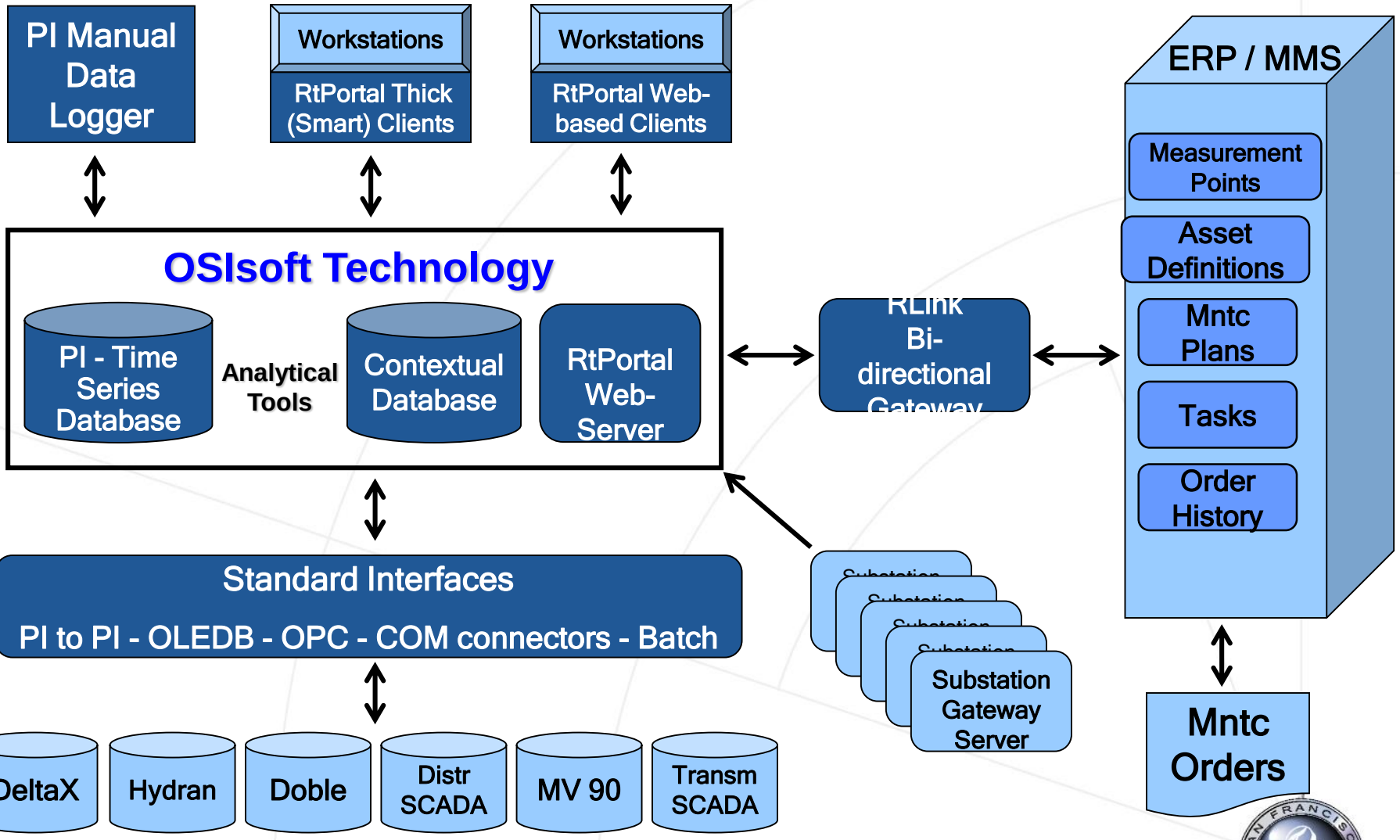
Typical Implementation Overview



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PSE&G's Estimated Savings with OSIsoft-based CBM Deployment

Assessment

- **2003 - $300,000**
  - Oil Diagnostics targeted 16 LTC's, 5 had contact problems
- **2004 - $1.2M**
  - 5 Transformers were targeted and 2 were identified to have major issues
  - 10 LTC's were targeted and 1 had the potential to create major damage.
- **2005 Projected ~ $2M**

Notification

- **2003 - $264,600**
  - 9 LTC's and 2 GCB's
- **2004 - $800,000**
  - 5 Transformers
- **2005 Projected ~ $1M**

With real-time data, we can do even better!

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SDG&E

(San Diego Gas & Electric)

RtCBM Program

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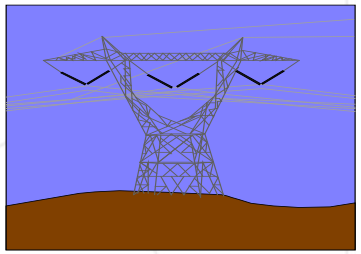
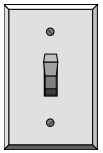
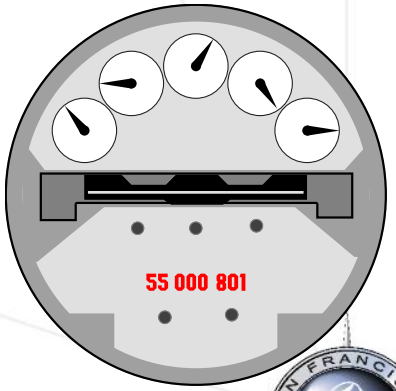
SDG&E – System Statistics

FERC
CAISO
CPUC

- *2 Generation Facilities (590 MW)*
- *1,805 Electric Transmission Miles*
- *18,000 Transmission Structures*
- *120 Substations*
- *906 Distribution Circuits*
- *7,941 Underground Circuit Miles*
- *6,875 Overhead Circuit Miles*
- *220,362 Distribution Poles*
- *145,764 Distribution Transformers*
- *1,315,134 Electric Meters*







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SAN FRANCISCO OSISOFT USER CONFERENCES 2006 FRANKFURT

SDG&E RtCBM Objectives

- Minimize personnel dependency (resources & training needed for asset data analysis)
- Provide a equipment monitoring and analysis platform for access to all data
- Provide drill down navigation abilities through data integration
- Notify personnel to respond to equipment conditions
  - Automated analysis
  - Automated trigger
  - Automated notification
    - Pager, Email, & Investigating Work Orders
  - Reporting capabilities

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RtCBM Process Enhancement and More

- Equipment benchmarks (with normalized data)
- Refining equipment specifications design validation and new equipment procurement practice
- Provide insights into substation design & configuration geographical variations
- Standardization of analysis – designing & adopting trigger algorithms
- Flexible application of numerous factors like asset age, environment, customer impact
- Enhance operational and planning decision support – e.g. equipment impact due to load transfer
- Further define equipment utilization, performance trade-offs

