Electrical Maintenance Workshop

Transformer Maintenance & Testing

Thursday, November 6, 2003

Progress Energy

Transformer Maintenance & Testing

Purpose

- 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

Transformer Maintenance

Types of transformers

- **Dry type transformers**
  - **Varnished coils**

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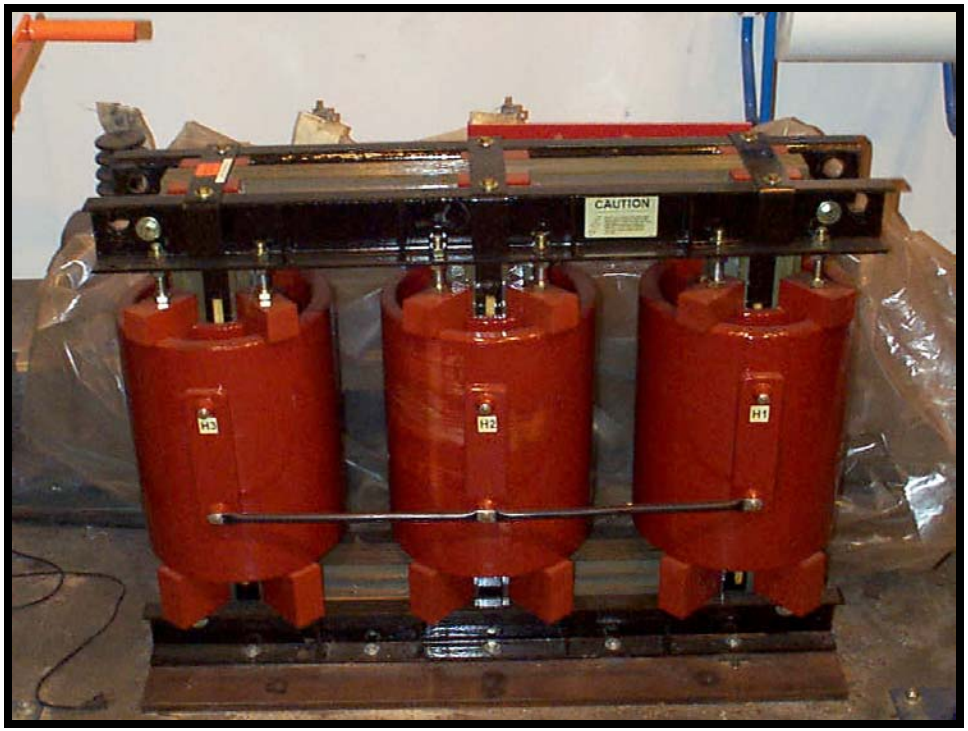
Transformer Maintenance

Types of transformers

- **Dry type transformers**
  - **Cast coils**



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Transformer Maintenance

Type of transformers

- **Oil filled transformers**
  - **Sealed tank**

Transformer Maintenance

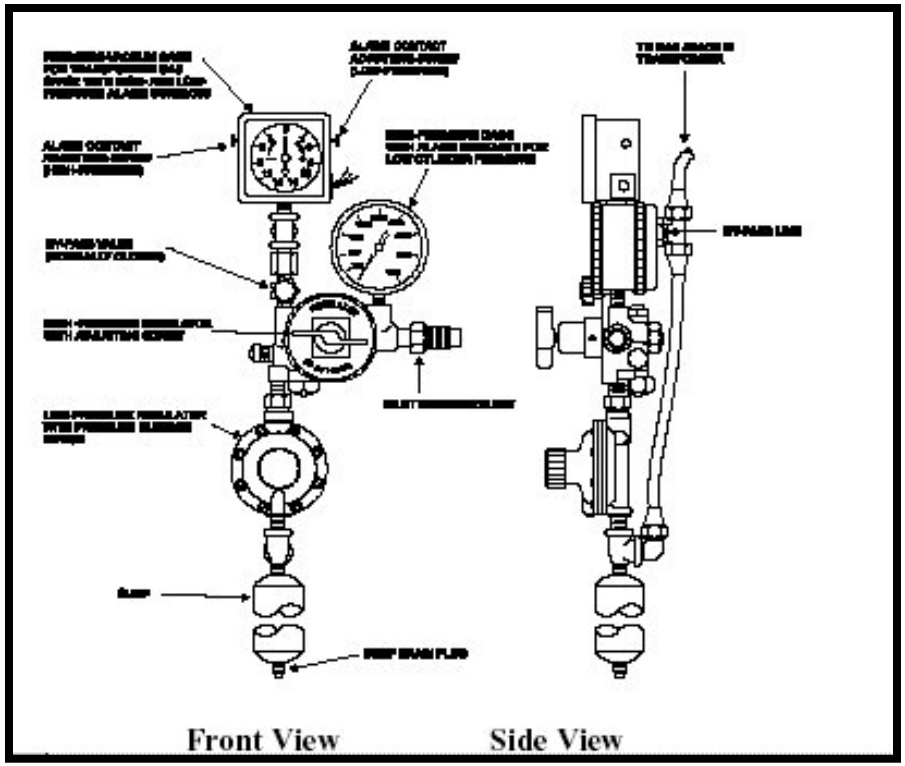
Type of transformers

- **Oil filled transformers**
  - **Conservator system**

Transformer Maintenance

Type of transformers

- **Oil filled transformers**
  - **Nitrogen blanket**



Pressure regulator for Nitrogen Blanket transformer

Transformer Maintenance

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.

