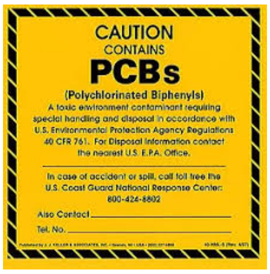
Quick Info



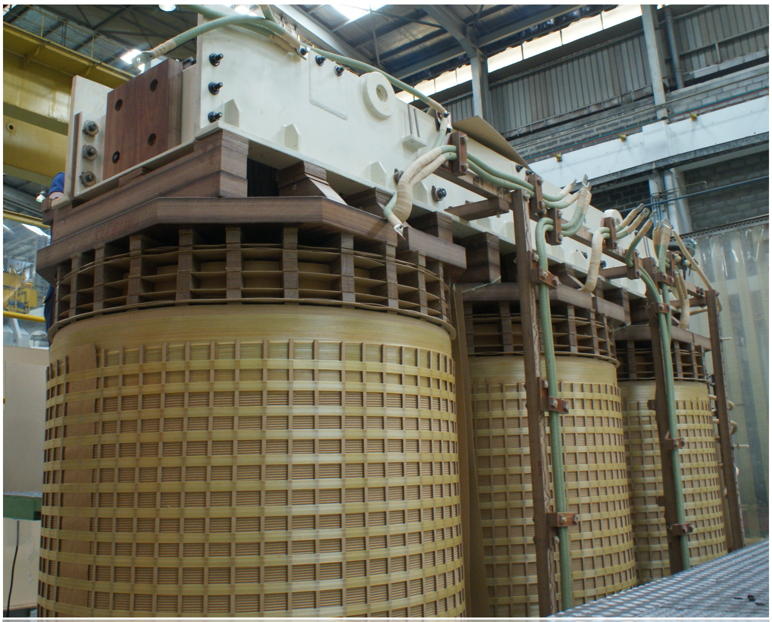
POLYCHLORINATED BIPHENYL (PCB) HAS BEEN BANNED IN TRANSFORMER SINCE 1979 DUE TO ITS TOXICITY

Next Issue

ENVIRONMENTAL FRIENDLY IN POWER TRANSFORMER DESIGN

EDITION 1/2020 - ISSUE 3

AGEING OF TRANSFORMER INSULATION: HOW TO MITIGATE IT?

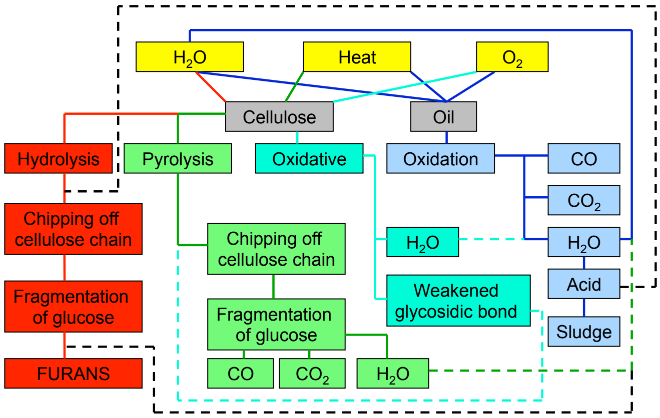


The power utilities and plant operator over the globe faced an issues of an ageing transformer population within their network and the risk of failure increases exponentially proportions towards the end of the transformers life. It is essential to have better understanding and quantify the ageing kinetics and to learn how they may be controlled, so that costly maintenance and future investment can be minimised and optimised. It is recognised by IEEE that 80% of transformer failure occurs caused by failure of insulation system. Of all the component parts in transformer, cellulose paper insulation is the most vulnerable component. The ageing of cellulose material is irreversible and the life of transformer is forever shortened. Thus, anything we do to prevent or mitigate damage to the paper insulation will enhance the life of in-service transformer.