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RtCBM – Data Integration

- Weekly general inspections
  - *LTC operations*
  - *Alarms, temperature, visual*
- Monthly equipment inspections
  - *Operation counters*
  - *Temperature, Pressure*
  - *Voltage*
  - *Functional check*
- General asset
  - *Rating*
  - *Age, Type, Design*
  - *Operating limits*
- Operational
  - **Relays & Digital fault recorders**
  - **PQ Monitors**
- Specific equipment
  - *Operating conditions*
  - *Stress factors*
  - *Trouble history*
  - *Maintenance data*
  - *Oil test data*
  - *Electrical test data*
  - *Operating speed*
- Real-time
  - *Voltage & Current*
  - *Temperature*
  - *Bushing On-line Power Factor*
  - *Hydrogen in Oil*
- Simulated
- System & Engineering

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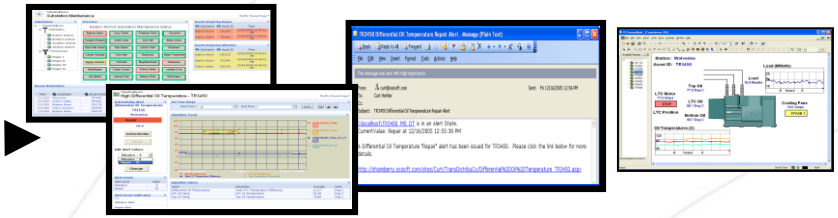
SDG&E RtCBM Architecture

Microsoft SharePoint Server

RtWebParts

Maintenance PI Server
Algorithms
Email Alerts



User Interface
and
Analysis Tools

Operations PI Server

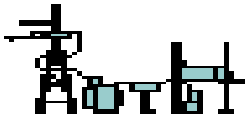
Relational Databases

Maintenance System

Dissolved Gas Analysis

Others

SCADA



WiMax/ Wired LAN Connection

On-line Monitors / IEDs

16 Port Ethernet Gateway (DNP3)

Real-time Equipment Data

Temperature
-Winding,
-Top Oil,
-LTC

Bushing Monitors Phase A, B & C

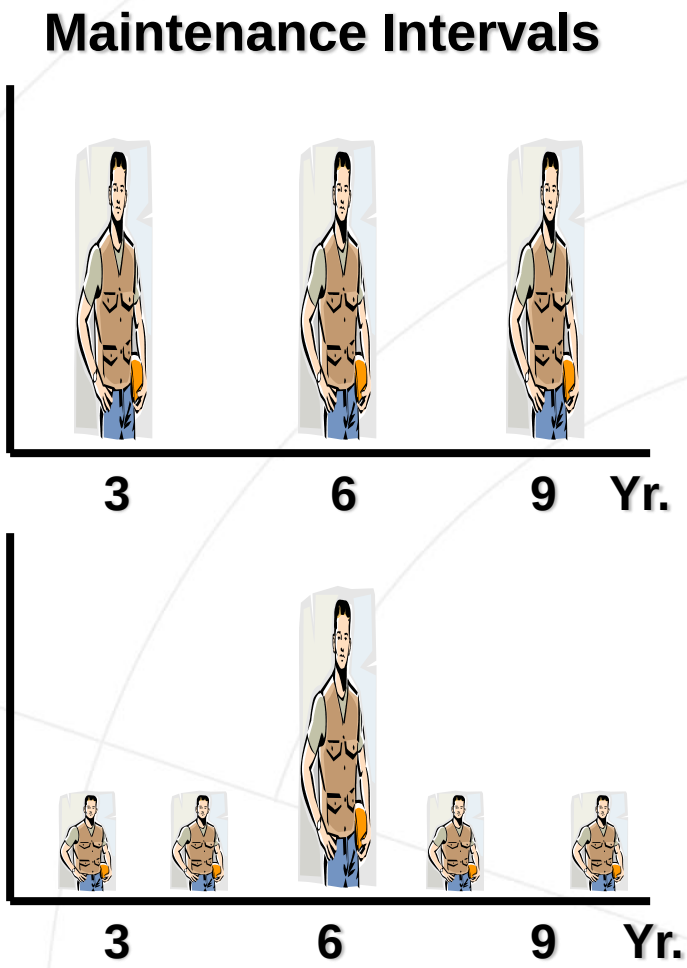
Hydrogen/Water in Oil Monitor

LTC Tap Position Indicator

Time-based to RtCBM – Circuit Breakers

Data Available

- Weekly safety inspections
- Monthly equipment insp.
- Asset Data
- Historical Data
  - Operating conditions
  - Stress factors
  - Trouble
  - Maintenance data
  - Test data (insul & elec)
- Operational data
  - Relays & Digital fault recorders
  - PQ Monitors
- Real-time data
  - Voltage & Current
  - I^2T and Contact Wear
  - Operations Counter



