APPLICATION NOTE

TOGAS - A Transformer Oil Gas Analysis System

Abstract

The analysis of gas in transformer oil is not a new requirement. Care and Maintenance of expensive transformers has been facilitated by routinely sampling the transformer oil and determining the concentration of various gases.

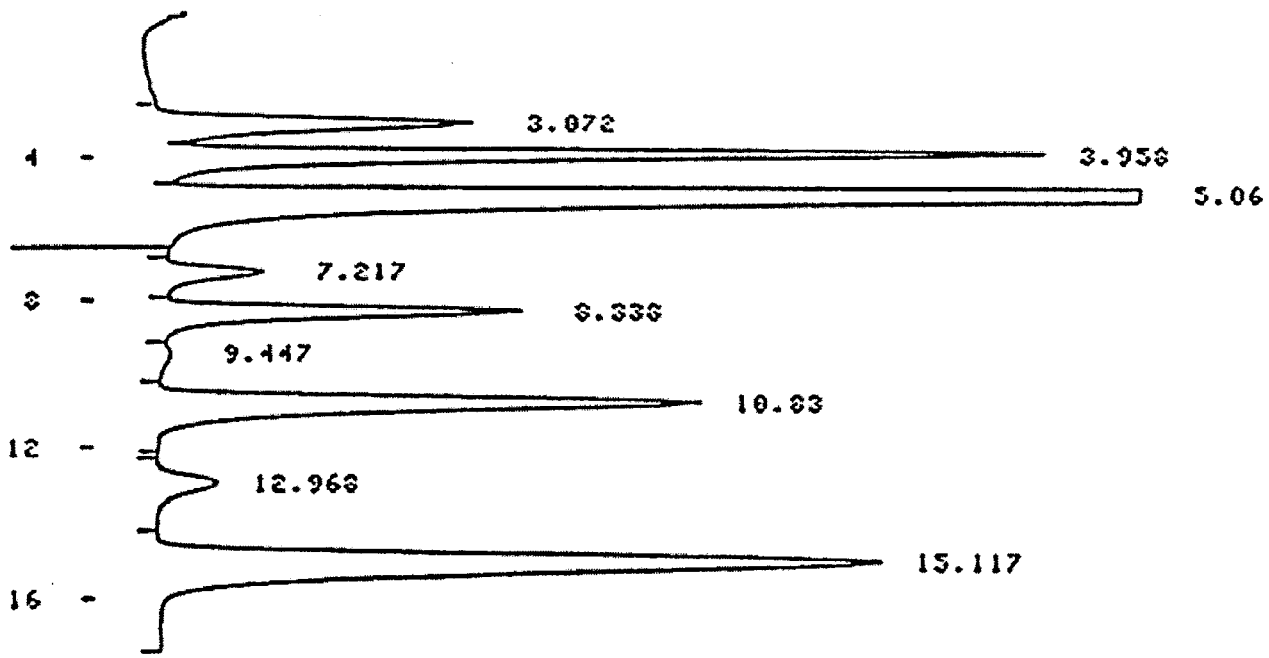
The fluctuations of the gas concentrations within the oil will provide information on what has occurred within the transformer. This information will allow decisions to be made on how to plan a maintenance schedule for individual transformers.

The current ASTM method D3612, requires vacuum extraction of the oil utilizing a glass apparatus with Mercury and a vacuum pump. This procedure is necessarily cumbersome and is subject to considerable error.

An alternative method has been developed which allows direct injection of oil into an instrument where the gas is automatically separated from the oil and subsequently analyzed. The systems design is protected by US patent 4,587,834 issued to General Electric.

Description

A 5 to 8 mL aliquot of oil is injected directly into the system. The system consists of a GC-14A gas chromatograph equipped with a TCD, FID, customized valving, methanizer C-R8A data processor and patented oil stripper. The system is completely interactive so that pressing the GC start button initiates the analysis and a complete report is printed out approximately 20 minutes later. An example of the printed data output is shown in Figure 1.

