Turning data from monitoring and condition assessment into transformer reliability information

or dealing with the Big Data tsunami!

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Asset management: The world used to be so much simpler... Is monitoring the answer?

- Today, resources are more constrained than ever
  - O&M budgets are being reduced
  - Aging assets require more resources
  - Doing more with less

- While dealing with
  - Aging workforce
  - Improving reliability and security
  - Regulations & data constraints

Day-to-day life is consumed with managing operations and maintenance budget cuts, managing asset efficiencies and reliability and doing more with less while dealing with an aging workforce and maintaining lower rates.
In the old days: An evaluation by an equipment expert was the only way to determine condition

- **Problem:** Neither the condition of equipment nor the actions that are required to maintain it at optimal operating condition are known.
- **Solution:** Engineering inspections focus on the areas of real risk identifying: what to inspect, where to inspect, how to inspect, and when to inspect.
- **Value:** The engineering inspection identified issues and provided valuable information on the condition of your equipment and the actions that are required to return it to reliable operation.
The first steps to understanding reliability and remaining equipment life

- **Problem:** Businesses need to proactively assess the condition of their plants and put in place effective asset strategies that support the achievement of business objectives.

- **Solution:** Asset Life Assessment identifies investments that restore integrity and sustain or improve present operating performance to meet future production requirements for the longer term of 10 to 20 years.

- **Value:** A Life Assessment study provides an understanding of the sustainability of assets based on a detailed understanding of the design combined with loading and environmental conditions. This helps direct service actions that allow operation of assets well beyond their theoretical design lives.
Risk mitigation process

- **Asset optimization algorithms**
- **System importance**
- **Transformers data**

Transformer fleet

- **Risk mitigation plan L4**
- **Risk mitigation plan L3**
- **Risk mitigation plan L1+L2**

- **Manual data collection**
- **Automated data collection**

- Off-line data stored in database(s)
- Automated input (from SCADA and monitors)

**L1 – ASAP**
**L2 – 1 year**
**L3 – 2-3 years**
**L4 – 3-5 years**
ABB

Load

Events

Trxf. 1

Trxf. 2

Trxf. 3

…

Trxf. \(n\)

Top Oil

T. amb

Tap pos.

SCADA

Online Sensors

Enterprise Headquarters

Events

Load

Top Oil

T. amb

Tap pos.

MTMP TOOL

IEEE PES

Power & Energy Society®

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Typical off-line transformer performance model data

<table>
<thead>
<tr>
<th>Performance algorithm</th>
<th>Offline DGA</th>
<th>Standard oil tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer specific information</td>
<td>Offline DGA</td>
<td>Standard Oil Test</td>
</tr>
<tr>
<td>Accessory risk multiplier</td>
<td>Asset ID</td>
<td>Asset ID</td>
</tr>
<tr>
<td>Arrester risk factor</td>
<td>Test Date</td>
<td>Test Date</td>
</tr>
<tr>
<td>Base power</td>
<td>Degree of Polymerization (DP)</td>
<td>Acid Number</td>
</tr>
<tr>
<td>(Base power) factor</td>
<td>Oil Preservation System</td>
<td>Dielectric Strength at 1mm</td>
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<tr>
<td>Basic insulation level dielectric factor</td>
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<tr>
<td>Basic insulation level short circuit factor</td>
<td>Latest Bushing Replacement</td>
<td>Inhibitor Content</td>
</tr>
<tr>
<td>Bushing manufacturer</td>
<td>Latest LTC Contact Replacement</td>
<td>Interfacial Tension</td>
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<tr>
<td>Bushing model</td>
<td>Acetylene ppm</td>
<td>Moisture</td>
</tr>
<tr>
<td>Bushing winding</td>
<td>Carbon Dioxide ppm</td>
<td>Power Factor at 25°C</td>
</tr>
<tr>
<td>Bushing phase</td>
<td>Carbon Monoxide ppm</td>
<td>Power Factor at 100°C</td>
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<tr>
<td>Cooling type</td>
<td>Ethane ppm</td>
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<tr>
<td>Design factor</td>
<td>Ethylene ppm</td>
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<td>Dielectric failure multiplier</td>
<td>Hydrogen ppm</td>
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<tr>
<td>High risk location factor (*)</td>
<td>Methane ppm</td>
<td></td>
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<tr>
<td>High temperature multiplier</td>
<td>Moisture</td>
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<tr>
<td>High voltage factor</td>
<td>Temperature</td>
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<td>Low voltage factor</td>
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<td>LTC oil preservation</td>
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<tr>
<td>LTC type factor</td>
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<td>Oil Preservation System</td>
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<td>Random failure multiplier</td>
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<td>Reclosing practice factor</td>
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<tr>
<td>Seismic factor (*)</td>
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</tbody>
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Key parameters critical to thorough asset condition understanding
Transformer data collected from both on-line and off-line sources and desired algorithm routines

- Gas in oil, level and trend
- Moisture in oil
- Oil dielectric strength and power factor
- Correlations between water in oil, dielectric strength and power factor
- Oil aging parameters
- Load, tap position, ambient and top oil temperatures
- Bushing and main power factor
- Calculation of risk of failure
- Alert notification system
- Initial transformer fleet assessment
- GIC (Geo-magnetically Induced Current) susceptibility
- Offline DGA lab accuracy compensation
- MTMP insulation power factor calculation
- Utilize sensor accuracies in trend analysis
- Moisture handling in Calisto1 algorithm
- Effective load calculation
- Configurable trend limits
- Maintain ROF contribution tree
- Predictive messages in trend analysis
- Expert system
- Manual MTMP inputs from FocalPoint Form
- GIC algorithms for transformer impact
- Bushing Monitoring (pending hardware availability) – data pass-through for non-ABB hardware
- Partial Discharge (requires information about the particular hardware and methodology)
- Furan analysis
- Multiple sensor handling (for example, the system will support multiple gas monitors on one transformer)
- Particle count
- Thermal profile / Insulation Aging
- Loadability
- Predictive hot spot
- GIC system impact – VAR demand & harmonics
On-line Condition Monitoring improvements and impact

- OLCM Improvement areas
  - Need for rich algorithms to look beyond the “easy stuff” (like DGA) and correlate challenging relationships that impact reliability
  - Must look at both off-line observations as well as on-line data

- Expected impact of mobile and smart sensing technologies on OLCM
  - Ability to minimize unexpected outages
  - Detection of issues before they put equipment at risk, thus maximizing equipment life
  - Reduction in overall maintenance cost by getting rid of non value added time based actions and focusing on condition improvement activities
  - Intelligent operation of equipment, maximizing performance
Thank You For Your Attention!

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