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Circuit Breaker Operations

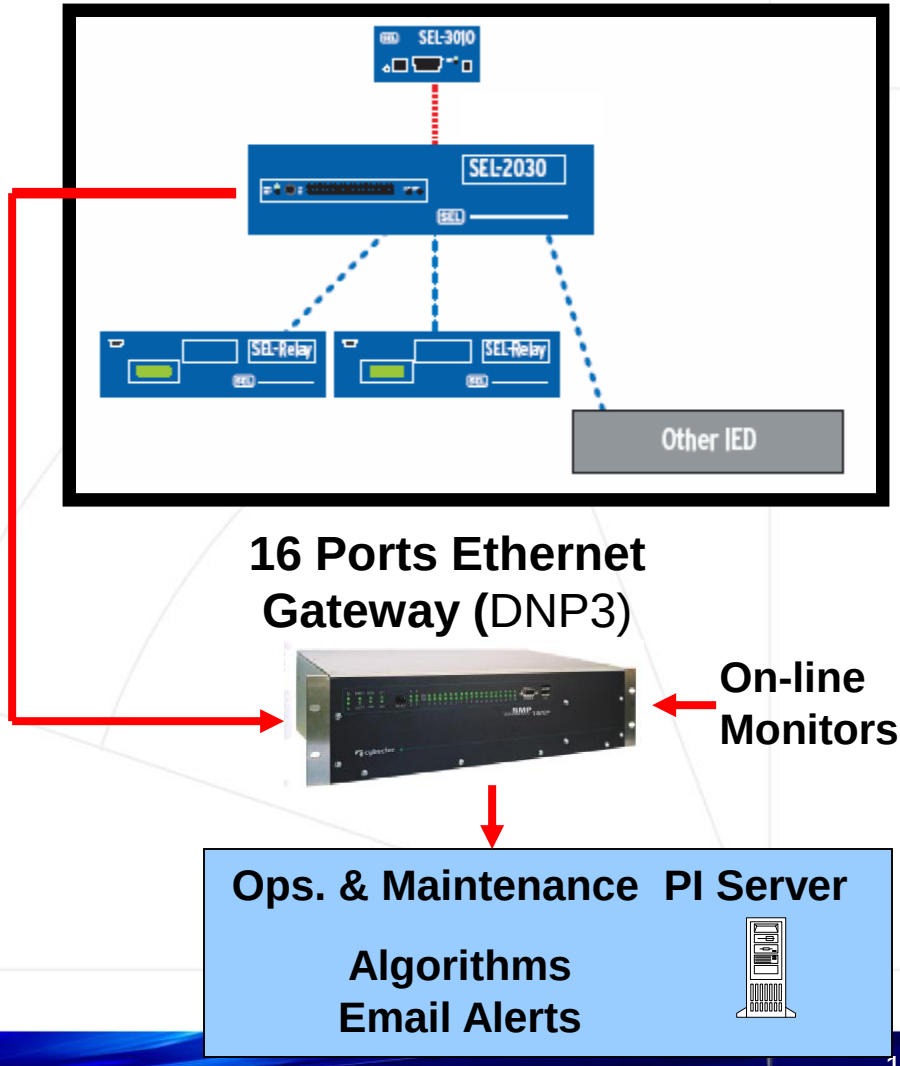
Concerns

- Proper fault clearing
- Fault testing with a circuit breaker

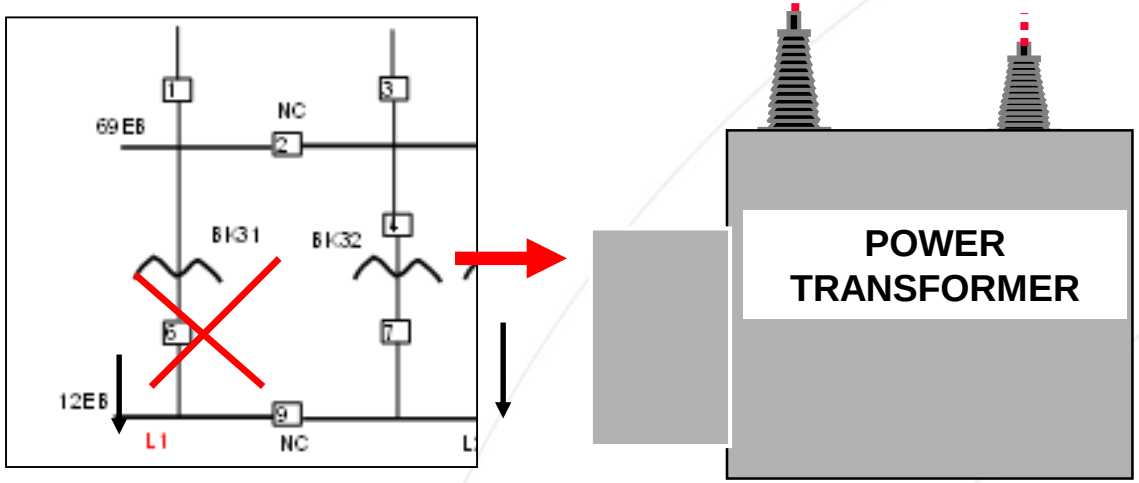
Solution

- Verify the health of CB
  - Contact wear
  - Insulation medium integrity
  - Bushings and accessories
  - Operating history
- Use historical and real-time contact wear data (I^2T) to make a decision

Substation Relays with Circuit Breaker Monitor



Transformer at Emergency Rating

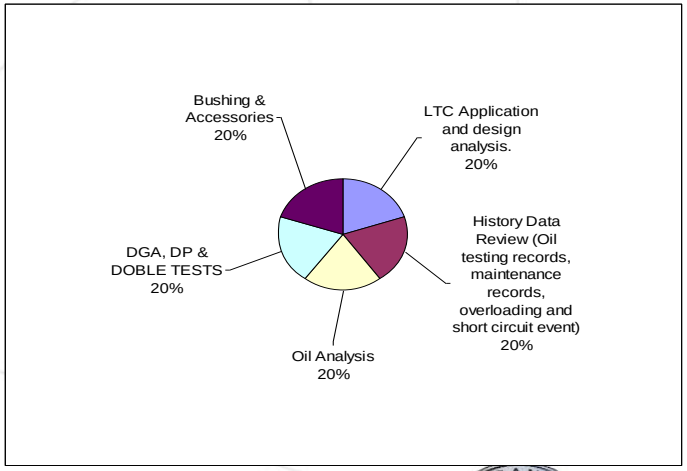


TRANSFORMER Health Indices

- Insulation Power Factor
- LTC Application & Design
- Oil Conditions
- Bushing & Accessories
- Operating History & Conditions

Paper Insulation Health

Location of Paper Sample	Degree of Polymerization (DP)
NLTC – Phase A	586
NLTC – Phase B	737
69kV Bushing C	688



New Insulation Paper: 1000 < DPv < 1300
Middle Aged Insulation Paper: DPv = 500
Old Age Insulation Paper: DPv < 251
Severely Degraded Insulation Paper: DPv < 151

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Transformer at Emergency Rating

