Analysis of Dissolved Gas in Transformer Oil by Gas Chromatography using a Stripper Column

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Introduction

Certain faults in electrical transformers may result in the generation of "fault" gases, which remain dissolved in the transformer fluid. If this happens and the problem remains unchecked, the transformer fluid and insulation materials will degrade, adversely affecting performance and, in come cases, completely destroying the transformer itself.

Identification and quantification of these gases can provide an early indication of developing problems in the equipment. ASTM D 3612 Method B describes the analysis of dissolved gases in electrical insulating oils using a stripper column. Transformer oil gas analysis, commonly referred to as TOGA, is based on this principle but has an extra feature which relies on back flushing the oil and unwanted components to vent.

Instrumentation

Technique: Varian 450-GC Gas Chromatograph
Dual channel stripper column oven
Dual channel gas sampling valve (GSV) system with full EFC control

Columns
Channel 1: Varian CP-PoraPLOT™ U, 25 m x 0.53 mm (pn: CP7584)
Channel 2: Varian CP-Molsieve™ 5 Å, 15 m x 0.53 mm (pn:CP7543)

Detector: FID with full DEFC control, TCD with full DEFC control

Sample Preparation

The system was equipped with luer lock connections for easy operation. This approach is widely used for TOGA field applications. The TOGA syringe infusion pump was used to introduce the oil sample to the TOGA analyzer.

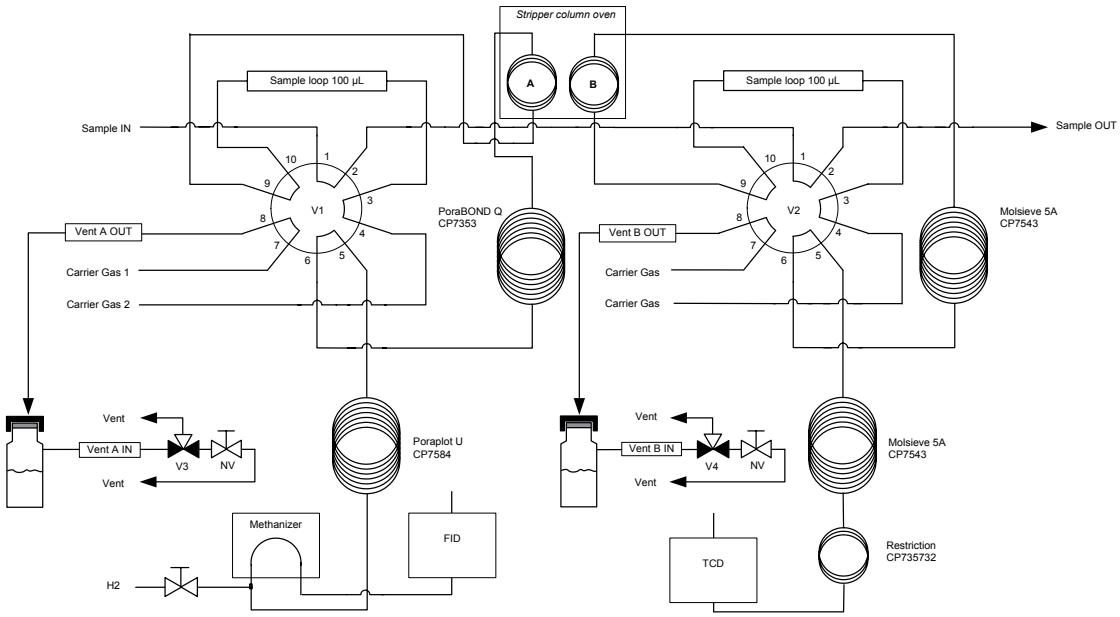

Figure 1. TOGA schematic overview.

