Electrical Maintenance Workshop

Transformer Maintenance & Testing

Thursday, November 6, 2003

Progress Energy
This presentation provides an overview of the major considerations associated with Transformer Maintenance and Testing.

Barker Edwards will provide the information for Transformer Maintenance & Testing.

Kate Brady will provide the information for Transformer Oil Testing.
Transformer Maintenance

Things to know!

Things you should know about keeping your transformer healthy!
Transformer Maintenance

Agenda

- Types of transformers
- Yearly checks
- Testing of transformers
- Vacuum pressure device
- Pressure relief device
- Sudden pressure relay
- Gaskets
- Paints
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Types of transformers

- Dry type transformers
  - Varnished coils
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Types of transformers

- Dry type transformers
  - Cast coils
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Type of transformers

- Oil filled transformers
  - Sealed tank
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Type of transformers

- Oil filled transformers
  - Conservator system
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Type of transformers

- Oil filled transformers
  - Nitrogen blanket

Pressure regulator for Nitrogen Blanket transformer
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Yearly transformer checks

- Check vacuum pressure gauge for pressure reading.
- Check oil level.
- Check temperature maximum and minimum.
- Check for leaks.
- Check paint condition.
- Check transformer top and radiators for foreign material.
- Check radiator condition.
- Check fans and cooling systems.
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Testing of transformers

- Megger test

600 megohms or better to ground is a good benchmark.
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Testing of transformers

- Power factor test or “Doble” test
  - Readings should be .5% or less on newer equipment.
  - Readings should be 1% or less on older equipment that has been in service for a number of years.
  - Padmount transformers will usually run .7% to 1%.
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Testing of transformers

- Infrared test
  - This equipment checks for hot connections and hot spots.
  - Can be used to check how the cooling is working on transformers.
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Testing of transformers

- TTR test - Transformer Turns Ratio test

3 phase TTR set

- Single phase TTR set

- Readings should not deviate more than ½ of 1% from the calculated value.
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Vacuum pressure devices

- Vacuum pressure devices

Used to control the amount of positive and negative pressure a transformer tank has on it.
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Pressure relief devices

- Pressure relief devices

Used to relieve pressure build up in the transformer.
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Sudden pressure relay

- Sudden pressure relay

This device detects a sudden rise in pressure in the transformer.
Gaskets shall be 1.33 times the height of groove and .75 times the width of the groove.

Types of gasket material:
- Cork / Corkprene
- Nitrile / Buna N Rubber
- Viton Rubber
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Paint

- Types
  - Acrylic enamel
  - Epoxy base
Transformer Oil Testing

Agenda

- Transformer oil
- Oil sampling
- Oil quality
- Dissolved gas analysis
- Cellulose insulation
- Oil processing
Transformer Oil Testing

Transformer oil

- Silicon based oil
- Mineral oil
- Synthetic oils
- Ester / vegetable oils
Transformer Oil Testing
Oil sampling

A Test is Only as Good as the Sample!
Start with good, clean syringes!
Transformer Oil Testing

Proper oil sampling

- Do Not use small sampling port on side of drain valve.
Transformer Oil Testing
Proper oil sampling

- Flush drain valve, tubing, and syringe.
Transformer Oil Testing
Proper oil sampling – (continued)

- Do not pull back on the syringe barrel – apply slight resistance and allow fluid pressure to fill syringe.
Filled syringe should have no bubbles, but some may form later – do not release these!
Excellent Sampling Guidelines available on Doble Engineering website

- www.Doble.com
- Click on “Laboratory Services”
- Sampling Guides:
  - Dielectric Liquids
  - Dissolved Gas Analysis
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Oil quality

- Interfacial tension
- Acidity
- Moisture
- Dielectric
- Power factor
- Color
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Interfacial Tension - IFT

- Measure of contamination
- Decreasing IFT = Increasing Contamination
- Can be corrected
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Acidity

- Measure of oxidation
- Creates acidic compounds
- Build-up of compounds forms sludge
- Affects dielectric and cooling
- Can be corrected
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Moisture

- Decreases dielectric
- Decreases IFT
- Degrades cellulose
- Failure risk
- Can be corrected
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Dielectric breakdown

- Voltage at which the oil begins to conduct
- Is reduced by moisture and contaminants
- Two ASTM test methods:
  - D-877
  - D-1816
- Can be corrected
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Power factor

- Indication of contamination and/or deterioration
  - moisture
  - carbon
  - varnish
  - soaps
  - other conducting matter
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Color

- Higher Number 🔄 Darker Oil
- Darker Oil 🔄 More Contamination, Deterioration
- Oil with Number of 5 is almost black
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Dissolved gas analysis

- DGA is the “blood test” for a transformer
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Dissolved gas analysis

- Partial discharge (Corona - “electrical rust”)
  - Hydrogen $H_2$
- High temperature heating
  - Methane $CH_4$, Ethane $C_2H_4$, Ethylene $C_2H_6$
- Arcing
  - Acetylene $C_2H_2$
- Cellulose involved
  - Carbon monoxide $CO$, and Carbon Dioxide $CO_2$
The Life of the Transformer is directly related to the condition of the cellulose

- Paper – windings, leads, shields
- Pressboard – spacers, blocks, oil flows, tubes
- Particle boards – supports
- Laminates – structures, supports
- Wood - structure
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Paper

- Many layers of paper on this flux shield
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Pressboard

- Pressboard Sheets for directing oil flow
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Paper and pressboard

- Paper wrapped windings
- Pressboard spacers
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Particle board

- Particle Board Lead Support that flashed over
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Laminates

- Laminate Nuts
- Laminate lead support structure members
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Wood

- Birch
  Structure Support Members
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The Cellulose Polymer Chain

The life of a transformer is directly related to the condition of this polymer chain.
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Degree of polymerization

- Measure of mechanical strength
- New paper = 1000 – 1400
- Age increases → DP decreases
- Industry accepted “End of Life” of cellulose insulation is about 200
- Estimated DP from Furan test
What degrades the cellulose?

- Primary sources
  - Heat
  - Moisture
  - Oxygen

- Secondary sources
  - Acids from oil oxidation
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Why is this important?

- Reduced dielectric strength
  - Unable to withstand voltage stress from system transients
- Reduced mechanical strength
  - Unable to withstand mechanical stress from system faults
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What can we do about it?

● Keep the Transformer Healthy!
  - Do not overheat
  - Keep moisture and oxygen out

● If the Transformer is Sick, Get Help!
  - Investigate abnormal DGA results
  - Process or replace the oil
  - De-hydrate
  - Hot oil flush
Transformer Oil Testing
Transformer oil processing
Transformer Oil Testing

What processes?

- De-gas
- Dehydrate
- Hot oil flush
- Reclaim oil
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Other maintenance options

- Upgrades to oil preservation system
  - Bladders
  - De-hydrating breathers
  - N2 blanket

- On-line monitoring systems
  - Gas and moisture
  - Bushing monitors
Avoid Premature Failure!