Increasing Electrical Reliability

Utilizing

The IQ Program

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Insulation Sampling and Evaluation Technologies

There are three primary types of electrical insulation: liquid, gas and solid.

The most widely used type of liquid dielectric is mineral oil. Mineral oil is used in transformers primarily for insulating and cooling. Electrical transformers contain over 4.5 billion gallons of fluid in the United States alone. Circuit breakers, load tap changers and oil-fused cutouts utilize mineral oil for insulating and arc-quenching purposes.

In-service transformer oil sampling and analysis has been used for many decades to provide valuable information regarding both the condition of the dielectric and the electrical condition of the transformer itself. Because of the low cost of the analysis and the ease in which samples can be taken, oil sampling has become the most frequent test performed on transformers today.

In recent years a great deal of advancement has been made in the analysis of load tap changer and oil circuit breaker dielectric fluids. Sampling of these devices is being adopted into more and more maintenance programs today.

Except for air, sulpher-hexaflouride (SF6) is the most widely used gas dielectric in the electrical industry. SF6 is used primarily in high voltage circuit breakers for its good insulating and arc-quenching capabilities. Recent advancements in the analysis of SF6 samples have lead to the growing use of this technology for the assessment of breaker condition.

Solid insulation is the most widely used dielectric in the electrical industry. Switchgear, cables, dry-type transformers and many other electrical components employ various types of solid insulating materials. Unfortunately, no practical, non-intrusive insulation sampling and analysis method exists for solids. Until recently, this left traditional off-line dielectric testing as the only means to evaluate solid insulation.

Partial Discharge Analysis

Partial Discharge testing of medium and high voltage equipment has been recognized for several decades as a valuable means of assessing insulation condition in the laboratory environment for quality assurance purposes. Recent advancements in sensor technologies, measurement techniques, software and noise reduction has lead to the reliable assessment of solid insulation condition using field partial discharge test equipment to test electrical equipment while it remains in service.

The chief advantages of performing field partial discharge surveys are:

- It is a non-intrusive test, requiring no interruption of service and is performed under normal operation voltage.
- It is truly a predictive test, indicating specific symptoms in advance of the failure.
- It is a nondestructive test; it does not test to failure or adversely affect the equipment under test.
- It need not use any over-voltages, thereby not exposing the tested equipment to higher voltage stresses than those encountered under normal operating conditions.
- Trending can be accomplished by storing results to allow comparison with future tests.
- In many instances the site of the partial discharge occurrence can be located within the test object so the localized problem can be repaired.
- The cost to perform a partial discharge survey is relatively inexpensive, allowing annual surveys to be performed economically at most facilities.

Field partial discharge testing has been performed routinely overseas for many years and its popularity is growing very quickly in the United States. This testing has proven to be a very valuable on-line prediction tool to reduce failures of medium and high voltage equipment.

Depending on the apparatus that is being evaluated, partial discharge can be detected using electromagnetic, acoustic emission or capacitive sensors to measure the signals created by the minute "sparking" that occurs due to "partial failure" of the insulation.

Not Infrared

Annual partial discharge surveys of medium and high voltage switchgear, cables, transformers and other equipment is being applied in a similar manner as infrared surveys are used to detect "current related" problems such as loose connections or overloading. Partial discharge testing differs as it detects insulation or "voltage" related problems that cannot be found with infrared. Additionally, partial discharge testing does not require a clear "line of sight" to the object being evaluated as infrared does. Therefore, partial discharges occurring inside of switchgear, transformers or down lengths of cables can be detected and evaluated.

Difficulties with Field Partial Discharge Testing

There are two basic types of on-line solid insulation partial discharge testing equipment. One type is the well-known hand-held ultra-sonic emission detector, which is used for detecting air-borne partial discharge or "corona" in outdoor substations or inside switchgear. This device is useful and has led to the discovery of many problems. However, there are many disadvantages with this testing. The sensor requires a clear air path to the problem source and cannot look inside of equipment or cables. The equipment cannot distinguish the difference between corona (discharge into air), which may be harmless and partial discharge, which is very destructive. In electrical noisy environments such as high voltage substations, they are often ineffective due to the background noise. Additionally, no true quantitative measurement of partial discharge activity can be made.

The other type of on-line solid insulation testing equipment utilizes sophisticated measurement devices to detect and measure partial discharge. This type of equipment, shown in Figure 1, works extremely well to identify and quantify harmful partial discharge activity. This equipment also detects partial discharge within the insulation and does not require a clear "line of site" to the defect. Recently, this equipment is playing a key role in the condition assessment of electrical equipment employing solid insulation.

