Condition Monitoring
Finding the appropriate level

Summary
Not every transformer needs a multi-gas DGA device giving results every few hours, often needing lab checks at the same time. The combination of a Delphi Mini and Delphi Portable provides powerful real time monitoring, giving a composite value for the key gases of interest covering all faults, with rapid 'back up' from the Delphi Portable on site!

General Considerations
There are some general rules as regards to the application of condition monitoring which cover not just power transformers, but many large assets:

- What is the failure rate?
- What decisions do you need to make[1]?
- What information do you need to support those decisions?
- Will a monitor give data in a timely manner?
- Is it worth it – what is the value?

Answering these questions helps determine the appropriate level of condition monitoring for a particular application. This paper looks at these elements and makes recommendations for some power transformer applications.

[1] "Data and Decisions", T. McGrail, IEEE Smart Grid Conference, Perth, Australia, 2011

What is the failure rate of the asset?
It is unlikely that the asset in question has no failure mode; power transformers, for example, may fail through dielectric, thermal and mechanical causes[2]. A study by HSB insurance company, and reported at the Doble Client Conference in 2012 reviewed causes and noted that the failure rate of power transformer is likely to increase in coming years[3]. Failure rate may be closely related to individual manufacturer or designs, and may also depend on operation regimes. However, a failure rate of less than 1% per year is commonly achieved in practice by electric supply industry organizations.

Decisions to be made
The most common condition monitoring decision is to decide the fitness for purpose of the transformer. This may seem obvious – but the decision will be made in context of available information: maintenance history, manufacturer/design, effect of any through faults. Is there anything in the performance of the transformer which is anomalous and leads us to believe that there is deterioration outside of expectations? Particular transformer families may need more attention; those which are suspect may require condition monitoring to provide more frequent data for ongoing review.

Information needed
Over the decades, many technical papers have shown that dissolved gas analysis (DGA) of transformer oil is a cost effective and comprehensive technique to support transformer health decisions; when a fault develops in a transformer, it is usually accompanied by development of fault gases – the individual gases will be dependent on the type of fault – thermal faults, partial discharge (PD) or power arcing. Sampling of transformers for lab testing is performed by most transformer owners, with the frequency of sampling related to the size of the unit. GSU's and transmission transformers may be monitored annually, or every 6 months; smaller units and less critical units may be tested every couple of years. The actual details are dependent on the individual organization.

[2] "Transformer Asset Health Review",Doble MKT-SL-TAHR_01
[3] "Transformer Failures – a Review", W.Bartley, HSB, Doble Client Conference, Boston, USA, 2012

Online condition monitoring bridges the gap between regular lab samples and provides a greater opportunity to detect incipient faults in a timely manner. Other tests include partial discharge testing, bushing leakage current monitoring, temperature and infrared tests[4].

It is not necessary to have complete DGA details from a monitor to detect a developing problem. The Doble Delphi Mini, for example, provides a single value which is a composite indication of the key gases hydrogen, acetylene, ethylene and carbon monoxide[5]. These gases are present in each of the common transformer faults detectable by DGA – thermal, PD and arcing.

When the Delphi Mini shows rising DGA levels, perhaps through an alarm setting via SCADA, a sample can be taken for analysis. This analysis may be performed at a lab, or using a Portable Delphi on site, which gives a reading for each of the 7 key diagnostic gases plus moisture. The advantage of the Delphi Portable approach is that it gives confirmation of dissolved gases in a very timely manner – no need to wait for a lab to respond!

Timeliness of Information

The nature of transformer design is such that it takes time for the byproducts of the faults – the dissolved gases – to mix in the oil and arrive at the sensor itself: consequently there is a natural time lag in information received, which may amount to several hours[6]. The likelihood is, however, that well mixed oil will arrive at the sensor which is characteristic of the fault.

Online DGA through a Delphi Mini provides information in real time – continuously giving absolute DGA level and rate of change. Devices which provide 7 gases plus moisture take more time to process a sample – and they also need to be 'backed up' with a lab sample should they indicate a problem within the transformer. It is common to set a multi-gas online DGA device to measure every 12 or 24 hours, and then increase the frequency if there is a rise in DGA levels; this is reduced to a reading every few hours if the situation continues to deteriorate. One reason for this gap in sampling is that the multi-gas monitors require more maintenance and attention the more they operate; in addition, it takes time for each sample to run. This is the trade off with a multi-gas device – more information, but less frequently.

Value

Is it worth putting a more expensive multigas DGA device on every transformer? The short answer is "No!" A Delphi Mini gives good general indication of deterioration in transformer health, in real time, which can be backed up using a Delphi Portable. The multi gas device absolutely has its place with the large units and hyper-critical units, and comes with a cost associated – more investment in installation and upkeep and it is still recommended that a lab sample be taken should the multi-gas go into alarm.

It should also be noted that any condition monitoring will provide the possibility of both false positives and false negatives; depending on how the alarm levels are set[7]. Managing the possibilities is an asset management decision – as is planning a response when an alarm happens!

Conclusions

When considering appropriate Online DGA condition monitoring, care must be taken to look at the individual application – multi-gas DGA devices have their role for large transformers and hyper-critical units, but a combination of a Delphi Mini for general DGA indication, with a Delphi Portable for detailed analysis, is a powerful combination. The addition of Doble's IDD to address bushing issues and Doble's PD range to address partial discharge provides a valuable and appropriate monitoring package for any individual application.

[4] "Power Transformer Condition Monitoring and Life-Cycle Management", C. Johnstone, NG UK, EuroDoble, 2009
[5] IEEE Standard C57.104 Guideline for DGA
[6] "Using Dissolved Gas Analysis to Detect Active Faults in Oil-Insulated Electrical Equipment", Lance Lewand, Machinery Lubrication Magazine
[7] "Condition Monitoring in the Real World", G. Mackay, TransGrid, Australia, Doble Client Conference, USA, 2013