PTLOAD-Design - ...ion_ Assessment\eprisoft\El Cajon Bk33 64 mva.run

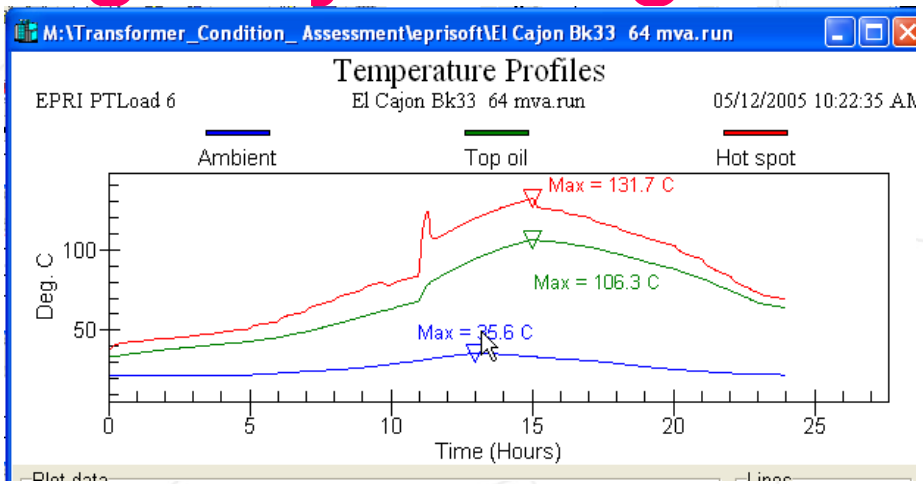
File Edit Tools Options Help

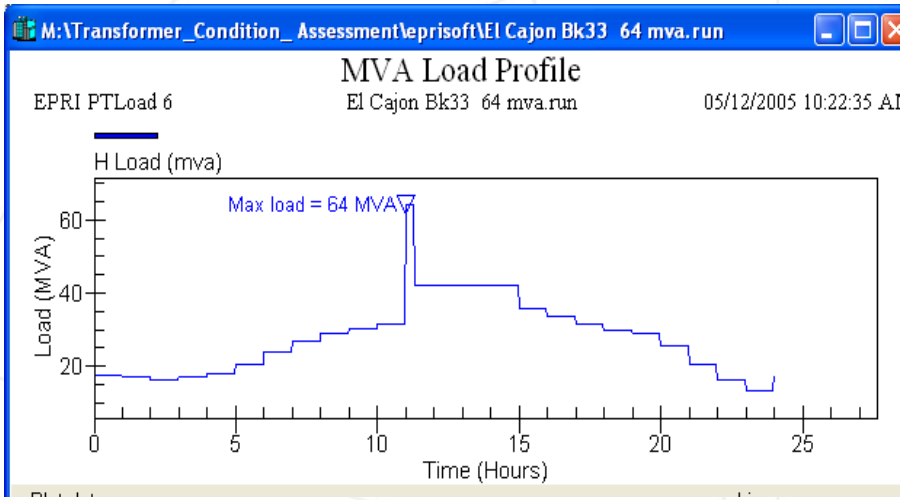
Transformer | Cooling | Ambient Cycle | Load Cycle | Bubbles | Calc Type | Results

A. OUTPUT SUMMARY

```
Date of Calculation        = 05/12/2005 10:22:35 AM
Number Iterations          = 6
Limiting factor            = Fixed upper limit
Contingency Load (Amps)    = 2963.145
Peak Load (MVA)            = 64
Peak Load (Amps)           = 2963.145
Peak Load (PU)             = 2.285714
** Warning: ratings in excess of 2.0 P.U. are not supported
by IEEE guidelines and the results may be unreliable.
Max Hot Spot (Deg C)       = 131.64
Max Top Oil (Deg C)        = 106.19
Peak Age Accel Factor      = 8.1068
Cumulative % Loss of Life  = 0.01401
Max Bubble Risk (mmHg)     = -799.5175

Bubbles are not likely to form given the temperature and load profile
```





Comparison of hot spot rise over top oil simulated versus actual

	Top Oil	Hot Spot	LOL
IEEE	105	176	.149
Ptload	105	145	.039
Actual HS rise	106	131	.014

Decision: Based on Transformer Unit Health and Real Time Conditions

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Summary of RtCBM Expected Results

- **Operations Benefits**
  - Avoid potential equipment failure
  - Increase asset availabilities
  - Respond to equipment alarms according to priorities
  - Maximize asset loading capabilities
- **Maintenance Benefits**
  - Early warning and indication to address conditions
  - Reduce overtime on reactive maintenance
  - Minimize equipment outages
- **Asset Planning Benefits**
  - Improve future equipment specification and application to maximize utilization and performance.

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OSIsoft Enabling Technology

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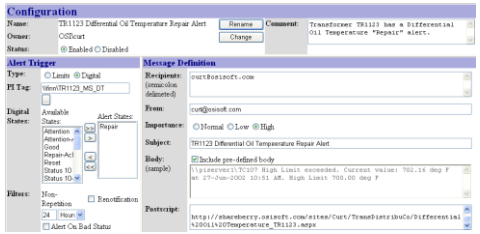
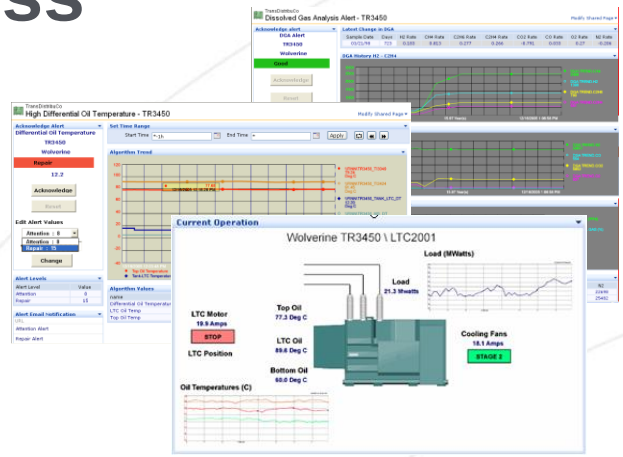
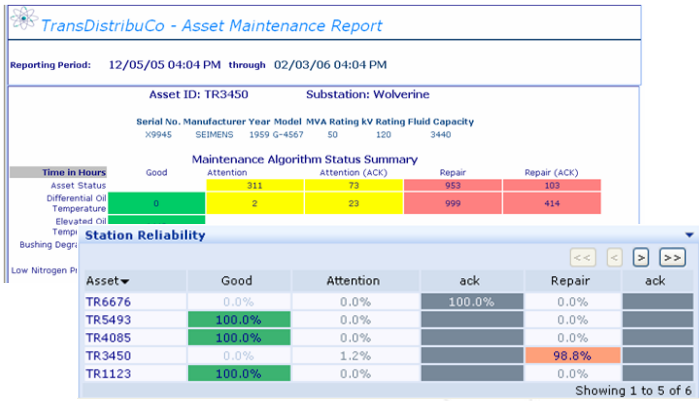
Real-time CBM Process



Alert Notification
(RtAlerts)
Work Order Generation
(RLINK)



Integrated Asset
Information
(RtWebParts)



Asset Information
Structure
(PI and RDB)

Real-time Rule
Assessment
(PI ACE)

Asset Reliability
(PI OLEDB and
RtReports)

