White paper

Applying dissolved gas analysis to distribution transformers

Scope

Dissolved Gas Analysis (DGA) is an important tool in the assessment of a transformer's operating condition. Careful analysis and consideration of the presence, or more importantly, the rate of change of dissolved combustible gases in the transformer insulating fluid can help diagnose the existence and type of issue(s) a transformer may have experienced. Unfortunately, DGA analysis is far from an exact science, and the lack of industry standards and relative lack of DGA experience with distribution transformers only adds to the overall confusion. The level of confusion has increased recently with the rapid growth of renewable energy applications, as relatively new and less experienced users of distribution transformers seek to monitor and understand the overall health of the distribution systems on their wind or solar farms.

Background

Dissolved gas analysis has been part of the transformer industry for many years as a valuable tool in monitoring the condition of power transformers. The IEEE Transformers Committee is presently analyzing over 500,000 sets of data for power transformers, but the majority of that data is still not for distribution transformers. IEEE Standard C57.104, offers guidelines and analytical tools for the initial analysis of individual gases and Total Dissolved Combustible Gas (TDCG) in transformers.

However, IEEE C57.104 is frequently misinterpreted as two key footnotes are often overlooked:

1) Table 1 assumes that no previous tests on the transformer for DGA have been made and that no recent history exists.

2) The numbers shown in Table 1 are in parts of gas per million parts of oil (ppm) volumetrically and are based on a large power transformer with several thousand gallons of oil.

These two key points are essential when interpreting the DGA results for distribution transformers. Misapplication of the tables in IEEE C57.104 to distribution transformer DGA results often leads to questions, confusion and misplaced concern and actions. It is important to consider these factors and the other limitations associated with DGA sampling as described in IEEE C57.104 before taking any major action regarding in service transformers.

The gases

The volume and relative concentrations of combustible gases can tell us much about the existence and type of issue(s) a transformer may have had or is currently experiencing. These potential issues include:

a) Partial discharge (corona – low energy arcing)
b) High energy electrical arcing
c) Thermal faults
d) Cellulose insulation breakdown
e) The overload history of a transformer

The principal or key gases associated with each type of issue are shown below:

– Hydrogen (H2): generated by partial discharges and arcing
– Methane (CH4): generated by relatively low elevated temperatures (150° C).
– Acetylene (C2H2): generated by arcing.
– Ethane (C2H6): generated by high temperatures (<300° C)
– Ethylene (C2H4): generated by high temperatures (>300° C)
– Carbon Monoxide (CO): generated by oxidation of cellulose insulation
– Carbon Dioxide (CO2): generated by oxidation of cellulose insulation

However, the rate of change of these gases is much more telling with respect to distribution transformers. In fact, it is quite normal for distribution transformers to exhibit some combination of these gases during normal healthy operation. Therefore, multiple samples taken at consistent intervals to determine if there is a significant increase or rate of change in any individual gas is the best indicator of potential problems in distribution transformers.

Gas analysis

Distribution transformers may exhibit the presence of dissolved combustible gases in the insulation fluid for a number of reasons that have no impact on the health or life of the transformer. Specifically, due to the much lower volume of insulation fluid, distribution transformer gas concentrations will be higher than those of power transformers since the gas concentration (ppm) is inversely proportional to the volume of fluid. In other words, simply because distribution transformers are smaller and have significantly less insulating fluid, we would expect the gas concentrations to be higher.

Similarly, many distribution transformers incorporate components such as expulsion style fusing and load break switches that will generate combustible gases in their normal operation. The gases generated by these components are similar to those associated with an arcing fault. However, the existence of these gases has no relation to any problems internal to the transformer, and poses no threat to the transformer's continued normal operation.

Finally, normal distribution transformer manufacturing procedures may result in the detection of certain combustible gases. For instance, the tank cover welding operations may result in the formation of detectable levels of acetylene gas. Therefore, it is important to develop a DGA base line for determining the initial concentrations of these gases when comparing to future DGA samples.

For these reasons, IEEE C57.104 should only be used with respect to distribution transformers as an initial reference to determine if additional, more frequent oil sampling and further analysis is warranted. Once a trend indicating a significant rate of change in the dissolved gassed is established, then a determination can be made as to the appropriate actions to take regarding the transformer.

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Summary

Dissolved gas analysis can be a valuable tool in determining the operating condition of any transformer; however, careful consideration of DGA results is especially necessary in assessing the health of distribution transformers. Smaller fluid volumes, normal component operation and standard manufacturing procedures can all lead to the existence of dissolved gases in distribution transformers. Therefore, it is critical to determine if a significant trend exists before taking any actions regarding distribution transformers resulting from a DGA sample.

If a user plans to utilize DGA sampling, then ABB suggests annual DGA sampling for monitoring of distribution transformer operating conditions. Those customers planning to maintain an annual DGA maintenance program should consider the option of a base line DGA test when ordering distribution transformers. Please contact your ABB sales representative for additional information.

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