Transformer Maintenance

Testing of transformers

- Megger test

600 megohms or better to ground is a good bench mark.

Transformer Maintenance

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%.**

Transformer Maintenance

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.

Transformer Maintenance

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.

Transformer Maintenance

Vacuum pressure devices

- Vacuum pressure devices

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

Transformer Maintenance

Pressure relief devices

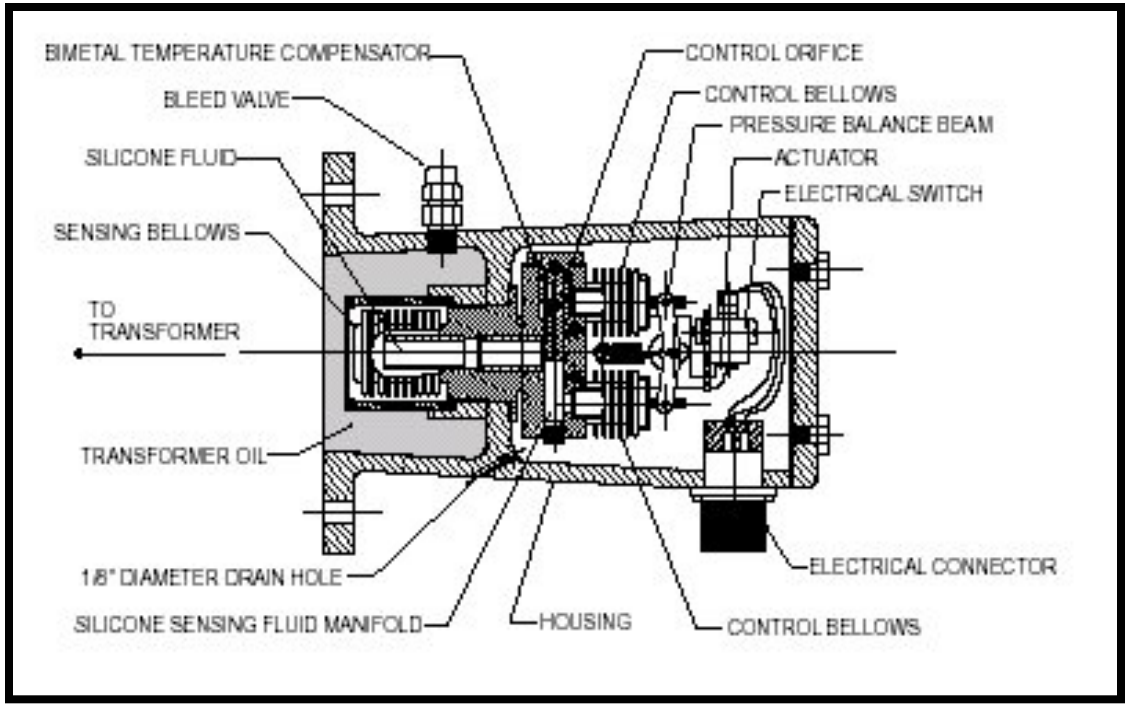
- Pressure relief devices

Used to relieve pressure build up in the transformer.

Transformer Maintenance

Sudden pressure relay

- Sudden pressure relay



This device detects a sudden rise in pressure in the transformer.