Improve Reliability

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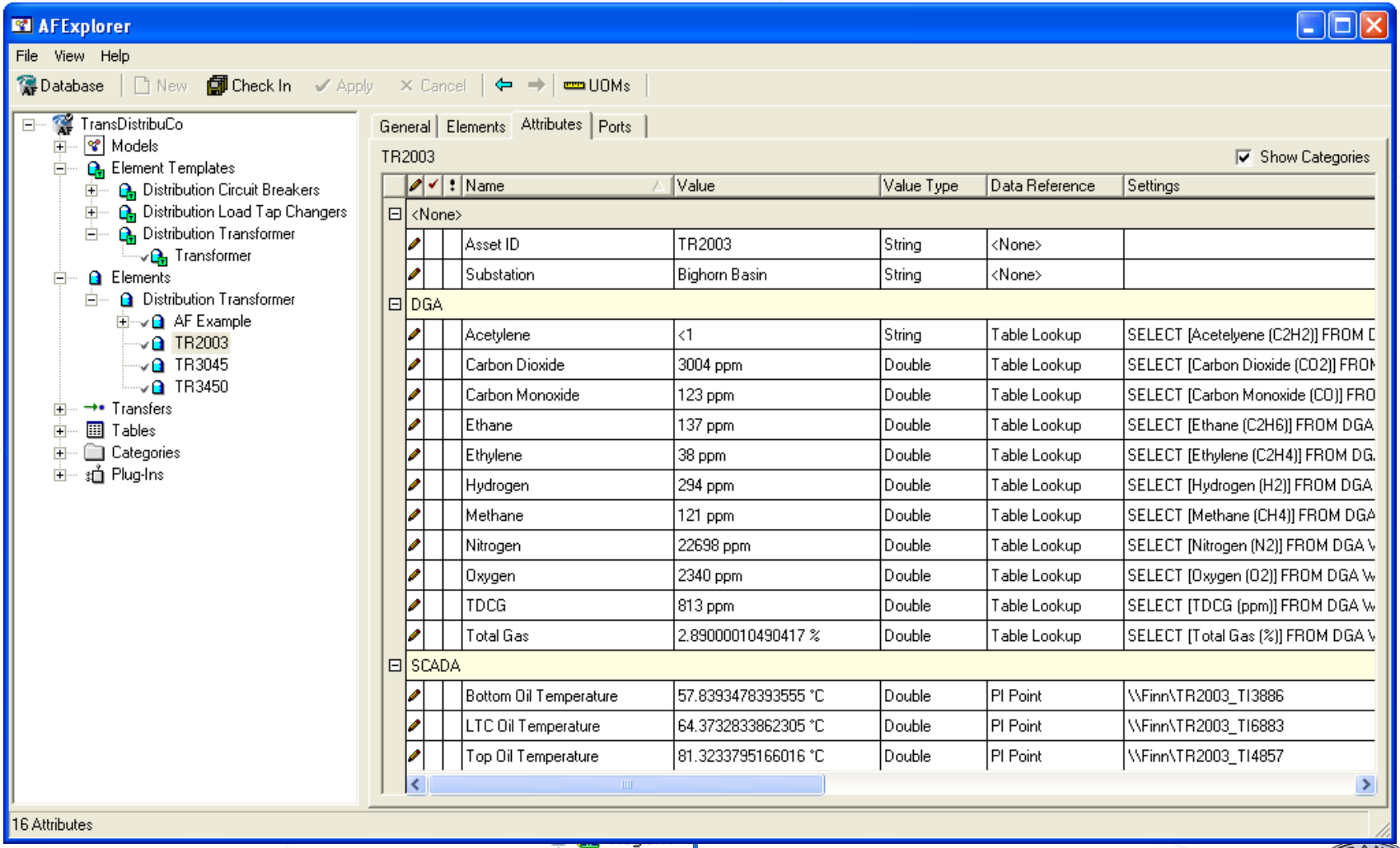
Asset Information Structure



Region II
Region III
Region IV

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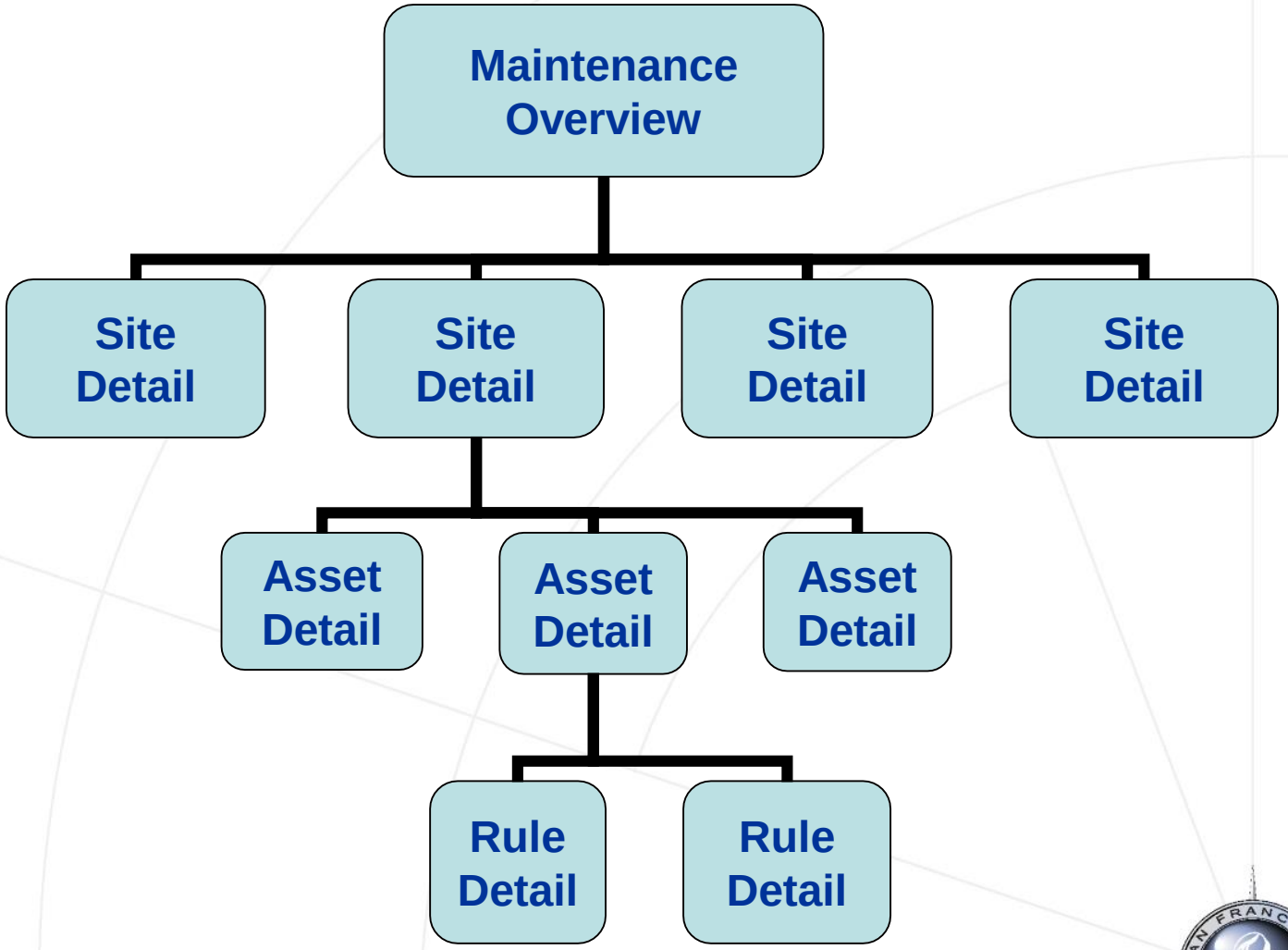
Asset Information Integration Hierarchy



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Maintenance Overview – Level 1

