Advancements in Dissolved Gas Analysis: Risk Assessment

Dr. Zachary H Draper & Dr. James J Dukarm

In general, the purpose of periodic screening with DGA for power transformers is risk assessment. Is any transformer likely to fail in service? If so, how severe is the problem? Previous articles in this series have described ways to improve DGA interpretation. In this article we provide a glimpse of what modern statistics can say about risk assessment, after the previous steps are performed.

Conventional practice with IEEE or IEC guidelines is to compare gas concentrations and rates of increase with predetermined limits and produce a grade school assessment of "Good", "Poor", or "Bad," [1, 2]. Often this carries the assumption that a bad result indicates a higher, yet undefined, risk of failure in service. In particular it has been assumed or implied that higher gas levels signify higher risk of failure. Everyone agrees that some rate of fault gas production is a bad sign, but the basis for defining limits has been to find large outliers, not to connect the gassing back to actual failure data.

Statistical survival analysis is used in reliability engineering to model how failures relate to observable quantities like service age, operating conditions, defects, and so on [3]. For applying survival analysis to DGA, the analysis requires DGA results as of the most recent in-service sample, date that the transformer failed, and circumstances of the failure [4]. All data should be compiled for failure cases to incorporate additional risk factors into a more holistic model. **Learn from failure.**

In a previous article, we explained normalized energy intensity (NEI) and gassing events [5]. NEI-HC is the sum of concentrations of methane, ethane, ethylene, and acetylene, weighted by their heats of formation from mineral oil and divided by a conversion factor. This approximates the energy released into the insulation by a fault in the transformer.

Application of survival analysis relating the most recent NEI-HC level prior to failure produces a "hazard rate" curve, shown in Figure 1, which illustrates the tendency to fail as a function of increasing NEI-HC. This curve illustrates two problems with previous assumptions on gas concentration limits. First, the 90th percentile NEI-HC level is just to the right of the curve's peak. If your transformer is gassing, waiting for the level to exceed the 90th percentile means waiting until the failure risk has peaked and started to decline. Second, the risk

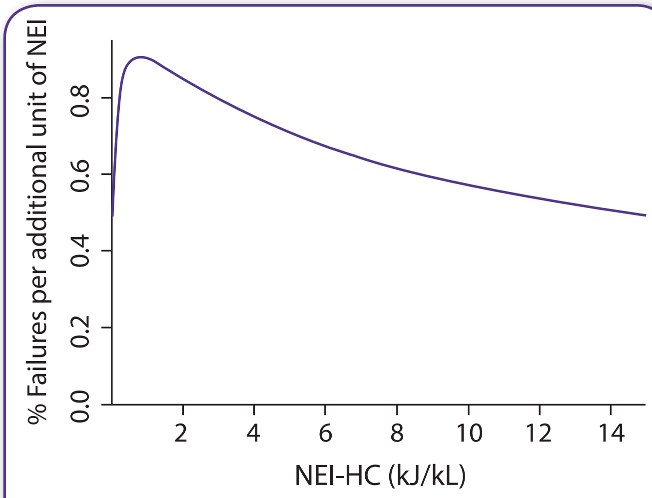

Figure 1: NEI-HC hazard rate

associated with NEI-HC gassing declines as the level increases, so higher gas levels beyond the 90th percentile do not indicate a higher risk of failure.

The NEI failure rate can also be multiplied by the rate of gassing to project into the near future the level of risk associated with a gassing event. Risk factors from other observable data such as NEI-CO, service age, moisture, and so on can be added in summation to develop a full risk model for the transformer. This is a far more objective way to build a so-called "health index". The risk of near-term failure associated with an active fault is only part of the story. Sometimes the transformer's DGA can provide evidence of past or recent stress that might have reduced the transformer's ability to withstand external events such as through faults or overloading. How to recognize and quantify that kind of long-term risk could be the subject of a future article.

REFERENCES

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