Transformer Maintenance

Gaskets

- 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

Transformer Maintenance

Paint

- Types
  - Acrylic enamel
  - Epoxy base

Break

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

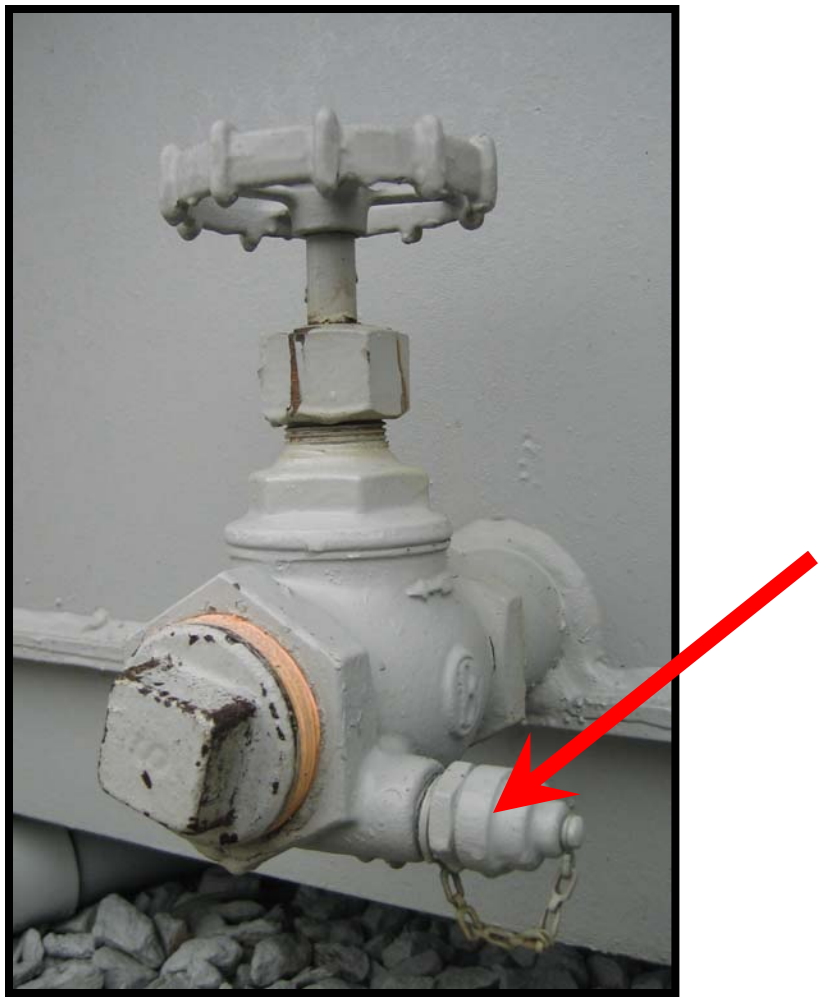
Oil sampling

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.**

Transformer Oil Testing

Proper oil sampling – (continued)

- **Filled syringe should have no bubbles, but some may form later – do not release these!**

Transformer Oil Testing

Proper oil sampling – (continued)

- **Excellent Sampling Guidelines available on Doble Engineering website**
  - **www.Doble.com**
  - **Click on "Laboratory Services"**
  - **Sampling Guides:**
    - ***Dielectric Liquids***
    - ***Dissolved Gas Analysis***