TransDistribuCo
Substation Maintenance

Modify Shared Page

Substations

- TransDistribuCo
  - Distribution
    - Eastern District
    - Northern District
    - Southern District
    - Western District
  - Transmission
    - Region I
    - Region II
    - Region III
    - Region IV

Overview

Eastern District Substation Maintenance Status

Bighorn Basin	Ivory Tower	Freedom Point	Yorkshire
Hungton Estates	Antler Lane	City Hall	Miller Arena
East 45th Street	Elm Street	Lincoln Park	Nicetown
Cental Hospital	York Park	Redwood	Water Treatment
Gypsy Junction	Thornhill	Mayfield Road	Wolverine
Washington	Crown Center	Victory Valley	Lobster Cove
3rd Street	Joshua Tree	Bakers Point	Wilmington

Assets Requiring Repair

Substation	Asset ID	Time
Bighorn Basin	TR3045	3/29/2006 8:35:10 AM
Bighorn Basin	CB1992	3/29/2006 2:35:10 PM
Victory Valley	TR9946	3/29/2006 2:40:20 PM
Wolverine	TR3450	3/29/2006 2:40:25 PM

Assets Requiring Attention

Substation	Asset ID	Time
Bighorn Basin	CB2033	3/29/2006 2:35:10 PM
Victory Valley	CB9376	3/29/2006 2:40:20 PM

Substation Reliability History

Substation	Good	Attention	Repair
Victory Valley	0.00%	0.00%	100.00%
Wolverine	0.00%	2.47%	97.53%
Gypsy Junction	0.00%	0.00%	0.00%
Bighorn Basin	0.00%	0.00%	100.00%

Recent Workorders

<< < > >>

Date	Substation	EquipmentID	Order No	Task	TaskType	Comments	Assigned To
7/3/2005	Bighorn Basin	TR3045	2004-4926	N2 CYL REPLACEMENT	New Installation	Please pump water	Davis, Ron
7/3/2005	Bighorn Basin	TR3045	2002-1234	NEW SETUP MAIN TANK	New Installation		Jones, Sarah
7/3/2005	Gypsy Junction	TR4522	2004-5629	OIL LEAK - INSPECTION	Other Maintenance		Davis, Ron
7/3/2005	Wolverine	TR3450	2004-4926	DOBLE TEST - MX	Preventive Maintenan		Jones, Sarah
7/3/2005	Gypsy Junction	TR4522	2002-1234	N2 SYSTEM REPAIR	Other Maintenance		Rogers, Joe

Showing 1 to 5 of 32

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Site Detail - Level 2

Trans
Wol

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Station Assets

- Circuit Breaker
- Load Tap Changer
- Transformer
  - TR1123
  - TR3450
  - TR4085

Field Inspection

Type	Date
	9/30/1989
	4/11/1972
	7/18/1963
	2/7/1958

Add new document

Station Contacts

First	Last	Mobile
lbert	Fredericks	(440)-555-1212
ill	Jones	(440)-555-1120

Add new item

RL
Maintenance Overview
Wolverine Substation
Algorithm E-Mail Alerts

Adobe Reader - [TR1123_9_30_89[1].PDF]

File Edit View Document Tools Window Help

50%

Help

Pages

Attachments

Comments

1 of 1

Recent Wolverine Workorders

Date	Equipme	Assigned To
1/5/2005	CB5095	Jones, Sarah
1/16/2005	TR3450	Davis, Ron
1/16/2005	CB5095	Saumuels, Tom
2/2/2005	TR3450	Rogers, Joe
2/5/2005	TR3450	Krupp, Robert

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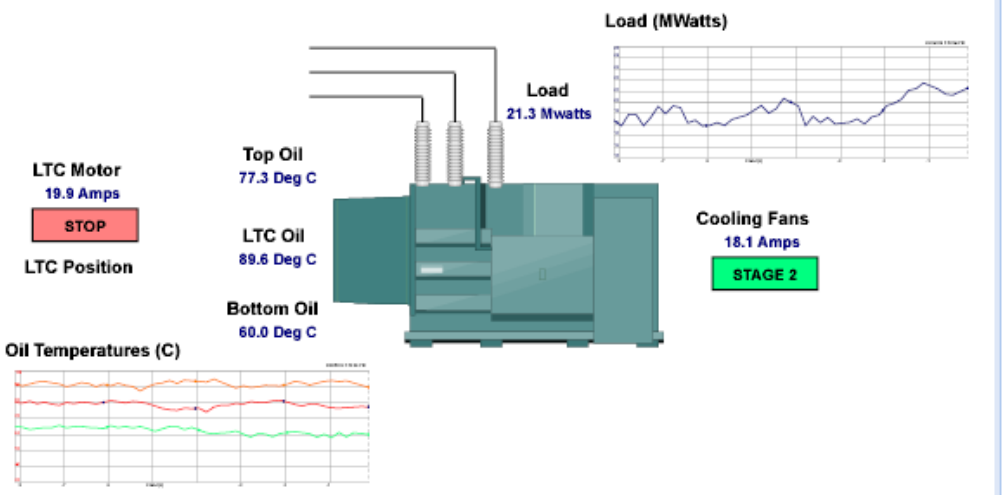
Asset Detail – Level 3

Manufacturer	Model	Year
SEIMENS	G-4567	1959

Station Equipment

- Wolverine
  - Batteries
  - Capacitor
  - Circuit Breaker
    - CB5095
  - Load Tap Changer
  - Transformer
    - TR1123
    - TR3450
    - TR4085
    - TR5493

Current Operation



Repair Status

Algorithm
- Differential Oil Temperature
- Bushing Degradation

Attention Status

Algorithm
- Low Nitrogen Pressure

Good Status

Algorithm
- Elevated Oil Temperature
- DGA Alert

URL
- Maintenance Overview
- Wolverine Substation
- Algorithm E-Mail Alerts

Set History Time

Start Time: *-30d

End Time: *

Apply

Asset Alert History

Algorithm	Good	Attention	ack	Repair	ack
Elevated Oil Temperature	100.0%	0.0%		0.0%	
High Temperature Differential	0.0%	0.8%	0.1%	98.8%	0.2%
DGA Alert	100.0%	0.0%		0.0%	
Low Nitrogen Pressure	0.0%	100.0%		0.0%	
Bushing Degradation	0.0%	0.0%		0.0%	100.0%

Disolved Gas Analysis

Sample Date	H2	CH4	C2H6	C2H4	C2H2	CO2	CO	O2	N2	TDCG (ppm)	Equiv. TCG (%)	Total Gas (%)	CO2/CO	O2/N2
09/26/90	193	115	137	38	<1	3004	223	2340	22698	813	2	2	13	0
08/01/94	279	185	164	51	<1	4213	341	2627	25482	1140	3	3	12	0
03/06/95	489	399	320	109	<1	1652	315	685	24333	1861	5	2	5	0
03/28/96	1258	1980	590	369	<1	6524	530	732	24800	5227	10	3	12	0

