Gas analysis is the analysis of the dissolved gasses found in the insulating oil. It is used to determine if the dissolved gasses are a result of atmospheric leaks, internal faults or are normal. If the gasses are the result of an electrical fault, the analysis can help identify the cause and severity of the fault.

The gas analysis begins with an oil sample obtained from the device under study. The sample of oil is introduced into an evacuated gas-extraction apparatus. Upon introduction to the very high vacuum, the dissolved gases are liberated quickly from the oil. By use of a series of valves, a portion of the gas is separated from the oil and pressurized to atmospheric pressure.

The collected gas is injected into a device called a gas chromatograph which separates it into its various components and quantifies them. The appearance of abnormal amounts of these gases indicates the presence of an incipient fault.

6.4.5 The Fault Gases and Their Meaning

The gas chromatograph can identify a variety of gases dissolved in the oil. The nine gases listed in Table 6-1 are of key interest in this analysis. Included in Table 6-3 are the approximate concentrations of each gas which indicate an incipient fault and the possible cause or source of these gases.

6.4.6 Diagnosis

There is no single criterion for interpreting the results of a fault gas analysis test. The decision as to whether the unit should remain in service is made by examining the trend of the results. Increases in the amounts of the various gases indicate the continued existence of the incipient fault, increase in the rate of gas formation indicates a worsening of the fault

The actual gas composition tells what particular type of problem is developing. Examination of the ratios of various gases to each other by such methods as the Rogers Ratio or Dorneberg Methods can give further insight into the source or cause of the problem. These methods while being extremely helpful, are not totally accurate and must be tempered with the knowledge gained through other diagnostic tests or past operating characteristics of the apparatus.

1 **Corona** is a low energy electrical fault. Electrical discharges result in the ionization of the oil surrounding the fault creating hydrogen gas.

2 **Sparking** is an intermittent high voltage flashover without high current Sparking generally results in increasing levels of methane and ethane gas.

3 **Over heating** of oil may be caused by overloads, core problems, etc. Overheating

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generally results in the formation of hydrogen, methane, ethane and ethylene gas.

4 **Arcing** is the most severe fault process. It involves high voltages, high currents and high temperatures. Arcing is characterized by the formation of acetylene gas.

5 **Cellulose** or paper may be involved in any of the above fault activities. Its involvement is characterized by the formation of carbon monoxide and carbon dioxide gas.

6.4.7 Example

Table 6-1 and table 6-2 illustrate the format used to display the results of a Fault Gas Analysis Test. The test is divided in the following five sections.

1 Nameplate and Sampling Information

This first section includes apparatus identification information, sample date and location, and miscellaneous test data.

2 Test Results

The second or middle section contains all the test results regarding the nine (9) individual gas components.

Column 1 - Contains the name of each gas and symbol. Total Gas, total Combustible Gas, Equivalent TCG Reading (%).

Column 2 - Date sample collected, report number, and list of all test results for each gas either in ppm or % Vol.

Volume percent in oil; states the volume percent of the gas dissolved in the oil for each gas component This information is used in the diagnosis of the problem.

Volume percent in gas; of the total gas dissolved in the oil, this column lists the percentage: each gas that make up the total gas volume.

3 Comments

The third section lists the possible causes or sources of the problem, it is based on the information listed under "Volume % in Gas" or "PPM" (abnormally high amounts of each gas will be indicated by an asterisk (•) or (") after each gas).

In the example listed in Table 6-3, the following gases are beyond their normal limits:

Ethylene Ethane Acetylene Methane

Ethylene and methane indicate severe local overheating of the oil; ethane indicates sparking and acetylene reveals the presence of more powerful arcing.

With the presence of these gases, it is hypothesized that there is a fault, probably arcing relatively high energy taking place. This arcing is between two conductors insulated by oil but not paper.

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4 Suggested Action

The first course of action is to verify that the sample was correct and not from a tap changer or other device where arcing is normal. Many times an immediate resample is prudent. After verifying the sample it must be determined whether to leave the apparatus in service with fault gas analysis being continued on a more frequent basis (monthly or weekly) or to take the apparatus out of service for more diagnostic testing or repair. If the apparatus is left in service, all subsequent tests should be carefully analyzed and the rate of gassing determined. An increase in the gassing rate generally indicates a worsening of the problem, a leveling off or decrease in the rate of gassing should be guarded with suspicion.

In general, most incipient faults do not clear up by themselves and typically becomes worse as time goes by. When acetylene gas appears, the incipient fault should be classified as permanent and severe and corrective actions readied for implementation.

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Fault GAS Analysis Result Sheet

Dissolved Gas-In-Oil Analysis (DGA)	ppm	%	%
Data Collected			
Report Number			
Oil Temperature			
Hydrogen (H_2)			
Methane (CH_4)			
Ethane (C_2H_6)			
Ethylene (C_2H_4)			
Acetylene (C_2H_2)			
Carbon Monoxide (CO)			
Carbon Dioxide (CO_2)			
Nitrogen (N_2)			
Oxygen (O_2)			
Total Gas			
Total Combustible Gas			
Equivalent TCG Reading (%)			
Comments			

Table 6-1

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Physical and Chemical Tests				
ASTM Method	Particulars	Unit	Result	Remarks
D-15338	Moisture in Oil	ppm		
D-971	Interfacial Tension	dynes/cm		
D974	Acid Number	mg KOH/g		
D-1500	Color Number	Relative		
D-1524	Visual Exam	Relative		
D-887	Dielectric Breakdown Voltage	KV		
D-1816	Dielectric Breakdown Voltage	KV		
D-445	Viscosity	SUS		
D-1298	Specific Gravity	Relative		
D-924	Power Factor @ 25°C	%		
D-924	Power Factor @ 100°C	%		
D-2668	Oxidation Inhibitor	%		
D-1807	Refractive Index	Relative		
D-097	Pour Point	°C		
D-92	Flash Point	°C		
PPM	PCB CONTENT AROCLOR	METALS IN OIL (PPM) ALUMINUM COPPER IRON LEAD SILVER TIN ZINC		

Table 6-2

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