Transformer Oil Testing

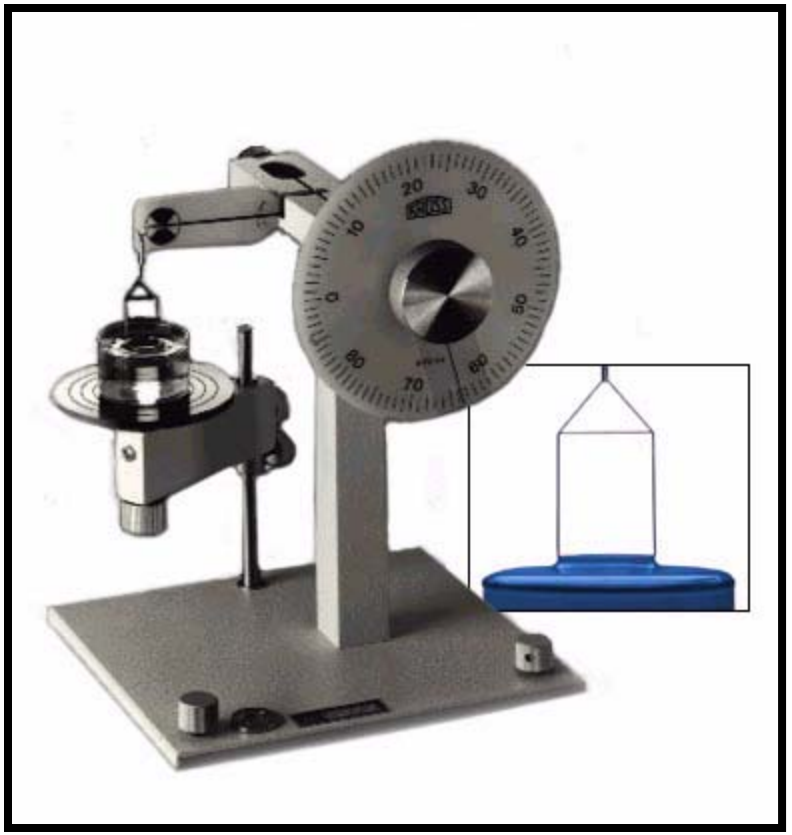
Oil quality

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

Transformer Oil Testing

Interfacial Tension - IFT

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



Transformer Oil Testing

Acidity

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

Transformer Oil Testing

Moisture

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

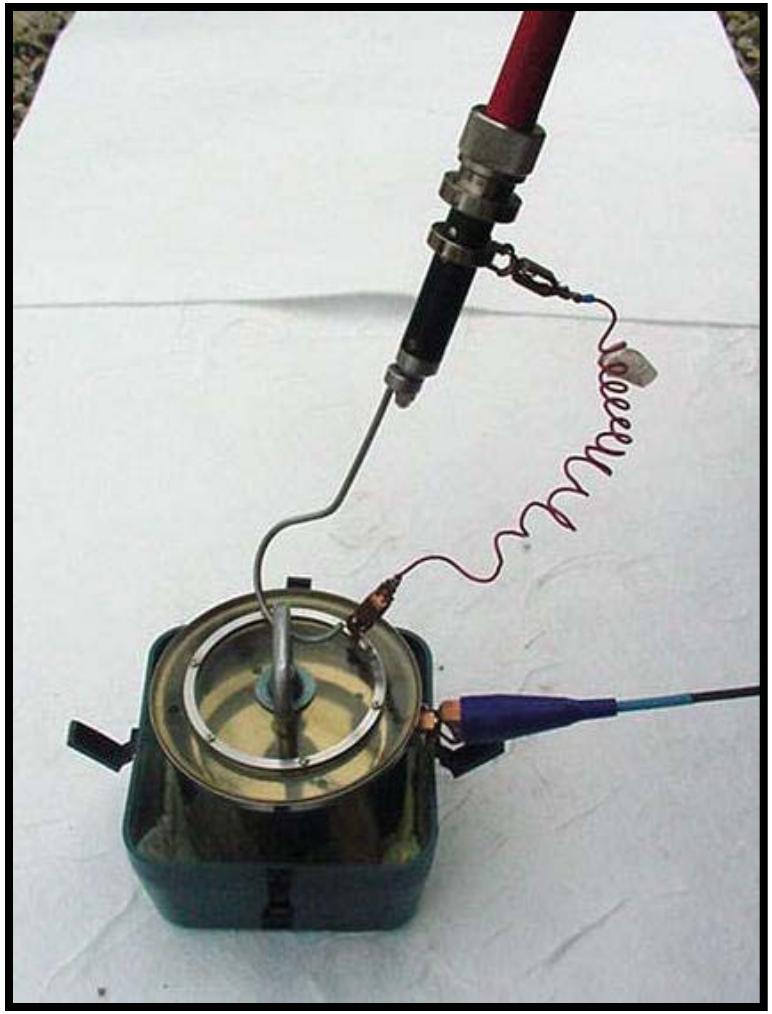
Transformer Oil Testing

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

Transformer Oil Testing

Power factor



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

Transformer Oil Testing

Color

- Higher Number ↑ Darker Oil
- Darker Oil ↑ More Contamination, Deterioration
- Oil with Number of 5 is almost black

Transformer Oil Testing
Dissolved gas analysis

- DGA is the “blood test” for a transformer

Transformer Oil Testing

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 C0, and Carbon Dioxide CO_2