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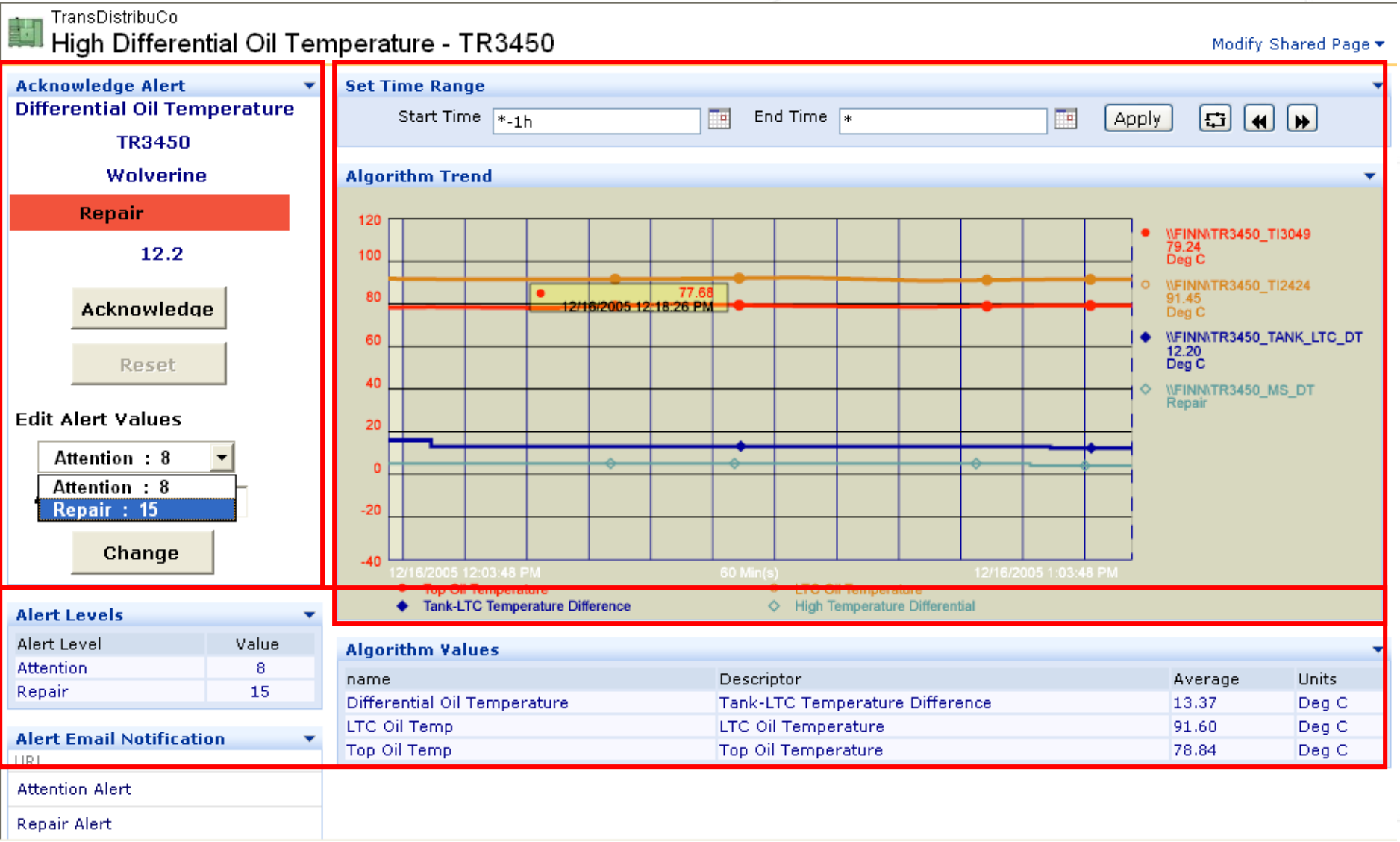
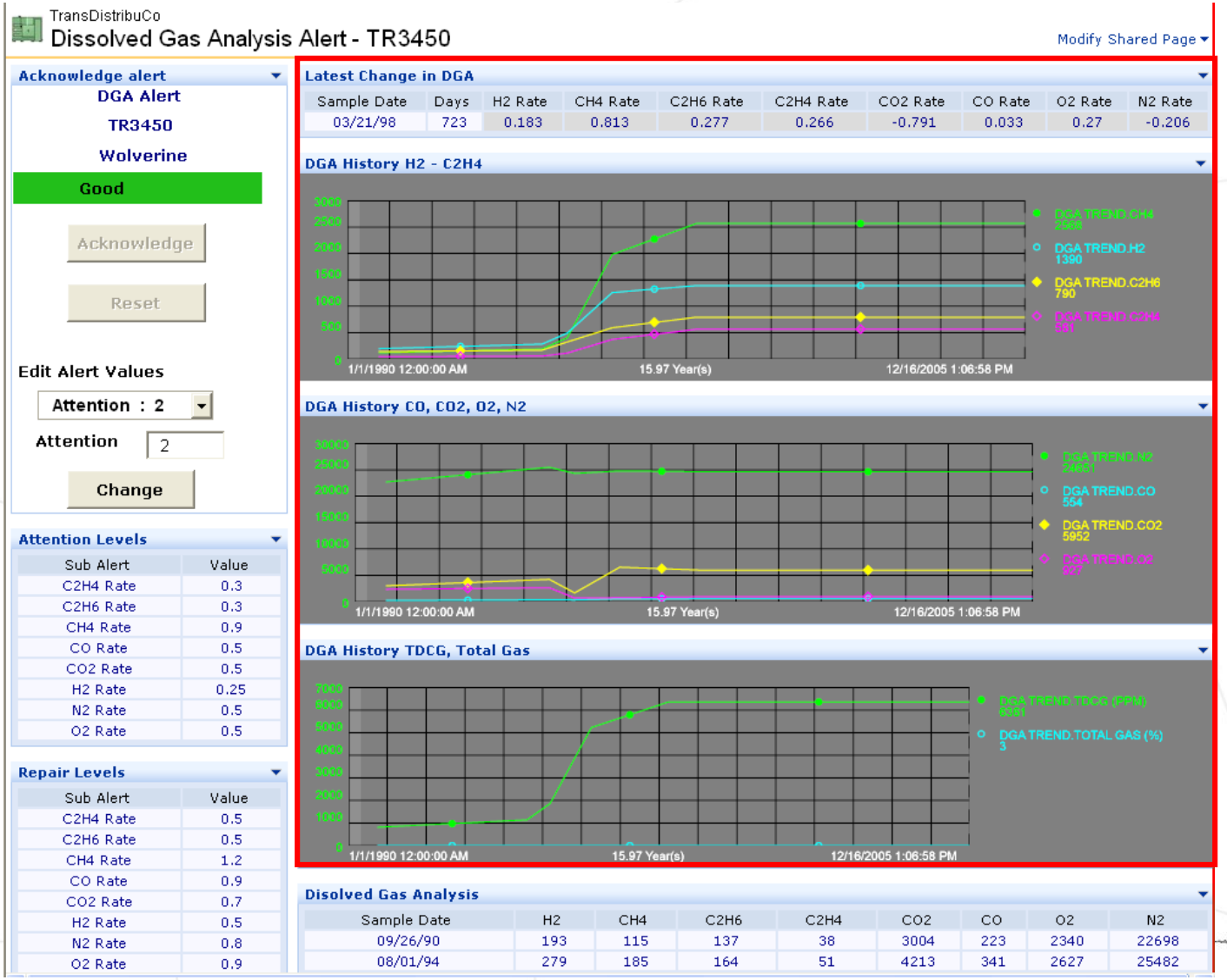
Rule Detail (PI) – Level 4



