DISSOLVED GAS ANALYSIS (DGA) OF INSULATING FLUIDS

Preventive Maintenance and Fault Analysis Using the ACTIve Extraction^{SM} Technique

Dissolved Gas Analysis (DGA) is the single most widely used and most effective test used today to determine if your transformer's operation is normal, questionable or has a fault condition. In association with other tests, inspections and analysis, DGA is key in determining the probable condition of operating transformers.

The ACTIve Extraction^{SM} Technique enables us to offer the most accurate and repeatable DGA results.

Understanding DGA and Interpreting the Results

Information from the analysis of the gases dissolved in insulating oils is valuable in a preventive maintenance program. Data from a DGA can provide:

1. **Advance warning of developing faults**
2. **A determination of the improper use of units**
3. **Status checks on new and repaired units**
4. **Low detection limits**
5. **Improved reproducibility**
6. **Detection of faults during the warranty period**
7. **Essential information for your Asset Management program**
8. **Recommendations for Additional Tests or Inspections**

Qualitative analysis of the gases present in the oil, allows identification of fault processes such as Partial Discharge, Sparking, Overheating and Arcing. Hydrocarbon (mineral base) oils are used as insulating fluids in transformers because of their high dielectric strength and chemical stability. Under normal operating conditions very little decomposition of the oil occurs. However, when a fault occurs, the oil and cellulose insulation will undergo chemical degradation. The fault induced breakdown products are low molecular weight gaseous compounds that are soluble in the oil.

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

Determining the concentration of fault gases in hydrocarbon oils is accomplished in a two-step process: **Extraction** and **Chromatographic Analysis**.

The first process, extraction, involves separating the gases from the oil. The oil sample is introduced into an inert gas-filled vial which is heated and agitated for a period of time. A set volume of the extracted gas is then transferred to the gas chromatograph for analysis.

The second process, gas chromatography, is a method of separating the different gases. The gases are injected into the gas chromatograph and transported through a separation column. The separation column selectively retards the sample gases and they are identified as they travel past a detector at different times. A plot of detector signal versus time is called the chromatogram. Our chemists interpret the chromatogram to determine the concentration of each of the dissolved gases.

The historical vacuum extraction or “Rack” method takes place at ambient temperature for an unspecified amount of time. The “Rack” method, ASTM D 3612-A, recommends the use of Ostwald solubility coefficients to correct for the residual gas in the oil. Use of the Ostwald coefficients assumes than an equilibrium distribution of the gases between the two phases has been obtained. This is a weak assumption since the extraction is conducted at room temperature. Studies in our laboratories indicate that the gases do not reach equilibrium distribution between the phases during the 20 minute extraction period at ambient temperature.

Better Methods and Better Diagnostic Test Results

A newer method, “**ACTIve Extraction^{SM} Technique**”, designated ASTM D 3612-C, has recently been approved by the ASTM. The extraction method differs significantly from the older method. Elevated temperature and extended agitation time are important differences between this method and the older ASTM D 3612-A, or “rack” method.

Chromatographic Analysis is a method of separating the different gases. The gases are injected into the chromatograph and transported through a column. The column selectively retards the sample gases and they are identified as they travel past a detector at different times. A plot of detector signal versus time is called the chromatogram. Our Chemists interpret the chromatogram to determine the concentration of each of the the dissolved gases.

Some advantages of the **ACTIve Extraction^{SM} Technique** include:

- Mercury-Free Environment
- True Gas Distribution Equilibrium Achieved
- Lower Detection Limits
- Better Reproducibility
- Smaller Oil Volumes Required (9ml vs. 35-50ml)
- Applicable to a Wider Concentration Range
- Replication of Test with Same 50 ml Sample

Acetylene should not be formed in a normally operating arc-free transformer; however, the **ACTIve Extraction^{SM} Technique** allows us to detect this critical fault gas and all other fault gasses at concentrations below 1 ppm. The equipment used in our process is highly automated which minimizes human error. Our experience is that better reproducibility and accuracy is achieved with the **ACTIve Extraction^{SM} Technique** as compared to the rack method.

Weidmann Diagnostic Solutions has developed very effective diagnostic programs for load tap changers (LTCs) and oil circuit breakers (OCBs). In both types of equipment arcing occurs during normal operations. Fault gas concentrations are significantly higher in normally operating LTCs and OCBs than in transformer main tanks. Problem LTCs and OCBs generate even higher fault gas levels. An unproven assumption is that ASTM D 3612-A is applicable over a very large concentration range that covers from 1 ppm to thousands of ppm. Calibration of the method uses low gas concentrations and it is simply assumed that the linear dynamic range extends to the higher concentrations. We find consistently higher concentration results on identical samples prepared with high fault gas concentrations between the rack and the **ACTIve Extraction^{SM} Technique**. Thus, we believe that ASTM D 3612-C is more accurate with higher fault gas concentration.

For more information about our Diagnostic Services and Monitoring Products, contact Weidmann Diagnostic Solutions at 916-455-2284 or 800-811-2284, by e-mail to diagnostics.wds@wicor.com or visit our website at www.weidmann-diagnostics.com