The life of the transformer is governed by the life of cellulose paper insulation

AGEING MECHANISM OF TRANSFORMER INSULATION SYSTEM

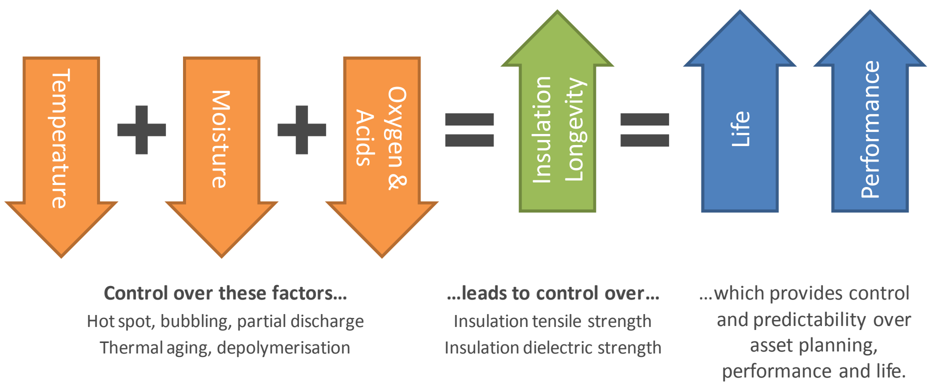
The ageing and degradation of electrical insulation system are phenomena that determine the life time of in-service power transformer or any other electrical apparatus. The intensities of these phenomena depend on the nature and values of electrical, mechanical, thermal and environmental stresses that act permanently or temporary on the insulations. The three basic factors that caused the ageing of transformer insulation system are heat, oxygen and moisture.



Insulation Longevity & Transformer Life: Depolymerisation under the effect of temperature is accelerated in the presence of moisture, oxygen and acids.

It is widely accepted that the main impact upon insulation longevity and depolymerisation of cellulose paper is heat or temperature. This process is further accelerated in the presence of moisture, oxygen and acids. A closer look on the impact of moisture, it has a serious role in premature ageing of insulation system including increases the risk of bubbling in the insulation and risk of partial discharge. At high enough levels of moisture in the paper flashover can occur at temperatures encountered in the normal operation of the unit.

Clearly determine the moisture level in transformer's insulation system is tremendous importance to avoid the catastrophic failure and safe operation of in-service power transformer. In addition, controlling the other ageing factor will increase the dielectric strength of insulation system, performance and life of transformer.



Transformer Ageing: Improving predictability and control over asset life.

DETECTION OF MOISTURE : PRACTICAL APPROACH

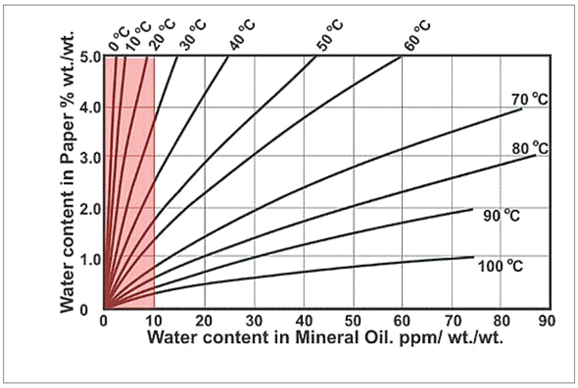
The distribution of moisture in the transformer is not uniform. The majority of the moisture in the transformer system resides in the solid insulation (paper and pressboard) and not in the oil.

This is because the paper insulation has a much greater affinity for water than does the oil. As a transformer operates, moisture will move from the insulation body (thin and thick insulation) into the oil as it heats and will move back to the insulation from the oil as it cools.

Therefore, it is very important to keep the solid insulation and oil as dry as possible and as free of oxygen as possible. However, the concentration of moisture in oil alone expressed in parts per million (ppm) does not provide sufficient information to obtain an adequate evaluation of the insulation system dryness, and therefore the assessment of moisture in the solid insulation should be determined.

