Safer, Stronger, Smarter Networks

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Partial Discharge, Survey or Monitor?

24-7 Partial Discharge monitoring is the ultimate tool for finding insulation weaknesses before they fail.

Introduction

It’s well established that Partial Discharge (PD) detection is an excellent technique to assess the condition of electrical equipment. Partial discharge detection gives operators the ability to find defects in insulation systems before they grow into catastrophic failures. This often takes the form of periodic partial discharge surveys taken every 6 months or every year.

The challenge is that partial discharge, even in advanced cases when the insulation has been irrevocably damaged and prone to failure, is not always present at the time periodic surveys are undertaken. Voltage, load, type of discharge, and environmental conditions all play a part in how prevalent the PD is and if it is detectable during a given survey.

24-7 Partial discharge monitoring overcomes this limitation and provides instant indication that catastrophic failure may be imminent. This paper will explore the advantages of full time monitoring and its application.

PD detection Overview

There are three main practices for detection of partial discharge in stationary equipment (Switchgear (AIS & GIS), bus ducts, cables, insulators, etc). Each has its advantages and disadvantages.

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Offline Testing

Offline testing is a significant tool for PD detection. In this method, the equipment is taken out of service and disconnected from the load and supply. Then, a specialized energizing supply and detector instruments are applied.

The separate energizing supply is typically one of three types. The simplest is a power frequency voltage generator. Because powering an electrical system to nominal operating voltage involves generating sufficient current to overcome the stray system capacitance, these must be very high power systems. They are usually large enough to require truck or trailer mounting when system voltages and power requirements increase.

VLF or Very Low Frequency systems overcome the charging current issue by running at very low frequencies (Less than 1 Hz). Because it is AC, space charge issues are avoided but being lower in frequency the power requirements are much smaller. Two-man portable units as high as 33 KV RMS are possible.

The third type of offline testing supply is a pulsed resonant arrangement for EHV equipment where a resonant circuit is formed to allow higher voltages with lower power requirements. These are often truck mounted as well but can test equipment in excess of 132 KV.

Once you have the equipment energized, specialized instruments that connect directly to the conductors under test can make accurate measurements of the partial discharge. The main advantage of offline testing is that you can vary the line voltage above and below nominal to find the point where PD starts and where it extinguishes.

The disadvantages of offline testing are obvious. This type of testing requires an outage, very large, expensive test gear, and highly trained technicians. Testing a single circuit can take an entire day. This testing is usually done as part of commissioning or when problems are already suspected.

Online Surveys

Online testing is done with the equipment in service with much smaller, easier to use equipment. Handheld devices can detect PD through Transient Earth Voltage (TEV) detection, Ultrasonic detection, and Radio Frequency Current Transformers mounted on cable ground straps.

With online testing, you cannot vary the system voltage but it carries many other advantages. Personnel safety is not at high risk like it is with offline testing and the system is carrying load, which can cause thermal effects that may not be present with offline tests. Using online methods, no outage is required and dozens of circuits can be tested in a single day with much lower expertise required.

Of course, the online test instruments must be sufficiently sensitive and selective to allow the accurate detection of PD under in service conditions.

Full time monitoring

Full time monitoring makes use of detectors that are installed and left for long periods of time. This can be done with intrusive sensors like those used for offline testing or non-intrusive sensors like those used in online testing. Advanced monitoring systems will incorporate environmental sensors and background EMI detection to allow the user to evaluate the conditions associated with PD detection.

Full time monitoring can be used to eliminate the major limitation of other test methods, the inability to detect intermittent PD. With any periodic test, the PD must be present on the day that the equipment is tested. If not, the problem may not be found. It has been proven that serious insulation damage caused by PD can exist and under the right environmental conditions, PD will not be present.

Non-Intrusive Monitoring overview

Non-intrusive monitoring takes the technologies and sensors used in online testing and uses them to continuously monitor the equipment. Additional sensing, like surface temperature, humidity, and background RF noise can be added to provide a complete picture when analysing the data.

A complete system will provide full coverage for all switchgear bays simultaneously so that precedence can be used to discriminate and locate the exact source of PD. When PD occurs in one location in a row of switchgear bays, the PD activity may be detectable at many locations. Precedence compares the arrival time of the PD signature at all sensors to determine its origin. Being able to determine which sensor sees the signature first out of a large number of bays requires that all sensors can be timed within nanosecond precision.

Unfortunately, not all PD events are cut and dried events. Often analyzing and trending the data is necessary to find slowly evolving faults. Long term monitor systems can compare historical data in a way that offline testing and periodic surveys are limited. For significant events, a quick reaction is necessary and systems that can provide alarms into SCADA systems or directly to engineers via SMS or e-mail can be a big advantage.