Conditions

Stripper column oven settings

	Temp (°C)	Rate (°C/min)	Hold (min)	Total (min)
Initial	90		9.00	9.00
	120	20	9.00	19.50

Column oven settings

	Temp (°C)	Rate (°C/min)	Hold (min)	Total (min)
Initial	25		0.10	0.10
	30	2	0.50	3.10
	150	20	8.40	17.50
	25	20	1.00	24.75

Carrier Gases: Helium, 35.5 psi; Argon, 10.4 psi
Methanizer Oven: 400 °C
Detection: TCD, 120 °C; FID, 200 °C

Options
Varian Galaxie™ Data Handling and GC Control Software
TOGA Calculation Software
TOGA Syringe Pump Kit

Results and Discussion

Calibration

A reference standard (low concentration) gas mixture is used to calibrate the system.

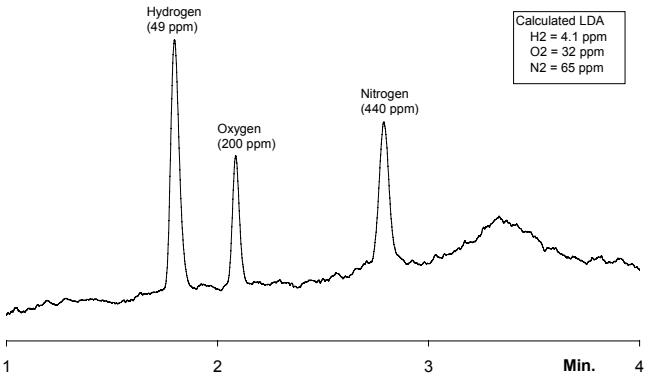

Figure 2. LDA determination.

From these measurements, lowest detection limits, commonly referred to as LDA, can be derived. In this case, the LDA from hydrogen, oxygen and nitrogen are determined (Figure 2). These figures are compliant with the specifications in the ASTM method.

Analysis Methodology

Through the use of a syringe infusion pump, the oil sample is injected via two, ten port valves, each equipped with sample loops connected to "stripper" columns. Each stripper column extracts the dissolved gases contained in the oil and passes them to two separate channels for analysis. One channel is equipped with two CP-Molsieve 5 Å columns using argon as the carrier gas. The column is optimized to separate lighter gases such as hydrogen, oxygen and nitrogen. The other channel is equipped with a CP-PoraBOND™ Q and a CP-PoraPLOT™ Q column and uses helium as the carrier gas. This channel is used to separate carbon gases including CO and CO_2.

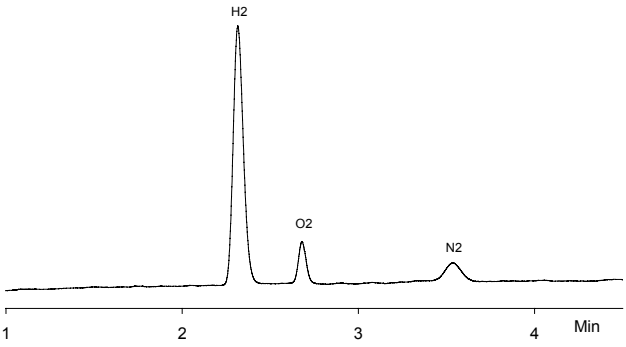

Figure 3. Gas sample, TCD channel.

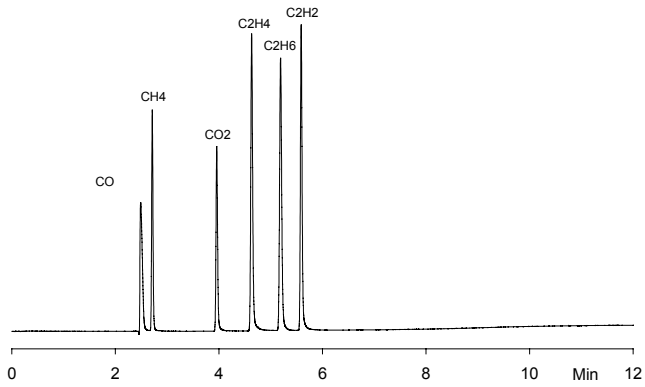

Figure 4. Gas sample, FID channel.