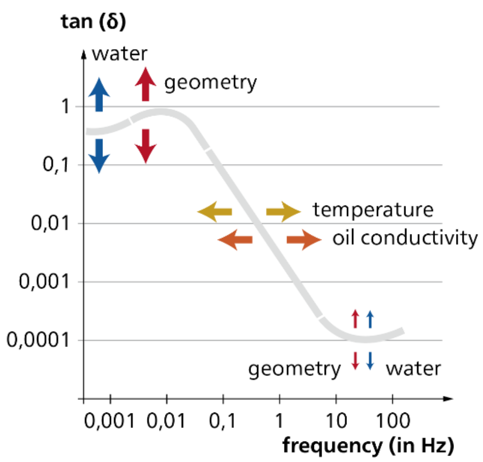
Moisture in cellulose is a difficult parameter to measure. There are two main methods to determine this and the results are not always reliable. Taking the actual paper sample from transformer probably the accurate method to determine the moisture content. However, this means that the unit must be out of service. In addition, any outside influence, such as atmospheric conditions and handling, will contaminate the sample and render it useless, and give incorrect results. Temperature and relative humidity at the time of taking the sample will have a significant impact.

Other method used equilibrium chart to estimate the level of moisture content in solid insulation. Using moisture in oil measurement to determine moisture in cellulose is a tricky business as the equilibrium plays the major role and due to the fact that different parts of the transformer are at different temperatures and states of equilibrium. There are a few technical papers that attempt to evaluate the mechanism, but there is still much doubt as to their accuracy.



Typical moisture equilibrium curve

In recent years, an approach to determine the moisture uses an electrical means and calculating the resultant moisture is proposed. This method is getting well accepted and is improving as the technology matures and gains momentum. Frequency domain spectroscopy (FDS) or variable frequency dissipation factor measurement takes both oil and solid insulation into consideration. A high dissipation factor value at line frequency does not provide information as to whether the reason is a high water content or a high oil conductivity. The dielectric properties of a combined oil paper insulation in a power transformer are dependent on a broad range of parameters such as internal geometry, oil conductivity, temperature and water content in the paper and pressboard insulation. A closer look shows that these influence factors are dominant at different frequencies. A higher oil conductivity or temperature will cause the curve to shift towards higher frequencies whereas a higher water content will increase the dissipation factor at higher and lower frequency but show very limited influence in between. For moisture assessment, the dominant part of the water content at lower frequencies provides much more reliable results.



Dielectric properties of a transformer oil paper winding insulation

WHAT REMEDIAL ACTION IS APPROPRIATE?

It is imperative that moisture should be removed from the oil and paper insulation for extending the service life of power transformers. The asset owner has five options pertaining to management of moisture in power transformer. The simple action is do nothing but the results are predictable; continuous degradation and resulting premature failure, outage and replacement. Second option is to replace the wet oil with dry oil but the moisture bound deep within the transformer's paper insulation will slowly leach into the new oil. In the end, this approach treats the symptom but does not solve the problem.

Over the years, the technology for moisture removal has been the main area of concern for the majority of transformer's owner. The well established processes for transformer drying include of oil circulation, vacuum drying oven and vacuum pressure impregnation (VPI). Using oil circulation method, the oil is circulating through oil purification equipment. After filtering the oil to remove the particles, the oil is heated in a so called vacuum degassing unit and all residual gasses are removed and the moisture contents of less than 5ppm can be reached. This is a necessary maintenance process for oil filled transformers but not very efficient for removing moisture as there in indirect heating of the insulation which takes a very long time.

In vacuum drying method, the transformer is kept in a vacuum oven where it is heated by means of electrical heaters. This results in water being evaporated which is present in the layers of insulation. Once the required temperature has been attained, vacuum is created in the oven with the help of vacuum pump so that the water vapour present in air around the transformer is extracted.

In VPI the transformer coils are heated initially to remove the moisture from the layers of insulation. After the desired temperature has been attained, vacuum is created in the tank so as remove the air along with the water vapour. On reaching the desired level of vacuum, resin, which is atmospheric pressure, is allowed to impregnate the coils at a low pressure. As a result of the pressure difference, resin impregnates the innermost parts of the coils thereby providing effective insulation.

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