Advancements in Dissolved Gas Analysis: Accounting for Gas Loss

Dr. Zachary H Draper & Dr. James J Dukarm

Dissolved gas analysis (DGA) in transformers is a very successful periodic screening method to identify transformers that may be having problems. It is a symptom-based assessment of health, rather than a condition-based assessment. That is because the gases themselves do not cause failure, but are just by-products of deteriorating insulation caused by abnormalities such as hot spots or electrical discharges. The abnormalities are what might fail the transformer. If the transformer loses fault gases, the measured gas production is less than the total gas production, and therefore the problem may remain undetected, or the severity of the problem will be underestimated, and fault diagnosis may be inaccurate. Conventional DGA assessments usually rely on a limits based approach where higher concentrations of dissolved fault gases are assumed to represent a worse condition.

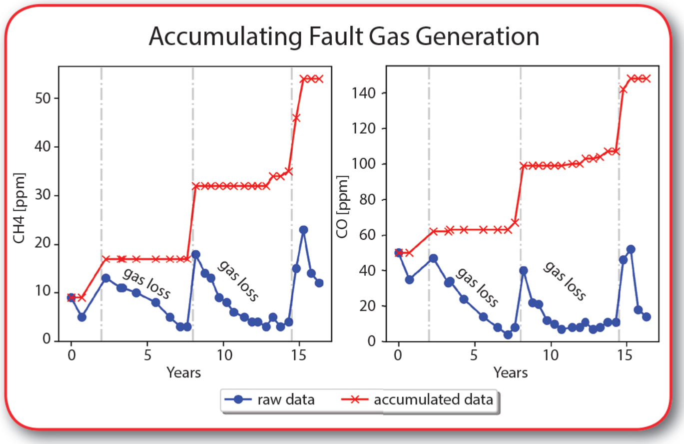
There are numerous reasons why fault gases in a transformer might be lost to the atmosphere, either on purpose or by accident. For example, some transformers are free-breathing by design. Others that are not supposed to be free-breathing may exchange gases with the atmosphere via a ruptured conservator bladder, a leaky bushing gasket, or loose fittings. Nitrogen blanketed transformers shed headspace gas to relieve high pressure and then later make up the lost gas with pure nitrogen. Because of the lowered fault gas concentrations in the headspace, some dissolved fault gases are released from the oil to re-establish equilibrium with the headspace. This results in a decline in dissolved fault gases as the transformer goes through thermal cycling and headspace pressure regulation. The loss of fault gas can be much worse if the transformer is leaking headspace gas. Be sure to track nitrogen consumption to identify leaking transformers.

One way to compensate partially for gas loss is to calculate the overall increase in each fault gas concentration by adding up positive increments between oil samples over the transformer's history, ignoring negative increments. It is usually not possible to know how much fault gas was lost, but often the use of cumulative gas concentrations is helpful to detect a problem and provide a low-ball estimate of its severity.

The figure illustrates a nitrogen blanketed transformer that had three gassing events, but due to gas loss between the events, the observed gas concentrations (blue) stayed below IEEE limits. Since the gas levels never exceeded any limits, the utility was surprised when turn-to-turn arcing tripped the transformer. A post-mortem inspection revealed extensive charring of the paper winding insulation. It is evident from the cumulative gas trend (red) that the transformer had a thermal problem affecting paper spanning several years.

When using cumulative gas concentrations for DGA interpretation, it is very often necessary to smooth the raw data to reduce the amount of sample-to-sample noise due to sampling and measurement uncertainty. Otherwise, the upward component of noise will contribute to the cumulative data.

Watch for more articles in this *Electricity Today* series about advancements in DGA interpretation.



Dr. Zachary Draper is a scientist with Delta-X Research Inc. His current research focuses on reliability statistics, multi-dimensional gas diagnostics for transformers and load tap changers, and seasonal variability and signal processing for online DGA monitors. He also provides training on how to interpret advanced analytics and reliability-based dissolved gas analysis. A member of both IEEE and CIGRE, Dr. Draper received a B.Sc. in Physics and Astronomy from the University of Washington, and a Ph.D. in Astrophysics from the University of Victoria. For more information on this article, please email info@deltaxresearch.com or visit www.deltaxresearch.com.