DGA Fault Type Identification

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Dissolved-gas analysis (DGA) is used to distinguish transformers that may be experiencing trouble from those that can be kept on regular maintenance until the next time that screening tests are performed. It is also used for monitoring transformers that are under stress or behaving abnormally to judge whether the transformer's condition is deteriorating.

The key to the detection and assessment of abnormalities is noticing active production of fault gases (hydrogen, methane, ethane, ethylene, acetylene, CO, and CO_2). Fault type identification, when increasing fault gas leads to suspicion that something may be wrong, is conventionally done by means of a gas ratio method (see [1] or [2]), or with Duval's triangles [3] or pentagons [4].

The way that DGA fault type identification methods are presented often leaves the impression that the reported gas concentrations are the appropriate inputs, but that is seldom the case. For diagnostic purposes, it is the nature of the process responsible for a particular episode of gas production that we want to know, not a mushy "average" of all the past and present contributors to the gas concentrations found in the oil.

When increasing fault gases raise suspicion of a fault in a transformer, it is necessary to calculate the gas increments (amounts of increase) representing the amounts of gas formed between the first and the last available oil sample demarcating the gassing event of interest. Those gas increments, not the gas concentrations reported by the laboratory (or DGA monitor), are the proper basis for fault type identification by any of the above mentioned methods.

The following example shows, using the Duval triangle 1 as the fault identification method, how to use gas increments to investigate what fault type explains a gassing event and what would happen if gas concentrations were used instead.

Table I
DGA History of Gassing Transformer

Sample #	1	2	3	4
Days	0	1366	2359	3191
Hydrogen	50	258	78	401
Methane	13	370	140	187
Ethane	6	320	302	308
Ethylene	12	370	183	356
Acetylene	2	10	3	123

Example

A transformer generated fault gas over a 1366 day period. The DGA data for the initial and final samples over that period are shown in columns 1 and 2 of Table I. The apparent fault type associated with this gassing event is determined by calculating the increments of methane, ethane, and ethylene concentration over that period and using them to plot a point (the round dot) in the Duval triangle. See Figure 1.

Δ Methane:	370	–	13	= 357
Δ Ethylene:	370	–	12	= 358
Δ Acetylene:	10	–	2	= 8

A second gassing event began about 393 days after the last sample of the first event and lasted for about 832 days. The DGA data for the first and last samples for that event are shown in columns 3 and 4 of Table I. The gas increments used to plot the square dot in the Duval Triangle of Figure 1 are:

Δ Methane:	187	–	140	= 47
Δ Ethylene:	356	–	183	= 173
Δ Acetylene:	123	–	3	= 120

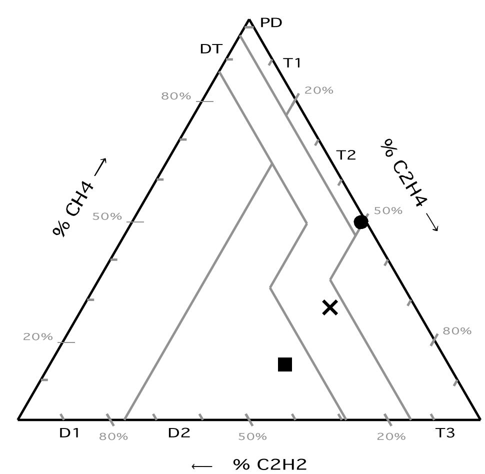

Figure 1. Duval triangle 1 – the first gassing event (round dot) is associated with fault type T2, and the second (square dot) with fault type D2. The fault type based on gas concentrations as of the end of the second event (cross) is DT.

The round dot representing the first gassing event is on the border between T2 (heating between 300 °C and 700 °C and T3 (heating above 700 °C). The square dot representing the second gassing event is in the D2 (strong arcing) zone. Evidently whatever is happening in the transformer has gotten a lot worse.

For comparison, the gas concentrations in the oil as of the last sample of the second gassing event (column 4 in Table I) are represented by the cross symbol located in the DT zone. The gas concentrations are unsurprisingly indicating a mixture of heating and electrical discharge, much less informative than the fault type information obtained by using the gas increments.

References

[1] "IEEE guide for the interpretation of gases generated in oil-immersed transformers," *IEEE Std C57.104-2008 (Revision of IEEE Std C57.104-1991)*, pp. 1–36, Feb 2009.

[2] *Mineral oil-filled electrical equipment in service – Guidance on the interpretation of dissolved and free gases analysis*, 3rd ed. International Electrotechnical Commission, Sep 2015, no. IEC 60599-2015-09.

[3] M. Duval, "The duval triangle for load tap changers, non-mineral oils and low temperature faults in transformers," *IEEE Electrical Insulation Magazine*, vol. 24, no. 6, pp. 22–29, November 2008.

[4] M. Duval and L. Lamarre, "The duval pentagon-a new complementary tool for the interpretation of dissolved gas analysis in transformers," *IEEE Electrical Insulation Magazine*, vol. 30, no. 6, pp. 9–12, November 2014.