Transformer Oil Testing

Cellulose insulation

- 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

Transformer Oil Testing

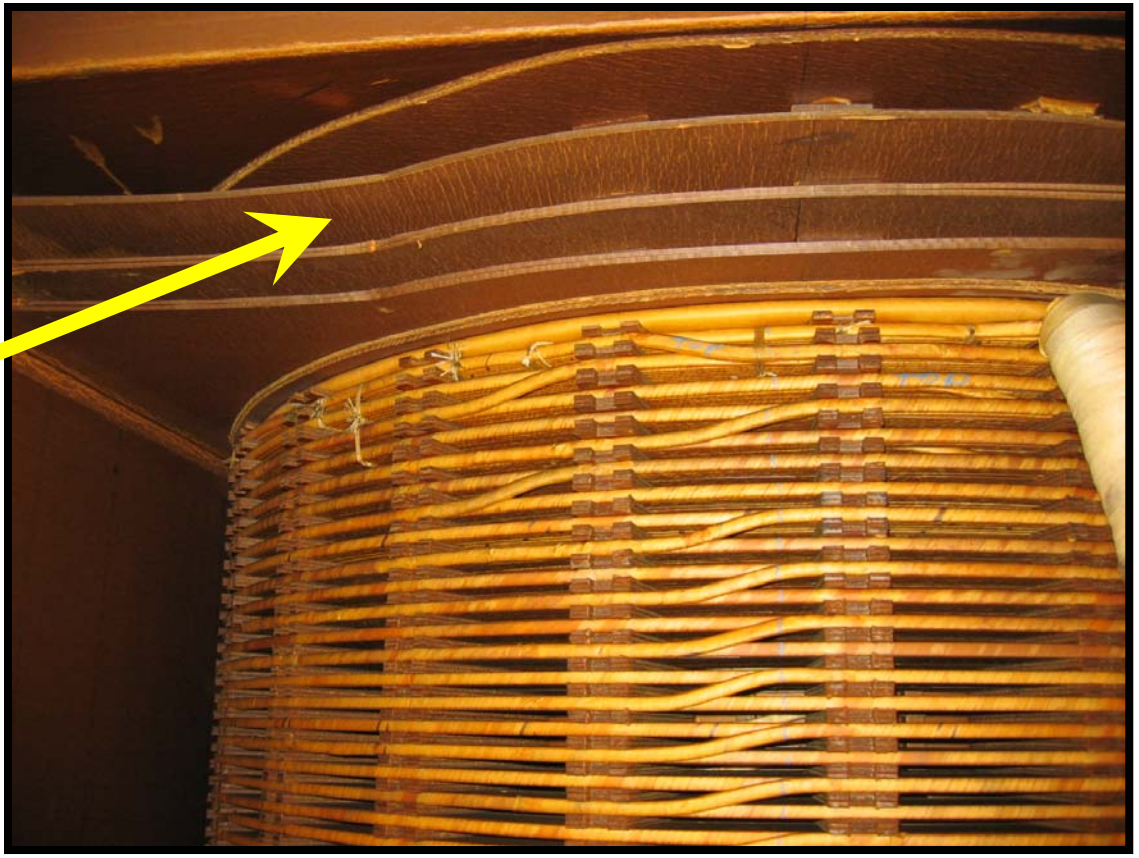
Paper

- **Many layers of paper on this flux shield**

Transformer Oil Testing

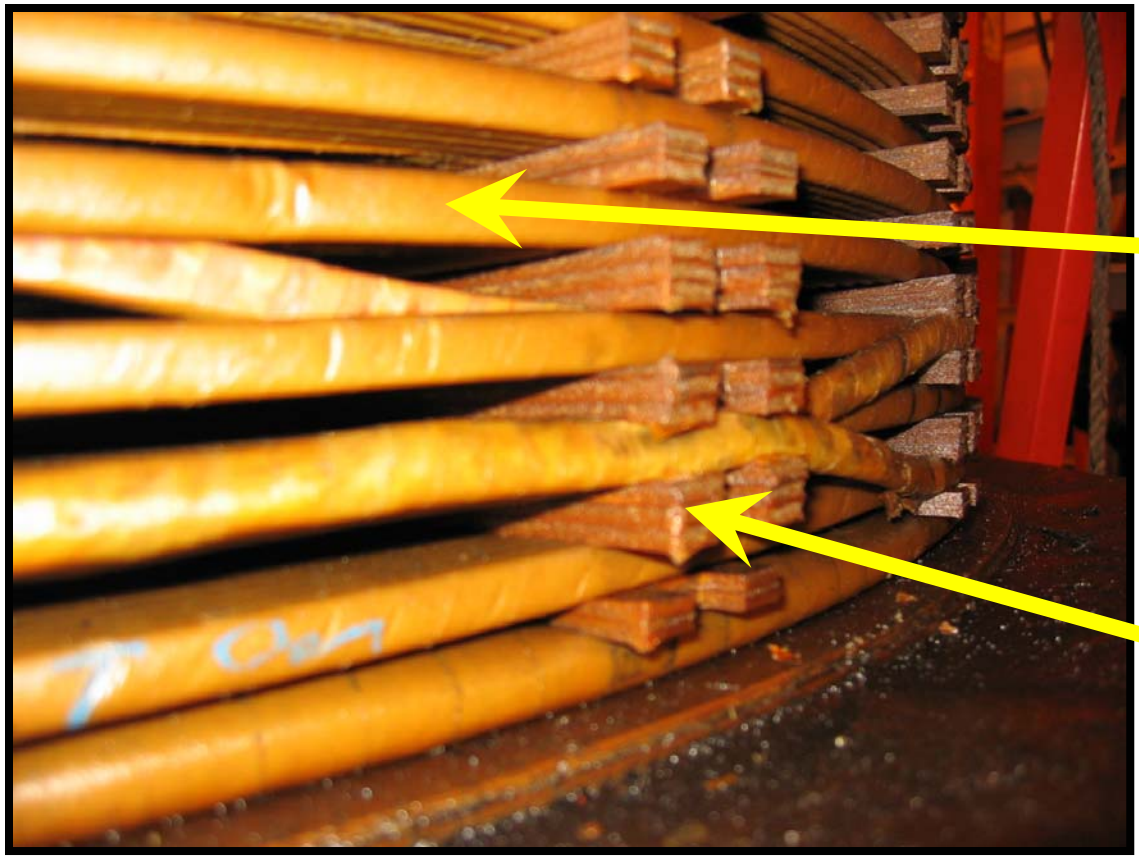
Pressboard

- **Pressboard Sheets for directing oil flow**



Transformer Oil Testing