There are two primary disadvantages to this type of test equipment and these disadvantages have prevented widespread field use of the equipment by service organizations and utilities in the U.S. - the equipment is very expensive ($50 - $100K) and it requires extensive analysis experience in order to obtain meaningful results.

New Solutions

Technological advances have lead to the development of new equipment and partial discharge survey methods that greatly reduce the cost of the instrumentation and greatly simplify the field sampling and laboratory data analysis processes.

The new field partial discharge sampling kit known as the Insulation Quality (IQ) System (shown in Figure 2) consists of three types of sensors, which interconnect to digital processing hardware and signal conditioning devices that then save the partial discharge signature to the internal computer. Simplified procedures allow the average technician to easily sample and record the solid insulation signatures to a file on the PC. When the job is complete, the electronic files are sent via internet upload or cd-rom to the laboratory where expert analysis and evaluation is performed. The customer receives a hard copy or electronic report as shown in Figure 3 for each item sampled. The IQ System is available by lease for a low monthly cost and each electronic file is analyzed for a small fee, making the system economically attractive. This method of sampling and analyzing solid insulation is similar to the approach used to sample and analyze transformer oil as follows.

A. The sampling procedure is easy, as shown in Figure 4.

B. The person performing the sampling need not possess a high level of specialized technical expertise.

C. The cost of the sampling equipment is low.

D. The information contained in the report provides an accurate indication of the insulation condition, the level of which is more informative than oil test reports.

E. Sampling is performed on-line and does not require an outage, but does not require contact with any live parts, so it is safe.

F. The results can be trended to predict impending failures.

Solid PD Sampling has the following additional advantages:

1. The sampling is very fast, about 1 minute per component.
2. The laboratory analysis cost is much less than that of an oil sample.
3. Electronic file transfers via email can allow for immediate analysis.
4. Continuous monitoring of critical equipment is possible via the internet with optional equipment.
5. There is no environmental spill risk or need for sample disposal.
6. In addition to solid insulation, Partial Discharge sampling can be successfully performed on liquid and gas apparatus also.
7. The lease arrangement minimizes equipment investment and eliminates equipment obsolescence risks to the service provider.

Since oil and gas sampling are also very good technologies, PD Sampling should not be used in lieu of these methods. Partial Discharge sampling of apparatus using these types of insulation should rather be used to supplement the traditional tests.

Conclusion

The low cost, easy to use IQ System now allows convenient and cost effective sampling of medium and high voltage components to be performed by local service organizations or on-site maintenance personnel. Experts remote from the job-site can inexpensively perform the difficult chore of identifying and evaluating the component's insulation condition by using electronic data transfer. Utilization of this new tool will allow a much greater amount of equipment to be analyzed non-intrusively and will result in a greater increase in electrical reliability that will reflect directly on the bottom line.

