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Dissolved Gas Analysis of Power Transformer

Introduction

Insulating oil in an electrical power transformer, commonly known as transformer oil, serves mainly two purposes: as insulation and as a coolant (i.e. help dissipates heat). Furthermore, transformer oil prevents direct contact of atmospheric oxygen with cellulose made paper insulation of windings, which is susceptible to oxidation. The breakdown of electrical insulating materials inside a transformer generates gas that adversely affect dielectric properties of the transformer. Oil sample analysis as well as dissolved gas analysis is useful to prevent premature failure of transformer.

Properties of Transformer Oil

Generally there are two types of transformer oil used in transformers: paraffin based transformer oil and naphtha based transformer oil. Naphtha oil is more easily oxidized than paraffin oil, but oxidation product (i.e. sludge) in naphtha oil is more soluble than paraffin oil. Some of the important properties of transformer oil includes: dielectric strength, specific resistance, dielectric dissipation factor, water content, acidity, sludge content, inter facial tension, viscosity, flash point, and pour point.

Effects of dissolved gases

Degeneration of transformer oil generates various types of gases. The gases that are of interest for dissolved gas analysis (DGA) are the following: H_2 – hydrogen CH_4 – methane C_2H_4 – ethylene C_2H_6 – ethane C_2H_2 – acetylene C_3H_6 – propene C_3H_8 – propane CO – carbon monoxide CO_2 – carbon dioxide O_2 – oxygen N_2 – nitrogen. Some gas generation is expected from normal aging of the transformer insulation. Therefore, it is important to differentiate between normal and excessive gassing rates. The amount of dissolved gases and the relative distribution of these gases affect Dielectric strength of transformer oil is also known as breakdown voltage of transformer oil or BDV of transformer oil.

Dissolved Gas Analysis Procedure

The DGA procedure consists of sampling of oil from the transformer, extracting of gases from the oil and analysis of the extracted gas mixture in a gas chromatography (GC). After extraction the extracted gas mixture is fed into adsorption columns in a GC where the different gases are adsorbed and separated to various degrees and consequently reaches the detector after different periods of time. In this way the gas mixture is separated into individual chemical compounds, identified and their concentrations in volume gas STP/volume oil is calculated and expressed in pm. (STP=standard temperature and pressure).

Composition of key gases indicates particular problem (i.e. presence of H_2) indicate partial discharges (PD). Determination of ratios between gases, normally between gas levels. Figure below shows presence of different gases normal level as well as composition of gases at increasing temperatures.

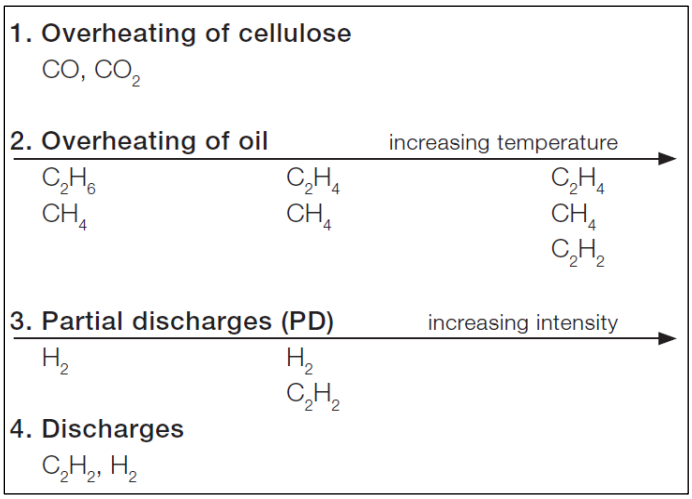

Figure 1. Characteristic key-gases, principal layout

Conclusion

DGA of transformers provides an insights into thermal and electrical stresses sustained by oil-immersed power transformers. In addition, DGA is a sensitive and reliable technique for detecting incipient fault conditions in oil-immersed transformers. DGA can help prevent further damage since test can detect incipient transformer faults. To protect the transformer from severe damage, DGA shall be performed

- When we suspect a fault (e.g. abnormal sounds).
- In case of signals from gas or pressure relay.
- Directly after, and within some weeks, after a short circuit.
- When a transformer essential to the network is taken into operation, followed by further tests after some months in operation.
- After an obvious overloading of the transformers.

References:

[1] Dissolved Gas Analysis: It Can Save Your Transformer IEEE Electrical Insulation Magazine, November/December 1989-Vol. 5, No. 6

[2] Transformer Fault Diagnosis by Dissolved-Gas Analysis IEEE Transactions on Industry Applications, Vol. IA-16, No. 6, November/December 1980

[3] Dissolved Gas Analysis Technique for Incipient Fault Diagnosis in Power Transformers: A Bibliographic Survey IEEE Electrical Insulation Magazine, Vol. 26, No. 6, November/December 2010