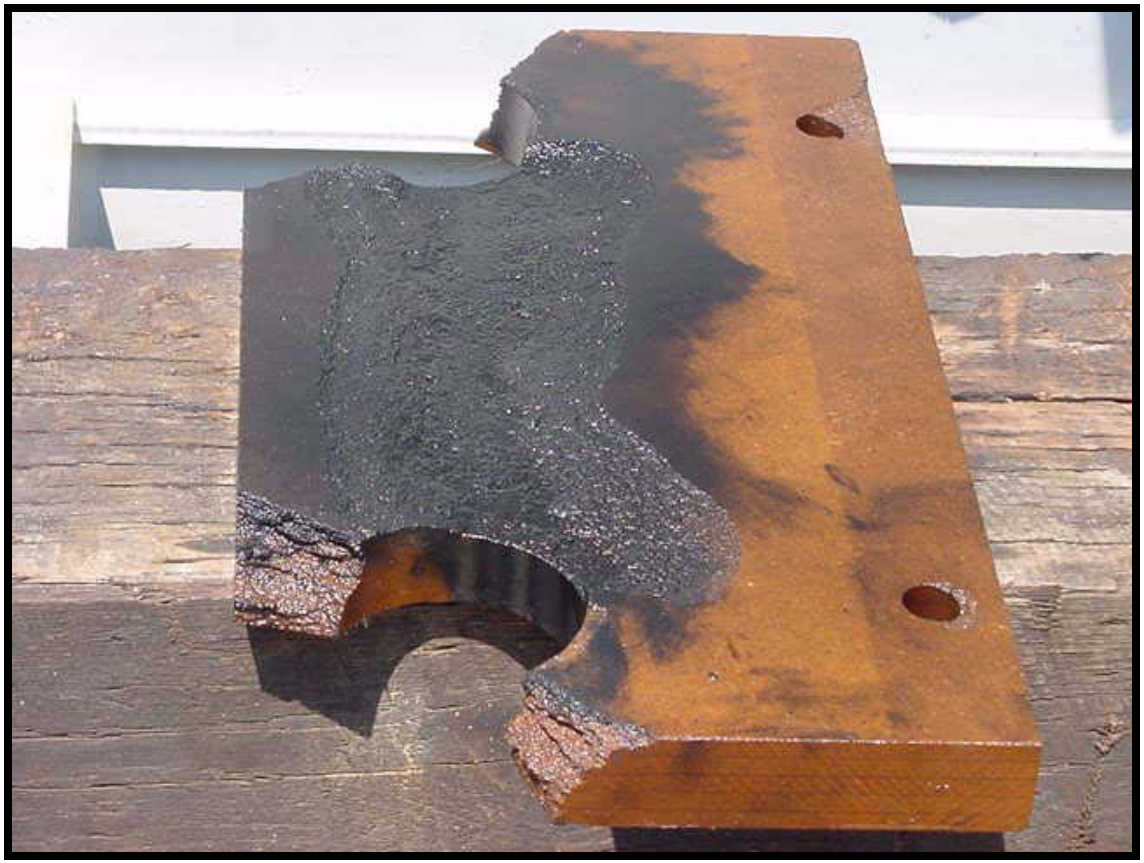
Paper and pressboard



- **Paper wrapped windings**
- **Pressboard spacers**

Transformer Oil Testing

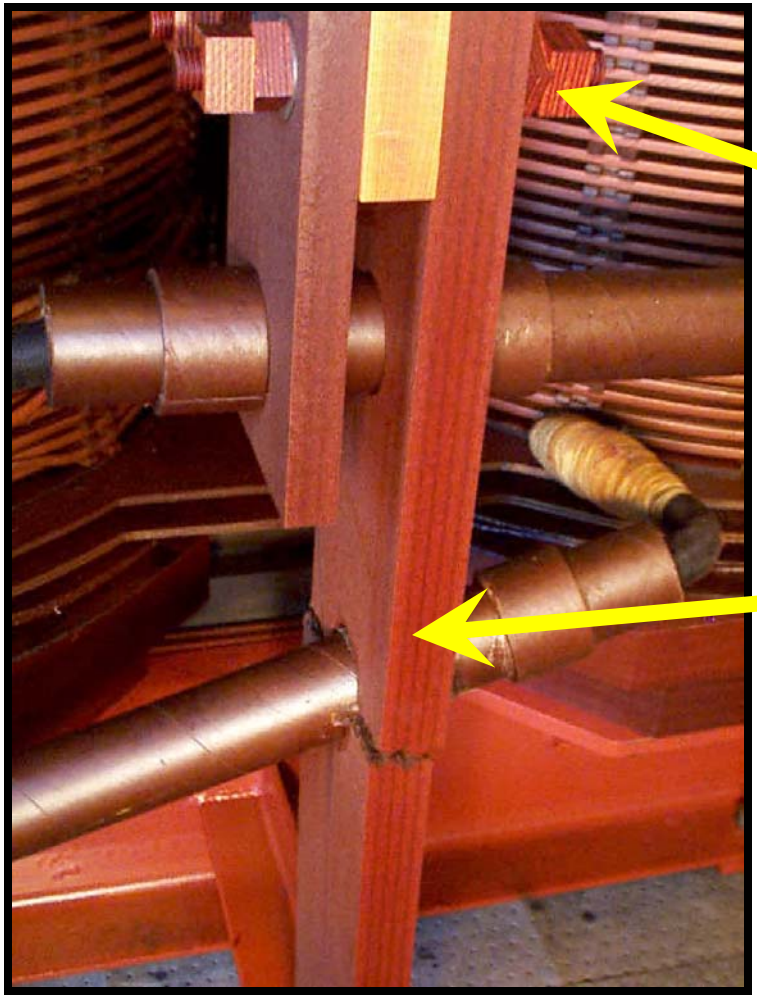
Particle board



- Particle Board Lead Support that flashed over

Transformer Oil Testing

Laminates

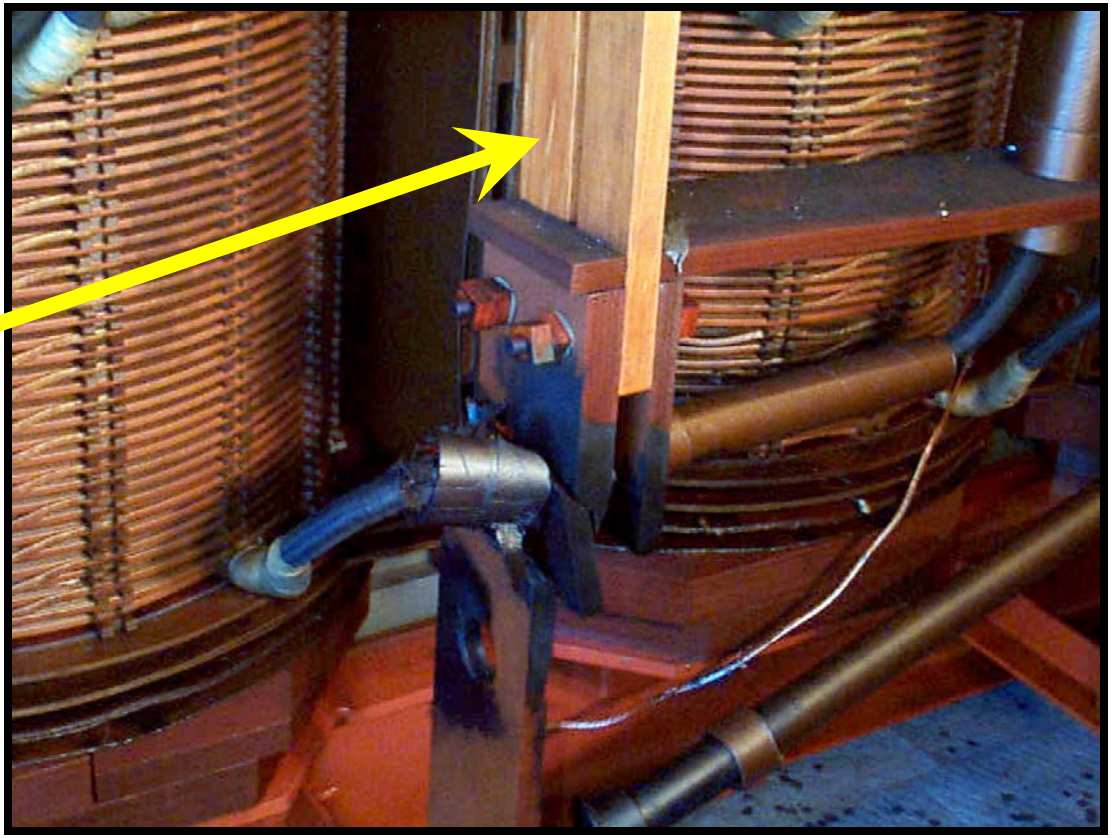


- Laminate Nuts
- Laminate lead support structure members

Transformer Oil Testing