Rule Detail (RDB) – Level 4



Maintenance Alert Notification

Configuration

Name: TR1123 Differential Oil Temperature Repair Alert [Rename]

Owner: OSI\curt [Change]

Status: (•) Enabled ( ) Disabled

Comment: Transformer TR1123 has a Differential Oil Temperature "Repair" alert.

Alert Trigger

Type: ( ) Limits (•) Digital

PI Tag: \\finn\TR1123_MS_DT [...]

Digital States:

Available States: Attention, Attention-, Good, Repair-Acl, Reset, Status 10, Status 10-

Alert States: Repair

[>>] [>] [<] [<<]

Filters: Non-Repetition [ ] Renotification

24 Hours

[ ] Alert On Bad Status

Message Definition

Recipients: (semicolon delimeted) curt@osisoft.com

From: curt@osisoft.com

Importance: ( ) Normal ( ) Low (•) High

Subject: TR1123 Differential Oil Tempeerature Repair Alert

Body: (sample) [x] Include pre-defined body

\\piserver1\TC107 High Limit exceeded. Current value: 702.16 deg F at 27-Jun-2002 10:51 AM. High Limit 700.00 deg F

Postscript:

http://shareberry.osisoft.com/sites/Curt/TransDistribuCo/Differential%20Oil%20Temperature_TR1123.aspx

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Asset Reliability Report

TransDistribuCo - Asset Maintenance Report

Reporting Period: 12/05/05 04:04 PM **through** 02/03/06 04:04 PM

Asset ID: TR3450 **Substation: Wolverine**

Serial No.	Manufacturer	Year	Model	MVA Rating	kV Rating	Fluid Capacity
X9945	SEIMENS	1959	G-4567	50	120	3440

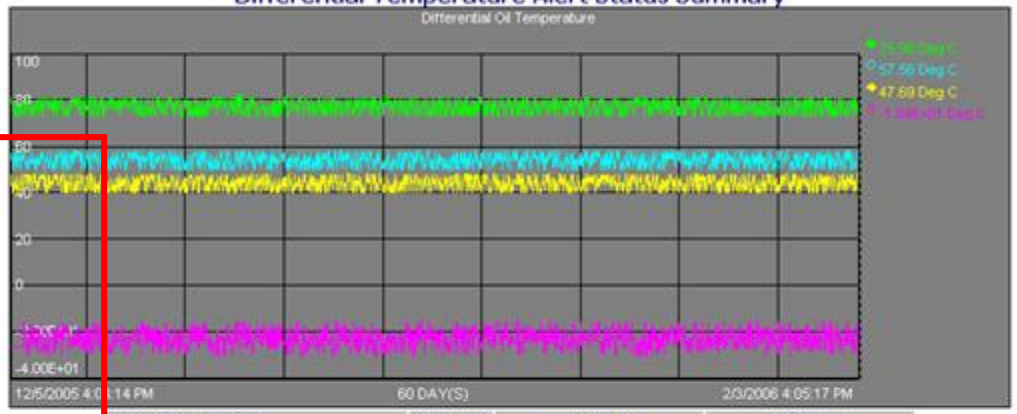
Maintenance Algorithm Status Summary

Time in Hours	Good	Attention	Attention (ACK)	Repair	Repair (ACK)
Asset Status		311	73	953	103
Differential Oil Temperature	0	2	23		
Elevated Oil Temperature	1440				
Bushing Degradation	90				
DGA	1440				
Low Nitrogen Pressure	261	1179			

Work Orders

Date	Work Order No	Task	Task Type	
7/11/2005	2004-1120	DOBLE TEST - MX	Preventive Maintenan	
7/7/2005	2003-1034	N2 TANK ADDED	Preventive Maintenan	
7/7/2005	2005-3999	DGA OIL SAMPLE	New Installation	
7/3/2005	2004-4926	DOBLE TEST - MX	Preventive Maintenan	
7/3/2005	2004-5629	TCG TEST - MAIN TANK	Other Maintenance	
7/2/2005	2003-1034	TCG TEST - MAIN TANK	New Installation	
6/2/2005	2003-1034	TCG TEST - MAIN TANK	Preventive Maintenan	
4/13/2005	2002-1234	N2 SYSTEM REPAIR	Other Maintenance	
4/13/2005	2002-1234	DOBLE TEST - MX	Other Maintenance	
3/5/2005	2003-1034	NEW SETUP MAIN TANK	Other Maintenance	
3/3/2005	2003-1034	N2 SYSTEM REPAIR	Other Maintenance	
3/3/2005	2002-1234	TCG TEST - MAIN TANK	New Installation	
3/3/2005	2004-5629	OIL QUALITY SAMPLE	Other Maintenance	
2/5/2005	2004-5629	OIL LEAK - INSPECTION	Other Maintenance	Davis, Ror
2/5/2005	2005-3999	OIL QUALITY SAMPLE	Preventive Maintenan	Krupp, Robert
2/2/2005	2004-1120	N2 CYL REPLACEMENT	Other Maintenance	Rogers, Joe
1/16/2005	2004-1194	OIL QUALITY SAMPLE	New Installation	Davis, Ror

Differential Temperature Alert Status Summary



Algorithm Input	Average	Maximum	Minimun
Top Oil Temperature	78.26	82.00 22-Jan-06 00:01	74.00 25-Dec-05 12:07
LTC Oil Temperature	91.22	95.00 24-Dec-05 01:07	87.00 30-Jan-06 21:16
Bottom Oil Temperature	62.13	66.00 11-Jan-06 18:07	58.00 18-Jan-06 09:27
Tank-LTC Temperature Difference	12.93	20.61 22-Dec-05 11:37	5.14 18-Jan-06 16:27

VALUE NOW, VALUE OVER TIME

QUESTIONS ?

VALUE NOW, VALUE OVER TIME