Transformer On-Line Monitoring

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Entergy

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Prologue

- Why On-Line Monitoring & Diagnostics?
- Aging and Failure Modes
- Failure Statistics
- Current Monitoring & Analysis Methods
Why On-Line Monitoring & Diagnostics?

- Aging Fleet
  - Reducing Probability of Catastrophic Failure
  - Reducing Non-Catastrophic Unscheduled Outages
  - Deferring Capital Costs of Upgrades/Replacements
    - Extending Overall Life of Equipment
- Allowing Short-Term Overloading
- Reducing O&M Costs

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Transformer Aging

- **Insulating Fluid**
  - 2 Main Purposes:
    - Dielectric Insulator
    - Thermal Transfer
  - **Additional Benefit:**
    - Transport Vehicle for Telltale Gases & Acoustical Signals
    - Combustible Gases are Released under Very Specific Circumstances
Transformer Aging (cont’d.)

- **Winding Insulation (i.e., Paper/Cellulose)**
  - The One Component with Non-Reversible Life Characteristic – It Will Age.

- **Factors Affecting Life of Cellulose:**
  - Heat
  - Paper Moisture (Main Source of Degradation)
  - Oxygen Content of Oil
Failure Statistics

- Outage Rates Generally Rising
  - Approximately 1.45% Prior to 1990
  - Approximately 5.5% After 1990

- Costs of Outages Due to Repairs
  - Major Failures
    - $1.5 million After Event Vs. $200k+ via Early Detection
  - Catastrophic Failures
    - $5+ million Post Event Vs. $200k+ via Early Detection
Current Monitoring Methods

- Thermal
- Dissolved Gas Analysis (DGA)
  - Manual
  - On-Line
  - Moisture Detection
Current Monitoring Methods (contd.)

- Bushings
- LTC Oil Dielectric Strength
- Acoustical Analysis
- Other Traditional Methods
Thermal

- Top & Bottom Oil
- Winding Temperature (Direct, Calculated or Simulated)
- Ambient Temperature (remote from any heat source in the substation)
- Control Cabinet Temperature
- Tank Temperature (surface mount)
Dissolved Gas Analysis

- DGA – Biggest Bang for the Buck!
  - Inexpensive
  - Very Sensitive to Changes in Main Tank
  - Can be applied to LTC’s and OCB’s
  - Extremely Reliable
  - Trendable
Dissolved Gas Analysis (contd.)

- **New Technologies**
  - On Line DGA/Fault Gas
  - On Line Hydrogen & Moisture
  - Some Suppliers GE-Hydran, Morgan & Schaefer
Bushings

- Manual Power Factor measurements (Doble, Vanguard, Omicron, Biddle, etc.)
- Capacitance tap bushing monitor. (Doble continuous measurement, others may require site visits in order to download data. (Cutler Hammer, ZTZ)
LTC/TCU/L

- Dielectric Strength Tester (on-line Developed by MIT & Entergy)
- Contact Wear Indicator (EPRI R&D project)
- DGA for LTC
- Infrared Monitoring
- Differential Temperature Monitoring
Fans & Pumps

- Pumps – apply bearing wear indicators to pump. Monitor voltage, current & flow.
- Fans - Monitor voltage, current and/or employ air flow indicator.
- Cycle lead and lag for fans (back up with mechanical control)
- Non-monitoring issue but important for fans – totally enclose fan cages to prevent bird cages.

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Voltage & Current

- Use for Dynamic loading and Loss of life calculations
- Current – Clip on CT’s (1:1) but hard wired CT’s more reliable (if transient measurements desired)
- Voltage – use existing PT’s, BPT’s or CCVT’s
Partial Discharge Detection

- Acoustic – short term testing (portable – magnetic accelerometers). Use for benchmarking and trouble investigations (gassing also detectable)
- Permanent installations for desired continuous monitoring (bushing mounted)
Monitoring Levels

1

Generator Step Up’s (base load) & Transmission Autotransformers,
Criticality - High

Maximum Monitoring
Monitoring Levels (contd.)

2
High MVA, Peaking GSU's
Criticality - Moderate
Medium Monitoring
Monitoring Levels (contd.)

3

Specific cases
Critical loads & Processes such as
Oil Refineries, Chemical Plants,
Medical Facilities, Military Installations
Maximum to Medium Monitoring

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Monitoring Levels (contd.)

4

Normal use age

Conventional Monitoring
New vs. Retrofit

- **New** – Factory installed (should be covered in purchase specification). Additional thermal wells, etc.
- **Retrofit** – Additional thermal wells (add to radiators?); magnetic RTD’s
- **Pumps** – Replace GER/Harley/Cardinal
Data Handling & Storage

- Information vs. data
- Expert System – Local and Remote
- Communications
  - Local - LAN, Fiber Optics, Twisted Pair
  - Remote – WAN, Fiber Optics, Twisted Pair, Satellite
  - HMI local and/or Remote
Conclusion

Why Transformer

On-Line Monitoring?