Wood

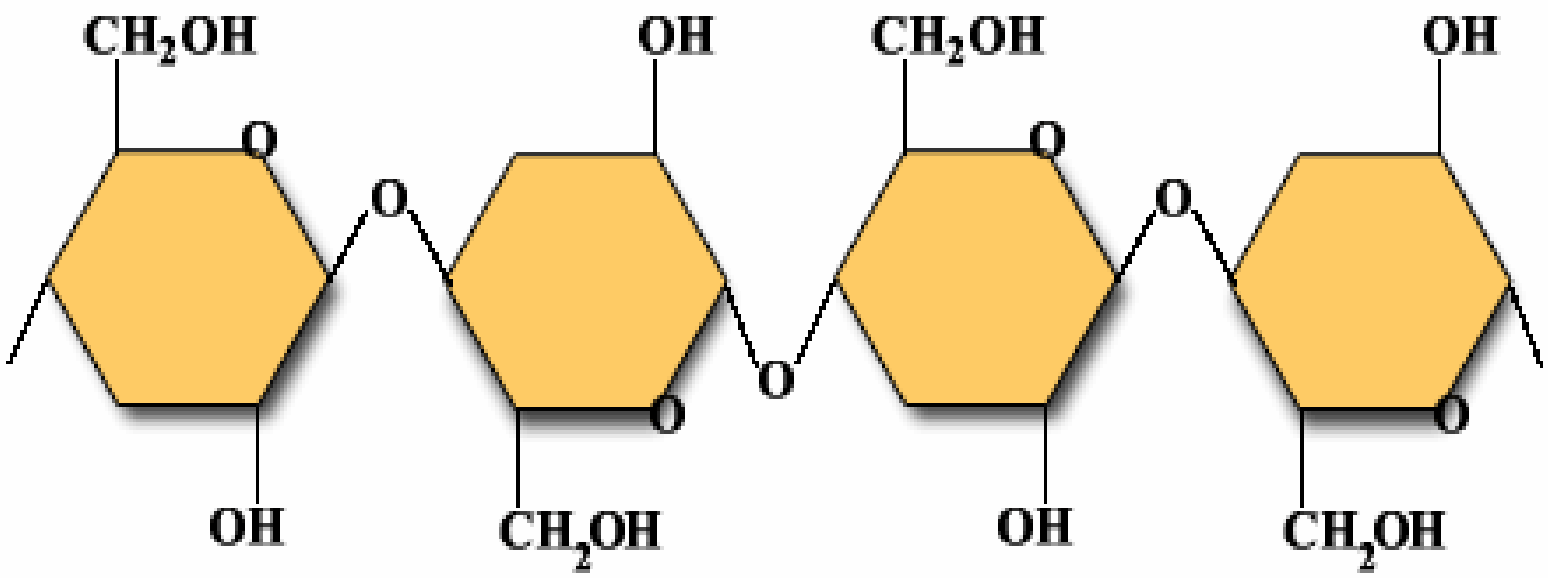
- **Birch Structure Support Members**



Transformer Oil Testing

The Cellulose Polymer Chain

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



Transformer Oil Testing

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

Transformer Oil Testing

What degrades the cellulose?

- Primary sources
  - Heat
  - Moisture
