POWER TRANSFORMER OIL SAMPLING

GENERAL INFORMATION

Insulating oil used within power transformers and related equipment can break down to liberate gases within the unit. The distribution of these gases can be related to the type of fault, and the rate of gas production can indicate the severity of the fault. The identity and concentrations of the gases being generated by a particular transformer unit can be very useful information in any preventative maintenance program.

The reliable performance of mineral oil in an insulation system depends upon certain basic oil characteristics that can affect the overall performance of the electrical equipment. In order to accomplish its role of a dielectric, heat-transfer agent and arc quencher, the oil needs to possess certain basic properties, in particular:

- High dielectric strength to withstand the electric stresses imposed in service;
- Sufficiently low viscosity so that its ability to circulate and transfer heat is not impaired;
- Adequate low temperature properties down to the lowest temperature expected at the installation site;
- Resistance to oxidation, which ensures maximum life in service.

Mineral oil in service is subject to degradation due to the conditions of its use. In many applications, insulating oil is in contact with air and is therefore subject to oxidation. Dielectric and thermal properties may be impaired [(1)].

SAMPLING TYPES

There are a large range of tests that can be performed to mineral type transformer oil. Of all the different type of tests available, PowerControl Services (Australia) P/L recommends the following suite of tests. These tests provide for the greatest amount of information to be derived, and are cost effective.

- DGA – (Dissolved Gas Analysis): This test determines quantities of gases that may be present. As the name suggests, various gases dissolve in the oil. Gases such as nitrogen, hydrogen, methane, oxygen, acetylene, carbon dioxide etc. The combination and volume of the gases are substantial indicators of the health of the unit. This test also provides baseline figures that are of great value in future years if a problem does develop. *This is considered the principle oil test for determining the overall condition of the oil.*

- Acidity – The acidity (neutralization value) of oil is a measure of the acidic constituents or contaminants in the oil. Determines acid values which can damage the transformer core winding insulation properties.

- Water content – Determines the amount of free water that may be present; important in outdoor units. *Degradation of cellulose (transformer winding insulation materials), and/or the oil itself are the two sources of water increase.*

- Resistivity – This parameter is sensitive to the presence of soluble polar contaminates, ageing products or colloids in the oil. Compounds such as metal salts, water, aldehydes, ketones and alcohols can also affect resistivity.

- Dielectric strength – This is a measure of the ability of the oil to withstand electric stress, its primary function.

- Furan - The main goal of furan testing is to determine whether the insulating paper in a given transformer has been or is being damaged by heat. Degradation of the paper causes it to lose its tensile strength and results in the release of furans. New paper is typically 1200 DPv at start of life, whereas paper is considered end of life at approx. 200 DPv. Note that this is a generalized result.

  Furans produced from temperature buildups are generated in two ways: the first being a localized area of high heat and paper damage, and the second being the general overall heating of the entire insulation system.

  Thermal, oxidative and hydrolytic breakdown of paper insulation can be detected through furan analysis. This test, in conjunction with dissolved fault gas analysis (DGA), gives you the best overview of the state of your transformer. A furan test can be included with yearly maintenance and trends developed to monitor the condition of the paper.

- TAPPA analysis is a specific suite of tests designed to indicate the oil condition of an On Line Tap Changer (OLTC). The analysis is specific to the internal condition of an OLTC, and reporting is slightly different to the standard suite of tests used elsewhere. TAPPA analysis is made up of dissolved gas (DGA), water content (WC), acid (Acid Number), dielectric strength (DS), interfacial tension (IFT), colour and particles analysis.

Many other analytical tests are available. Some other tests that are useful are as follows:

- Dielectric Dissipation Factor (DDF)
- Interfacial Tension (IFT)
- PCB analysis
- Colour
- Viscosity
- Flash Point
- Sediment & Sludge
- Pour & Fire Point
- Refractive Index

SAMPLING FREQUENCY

Routine transformer oil sampling is recommended at 12 monthly intervals, which allows for consistent trending data to be obtained. If problems do exist, then this frequency may be increased to 6 or 3 monthly intervals, as requested by the testing authority.

SAMPLING REQUIREMENTS

It is best to conduct sampling when the transformer unit/s are in service, and preferably when fully loaded. Sampling should be avoided during wet weather, as any external moisture introduced may detract from the result.

The volume of oil taken per sample is as follows:

1. DGA, WC, Acidity, DS, Resistivity samples – approx. 0.5 litre
2. Di-electric samples only – approx. 0.3 litre
3. PCB samples – approx. 0.5 ml (separate sample bottle).

Certain kiosk type transformers have the location of the main tank valve situated close to the high voltage cable bushings (connections), and in this instance it is preferable to have the unit isolated just prior to taking the sample.

References:

[1] IEC 60422: Supervision and maintenance guide for mineral insulating oils in electrical equipment.