Dissolved Gas Analysis – Oncor's Past, Present, and Future

Dustin Best

Engineer – Transmission Equipment Support

Oncor Electric Delivery

Fort Worth, Texas

Russell W. Smith

Consulting Engineer – Transmission Equipment Support

Oncor Electric Delivery

Fort Worth, Texas

Hannah Webb

Engineer – Transmission Equipment Support

Oncor Electric Delivery

Fort Worth, Texas

Abstract:

Oncor Electric Delivery will present its past, present and future processes with transformer dissolved gas analysis (DGA). With DGAs being Oncor's main test in determining the condition of a transformer and LTC, it is crucial that each DGA is analyzed and not overlooked. Therefore, this paper will discuss the history of DGAs, the current best practices used at Oncor as well as the development and refinement of the automatic DGA notification triggers used to analyze the results. The number of saves, due to the DGA notification triggers, for both main tanks and LTCs since 2016 will also be discussed. Currently, there are plans being made to refine the DGA triggers even farther and to develop an online dashboard to trend the DGAs for a better visualization that the individual work centers can utilize.

Introduction:

Before dissolved gas analysis (DGA), the condition of a transformer was for the most part unknown and maintenance practices were heavily based upon a time interval. Once DGAs were developed, a better assessment of the condition was able to be made, making this an integral part in the evolution of the utility industry. This became one of the first diagnostic tests used for condition based maintenance. With Oncor having approximately two thousand (2000) transformer assets that are sampled every year, management of this data is crucial in order to prioritize which transformers to resample and/or maintain. The automation of dissolved gas analysis through email notifications ensures that all results are analyzed and never overlooked. The progression of DGAs at Oncor is an example of how maintenance practices transformed through the analytical development of dissolved gas results.

Timeline:

In the early 1980's, internal inspections and time-based maintenance were heavily relied upon for transformer reliability and/or identifying problems. Oncor's maintenance practice during this time was to inspect on a time-based interval of one (1) year for every load tap changer (LTC). This eventually moved to a three (3) year interval. Maintaining LTCs required a crew to de-energize the transformer (isolate, hang grounds, place "danger" tags, etc.), evacuate oil, remove compartment door, inspect, and identify any problems. If problems were identified, needed parts were acquired, replaced, oil processed, and work was performed to energize the transformer. This process was very time consuming and costly.

In the mid to late 1980's, Oncor began to perform dissolved gas analysis (DGA) on transformer main tanks by utilizing regional, in-house and outside labs to obtain the gas value results. DGA "memos" were mailed to the regional operations engineer for sole review. The individual's main focus was analyzing moisture content, acetylene, and total combustible gas levels.

In the early to mid-1990's, Oncor's maintenance practice to inspect every LTC moved to a six (6) year time-based interval or after 30,000 operations. DGAs on main tanks became more proficient during this time in identifying problems and LTC DGAs began. DGAs on LTCs were taken when a problem was suspected after an event occurred. These samples were analyzed by one person who developed key gas relationships on detecting possible issues. All decisions on when to inspect LTCs were decided by this single person. Even though these relationships were not always consistent in determining the condition of

the LTC, progression of DGAs continued and land was procured to establish a permanent oil analysis lab for all of Oncor's assets.

In the late 1990's, an Oncor committee was formed to begin focusing on improving the consistency of analyzing LTC DGAs by reviewing failure data and relationships of gases. From this research, the key relationship found was the correlation between ethylene and acetylene. At the time, it was not known how to separate between normal arcing in oil and overheating that would produce coking or how coking was being created. In 1999, while an individual was taking out the trash, curiosity emerged on how trash bags were made. This led to the research of manufacturing polyethylene and the process called steam cracking that produces the raw material ethylene. The biggest issues with steam cracking were discovered to be coking of the pipes caused by heating oil to 800°C during production. This coking was the same type of material that was found in failed LTCs.

In the early 2000's, Oncor's permanent in house lab started performing oil analysis for all of its assets. During this time, the committee began experimenting with arcing in oil and reviewing the gas relationships. Brand new oil was arced 10 times, 20 times, and with water added. Results found that the ethylene to acetylene ratio was approximately 0.11 in good operating LTCs regardless of the number of times the oil was arced. DGA guidelines were developed for when to perform internal inspections, but many of the cases were caught too early and little to no evidence of the problem was present. This was due to low amounts of gases produced or the ethylene/acetylene ratio was too low. It was found that waiting for the ratio to become greater and gases to increase allowed the problem to become more evident. From these results and saves, condition-based maintenance was implemented for LTCs with a DGA sample interval of every two (2) years.