  - Oxygen
- Secondary sources
  - Acids from oil oxidation

Transformer Oil Testing

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

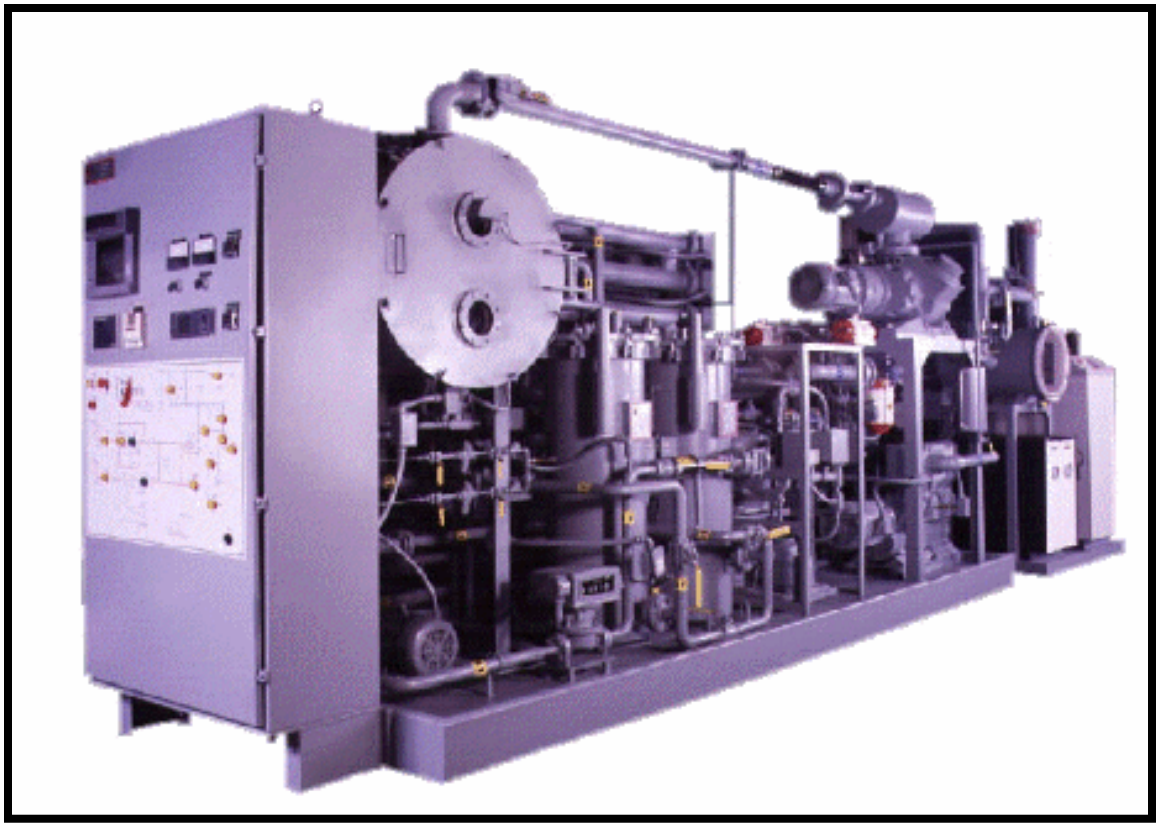
Transformer Oil Testing

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

Transformer Oil Testing

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!

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