A special catalytic bed (methanizer) is used in combination with the flame ionization detector (FID) so that the carbon gases are converted to hydrocarbons, which enables them to be detected at low ppm levels. The use of argon as one of the carrier gases ensures that the best detection levels for hydrogen are obtained while still providing more than adequate detection levels for both oxygen and nitrogen. Once the extraction of the oil has been completed, all remaining components (of non interest) are back flushed (the flow is reversed) and vented. The components of interest in

the extracted gas are typically hydrogen, oxygen, nitrogen, carbon monoxide, carbon dioxide, methane, ethane, ethylene, acetylene, propane and propylene. Figures 5 and 6 show representative chromatograms from the two GC channels.

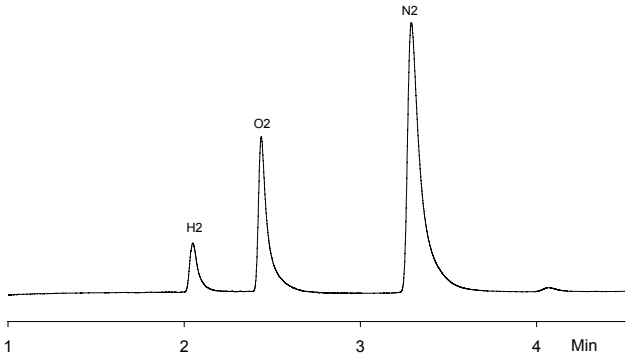

Figure 5. Oil sample, TCD channel.

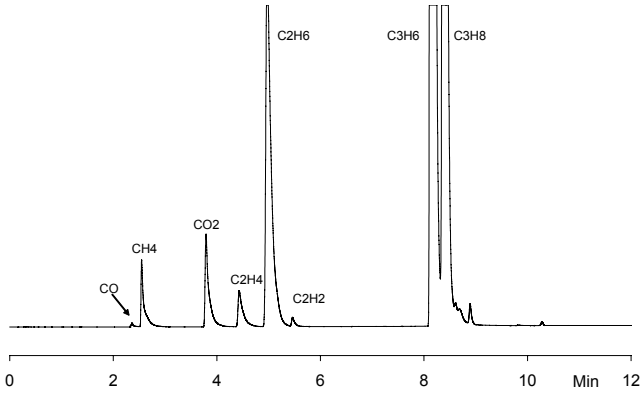

Figure 6. Oil sample, FID channel.

Table 1. Repeatability values from the oil sample analysis.

Repeatability Report TOGA Oil Analysis Serial Nr 101542									
Area Report Run #	H_2	O_2	N_2	CO	CH_4	CO_2	C_2H_4	C_2H_6	C_2H_2
1	36623	133420	327291	8731	161590	278065	140199	1590958	19245
2	36369	131356	328797	8387	158631	279063	140594	1590602	19643
3	36581	131691	328028	7431	155235	278398	140141	1587659	19829
n	3	3	3	3	3	3	3	3	3
Mean	36524	132156	328039	8183	158485	278509	140311	1589740	19572
St. Dev.	136	1108	753	674	3180	508	247	1811	298
Re. St. Dev. (%)	0.37	0.84	0.23	8.23	2.01	0.18	0.18	0.11	1.52

Analysis Results

The peak areas obtained from the analysis are summarized in Table 1. Also shown are the corresponding concentrations, all of which are in the % range. The repeatabilities shown are well in line with those called for in the ASTM method. It is important to note that the component peak shapes are significantly better when the gases are analyzed directly using GC than when the stripper method is used. This is due to the interaction of the dissolved gases with the stripper column and the length of time it takes for the gases to evaporate and move on to the analytic columns.

Reference

ASTM D 3612-02, "Analysis of Gases Dissolved in Electrical Insulationg Oil by Gas Chromatography. Method B, Stripper Column Extraction," ASTM International, West Conshohocken, PA, www.astm.org.

These data represent typical results.
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