In the mid 2000's, the manual process of analyzing DGA results by a specific group that would notify the districts of concerning results transitioned to automated DGA email notifications. This reporting system was implemented by using the algorithms developed by the committee to determine the condition of the asset based on the results of oil analysis. These conditions were broken down into levels of concern (caution, warning, wet, etc.) with a course of action included (resample in a time frame, plan for internal inspection, etc.). If a condition was met, an email notification was sent to field personnel for the transformers in their district. A specific group received email notifications for the entire Oncor system for their review as well. DGA results were considered normal if no condition was met; therefore no email notification was sent. This transition reduced the amount of DGA results an individual or group had to focus on at any given time.

In the late 2000's, Oncor began installing and evaluating different single and multi-gas online monitors on selected autotransformer main tanks. This evaluation would determine the approach Oncor would take for future online DGA monitoring. During this time, communication loss and component failures were common issues experienced by Oncor. Due to these issues, this pursuit slowed to allow for further advancement in online monitoring technology.

In the early 2010's, the DGA reporting system previously in place moved to a centralized asset data base. This data base had reporting system capabilities, where the same algorithms were utilized. This provided

better organization and tracking by allowing asset information and DGA history to be centralized into a single location.

In the mid 2010's, Oncor began to refine its DGA notification algorithms on both main tanks and LTCs. These refinements were implemented to reduce the number of "false positive" notifications sent out when a condition was met. They were decided by reviewing DGA notification history and determining when a notification resulted in a course of action or no action required. One of the refinements made was reducing the number of "false positive" moisture tracking notifications on main tanks when the top oil temperature was too low, resulting in the relative percent saturation to be high. This would have eliminated 541 out of 695 notifications from 2013 to 2016. Another refinement made was reducing the number of "false positive" LTC notifications due to low amounts of gases that created higher key gas ratio results. This would have eliminated 580 out of 802 notifications from 2013 to 2016. Totaling these two refinements, DGA notifications would have been greatly reduced by 1121 out of 1497 making them more reliable. During this time, the DGA sample interval moved to annually for condition based maintenance on main tanks and LTCs. It was also specified that all new medium power transformers come with single gas (hydrogen) online monitors for both main tanks and vacuum LTCs.

In the late 2010's, Oncor continued refining the DGA notification algorithms and began developing a basic fleet dashboard used for trending historical DGAs. The refinements include determining specific algorithms for each LTC model type. This will allow LTCs to be analyzed based on its signature gassing characteristics, instead of assuming every resistive/reactive, selector, or vacuum LTC model type would gas the same. A basic DGA fleet dashboard gives a visual look at the DGA trending of a region, district, substation, individual transformer, or the entire transformer fleet. It is also capable of analyzing identical transformer designs at the same time which allows prioritization for transformer maintenance. During this time, Oncor began tracking transformer and LTC saves (problem was found, corrected, and returned to service) based on DGAs. From 2016 to 2018 there were nineteen (19) transformer saves and thirty-six (36) LTC saves.

Asset health scores and an advanced DGA fleet dashboard are being developed to provide more than just visual trending. These asset health scores will allow for prioritization of maintenance and/or proactive replacements. The advanced DGA fleet dashboard would mimic the email notification by using the conditions to arrange the assets in order of highest priority or concern. These tools will add great benefit to the existing Oncor condition-based maintenance program.

Conclusion:

Over the years, the progression of DGAs within Oncor and the industry has led to condition-based maintenance for Oncor when managing its transformer fleet. This progress for Oncor can largely be contributed to the effort and initiative of the committee members in the early 2000's and the advancements of automated reporting tools in the mid 2000's. These contributions have led to the confidence of venturing away from the labor intensive time-based maintenance methodology. As the confidence in online monitoring, DGA algorithm refinements, dashboards, and asset health scores continues to grow, the hope of eventually targeting units for replacement right before end of life exists.

This thought process seems hard to imagine at this point in time, but through history so was moving to condition-based maintenance.