Figure 1 - Traditional partial discharge testing equipment

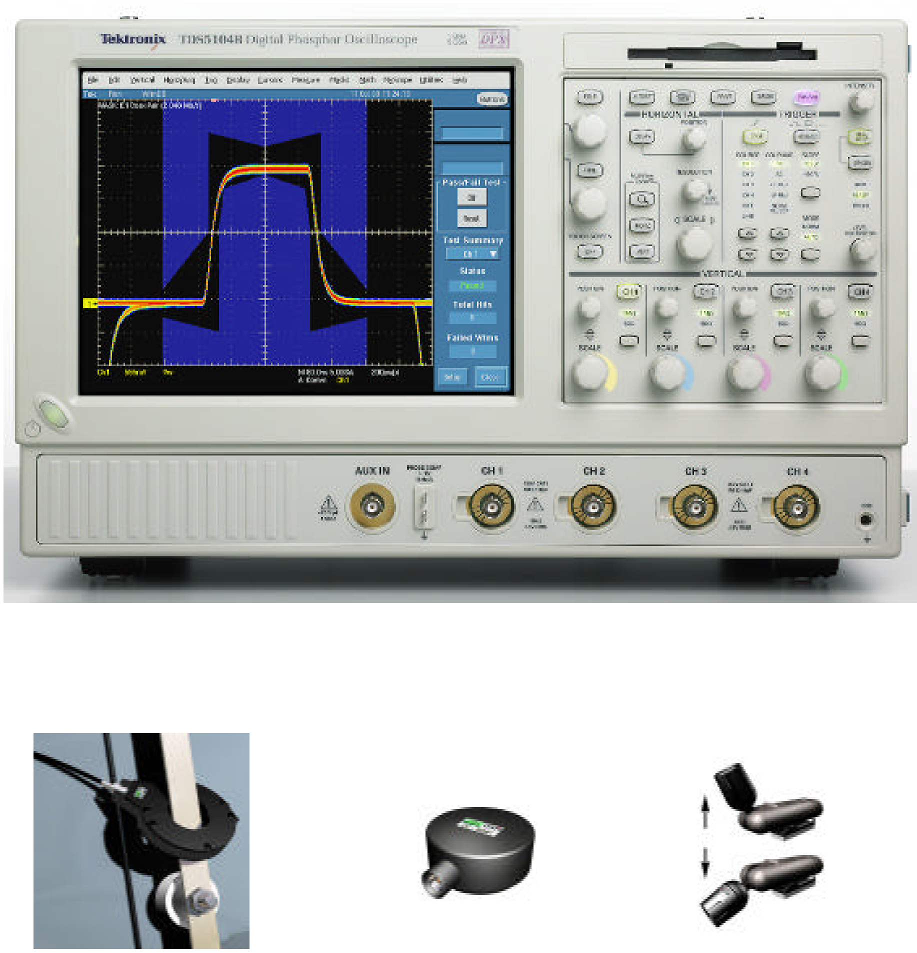
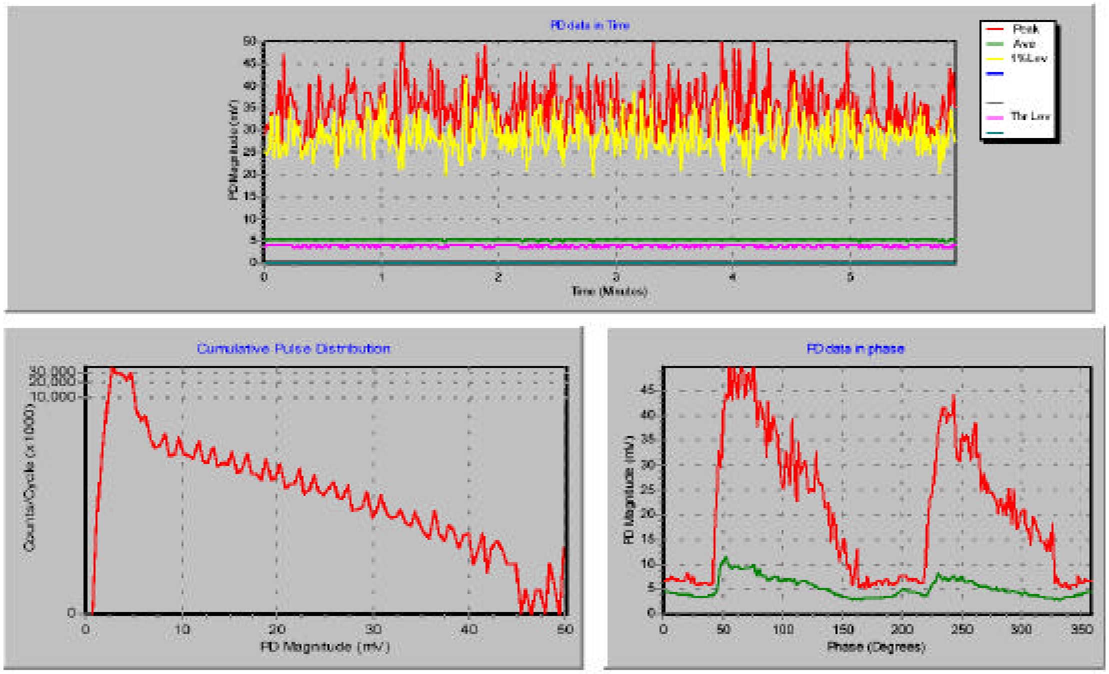


Figure 2 – IQ partial discharge sampling kit shown with high frequency current transformer, capacitive coupler and airborne acoustic sensors.



Filename of measurement | Date of Measurement | Time at Start

C:\Mydelphi\PDgold\TekMeasure\Results\IPEC\Stuart St 1	29/04/02	15:18:44

PD parameters measured between cursors

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Largest Peak Value........................ 50.20 mV
Largest Average Value..................... 5.49 mV
Largest 1% Level Value.................... 41.57 mV
Largest 5% Level Value.................... 20.78 mV
Largest Short Term Severity............... 4078.43 mV.Counts
Largest Counts per Cycle.................. 106.00 Counts/Cycle
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Comments

Measurement Comments

HFCT measurement on Circuit 21 Phase A termination.

Results Comments

A significant partial discharge was found.

Immediate termination repair is recommended.

Figure 3 – Sample Partial Discharge Test Report

Figure 4 – Technician installing sensor on 138KV cable shield