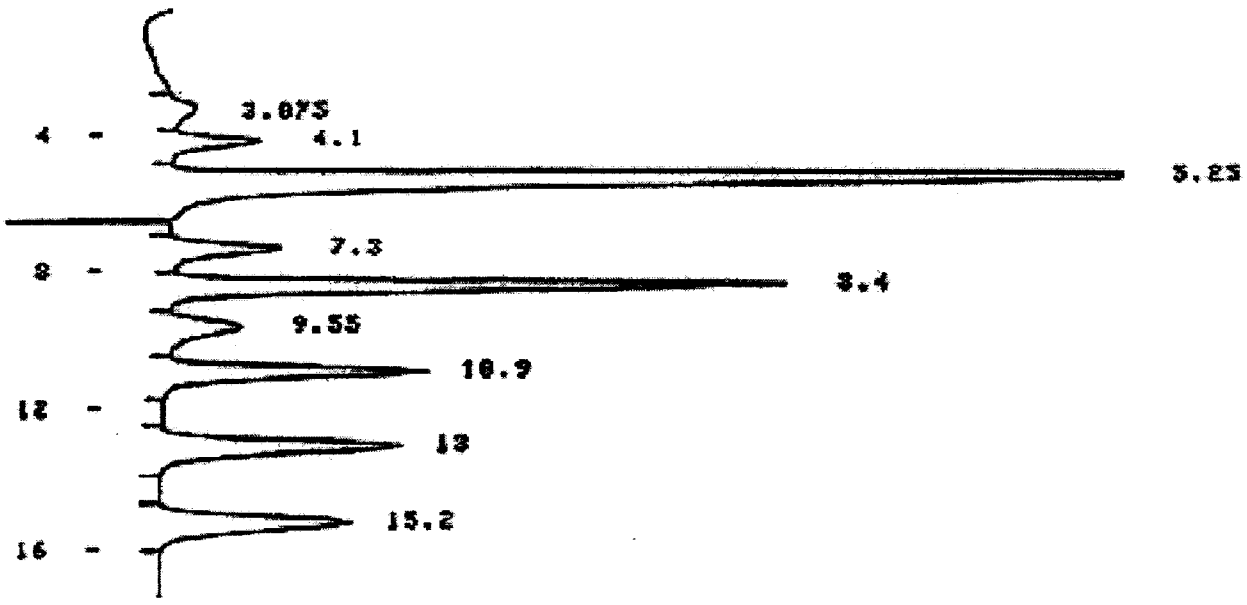


CHROMATOPAC	**C-R3A**	**FILE**	**0**
SAMPLE NO	**0**	**METHOD**	**424**
REPORT NO	**187**	**SAMPLE WT**	**100**

PKNO	TIME	AREA	MK	IDHO	CONC	NAME
1	3.072	61626		1	1954.4311	H2
2	3.958	136928	V	2	38739.4843	02
3	5.06	404589	V	3	262192	M2
4	7.217	74744		4	1552.1447	CH4
5	8.338	242159	V	5	4667.395	CO2
6	9.447	8002		6	163.6816	CO
7	10.83	459494		7	4081.2633	C2H4
8	12.968	61957		8	558.2924	C2H6
9	15.117	778325		9	7805.4155	C2H2
		---			---	
	TOTAL	-			--	
		2223123			321714	

Figure 1 **Typical Transformer Oil Sample Chromatogram from the Shimadzu TOGAS**

The calibration of the system is accomplished by injecting a standard gas mixture into the system. The gas mixture concentration entries in the data processor have been corrected for the extraction efficiency of the oil stripper. The extraction efficiency is the percentage of a gas which is extracted from the transformer oil by the carrier gas and the oil stripper. This corrected calibration enables the user to compensate for instrumental variances and enables the system to maintain a constant level of performance. An example of the gas standard chromatogram is shown in Figure 2.



CHROMATOPAC	**C-R3A**	**FILE**	**0**
SAMPLE NO	**0**	**METHOD**	**424**
REPORT NO	**214**	**SAMPLE WT**	**100**

PKNO	TIME	AREA	MK	IDHO	CONC	NAME
1	3.075	1407		1	105.7934	H2
2	4.1	3562		2	2539.7443	02
3	5.25	100554		3	45933.6757	M2
4	7.3	4949		4	98.9918	CH4
5	8.4	23649		5	417.186	CO2
6	9.55	4517		6	100.4072	CO
7	10.9	11996		7	96.1184	C2H4
8	13	13082		8	100.0263	C2H6
9	15.2	11576		9	112.2671	C2H2
		---			---	
	TOTAL	-			--	
		175293			49504.1953	

Figure 2 TOGAS Gas Standard Chromatogram

The repeatability of the system on standard gas mixtures is evident in the data noted in Table 1 which was produced on a standard system. The accuracy of the calculated gas concentration of transformer oil samples will be directly related to the accuracy of the standard gas utilized in the calibration procedure.

Repeatability for Standard Gas Mixture

	1	2	3	4	5	$\bar{x}$	σ	C.V.(%)
H_2	105	107	107	106	109	107	1.33	1.24
O_2	2518	2535	2520	2450	2542	2533	9.79	0.39
N_2	25695	25924	25892	25855	25705	25814	95.82	0.37
CH_4	98.2	98.4	98.5	98.6	99.0	98.5	0.27	0.27
CO_2	412	409	408	411	417	411	3.14	0.76
CO	98.5	101	102	101	100	101	1.8	1.18
C_2H_4	94.5	92.9	93.0	93.3	96.2	94.0	1.25	1.32
C_2H_6	98.4	95.7	95.6	96.0	100	97.1	1.76	1.81
C_2H_2	111	110	109	110	113	111	1.36	1.23

X = Mean
= Standard Deviation
C.V. = Coefficient of Variation

Tabel 1

The data obtained form oil samples will have a different level of precision than that of gas standards. This difference is due to an extra variable, that of the extraction of the dissolved gases from the oil. The various gases are extracted at different efficiencies, which reflects their different solubilities in the oil. This extraction efficiency is mathematically corrected for in the data processor so that the concentration print out

reflects parts per million of the gas in the oil. The data (Table 2) illustrates a system with a high level of precision. The lack of data for 0_2 is due to the low level of the gas in the gas mixture used to prepare the standard oil sample. The concentration of the 0_2 was below the quantitative, qualitative limit of detection of 500 ppm.

Repeatability for Standard Oil

	1	2	3	4	5	$\bar{x}$	σ	C.V.(%)
H_2	652	638	627	644	674	647	15.7	2.43
O_2	-----	-----	-----	-----	-----	-----	------	------
N_2	49930	50392	50121	49638	50636	50143	348	0.69
CH_4	91.7	93.7	1015	94.7	97.1	95.7	3.26	3.41
CO_2	130	131	133	129	128	130	1.83	1.40
CO	109	111	115	109	109	111	2.19	1.98
C_2H_4	103	1049	108	104	105	105	1.68	1.60
C_2H_6	101	101	107	102	102	103	2.29	2.23
C_2H_2	119	120	122	118	118	120	1.82	1.52

NOTE: Repeatability data cannot be guaranteed under all laboratory conditions.

Tabel 2

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