Need for continuous monitoring

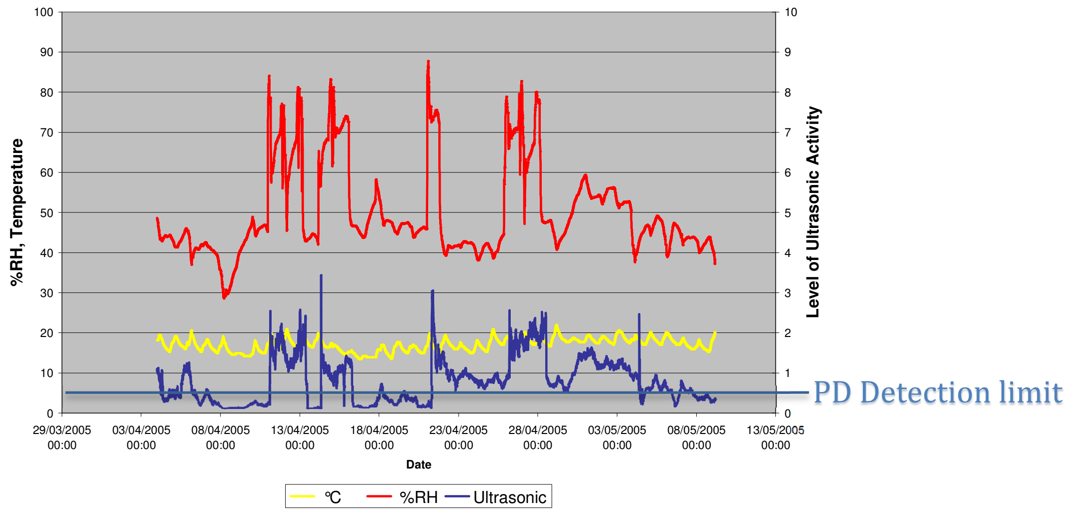
In a perfect world, PD would be detectable under all conditions and measuring its amplitude would give a precise indication of its severity. Unfortunately this is not the case. For example, Ultrasonic signals from PD activity vary greatly with relative humidity and may even stop entirely despite there being significant insulation damage. Partial discharge is highly voltage dependant and switching events on feeders might affect the results at any given time. Carrying high load can lead to localized heating and resulting mechanical displacement which can affect PD.

The only reliable solution for these issues is to monitor in service, 24-7. If partial discharge is not occurring when the testing is done, the problem may go unnoticed until catastrophic failure occurs. Timeliness of detection is also greatly improved. An annual PD testing program can leave a fault undetected for a long time before the next scheduled survey.

Case Study

Testing was performed on an 11KV breaker commonly used in the UK. It was in service for approximately 15 years and then moved to the lab and energized under controlled conditions.

When the circuit breaker was first energized no partial discharge was measured using any instruments. The humidity level was increased and within 5 minutes partial discharge activity was measured at 30pC, increasing to 200pC after a further 30 minutes. TEV measurements recorded 14dBmV with a count rate of 679 (approximately 7 pulses per cycle) and the UltraTEV ultrasonic indicator light showed red – this ultrasonic indication was apparent at the 30pC discharge level.



Testing continued for the next 12 months and the discharge activity varied between zero and 800pC largely depending upon the ambient conditions. However, although there was correlation, there was no direct link between the magnitude of discharge activity in pC, the magnitude of ultrasonic noise and the percentage Relative Humidity (%RH) in the atmosphere. Sixteen months into the testing, the partial discharge activity had become audible so the circuit breaker was de-energized and the truck was racked out and inspected for signs of partial discharge activity, See below.

Despite this level of damage, when the relative humidity dropped to around 40% RH, ultrasonic activity and directly measured PD activity dropped to undetectable levels. If an offline test or online survey of this equipment was done on a low relative humidity day, this damage would go undetected.

With 24-7 monitoring, the next high humidity day would alert the operator to a problem going on.

Summary

In summary, setting up a program of regular partial discharge online and offline testing can provide a wealth of information and potentially prevent catastrophic failure. However, a full time monitoring system can provide the best information and the earliest indication of an impending issue.

Implementing a full coverage full time partial discharge monitor is not inexpensive but for critical medium voltage power systems, it can pay for itself when the first catastrophic failure and resulting outage are prevented.

A high quality monitoring system should include the following features

- Transient Earth Voltage, Ultrasonic, and Radio Frequency Current Transformer sensing for internal, surface, and cable PD
- Sufficient channels to provide front and rear, top and bottom sensing for large installations
- Simultaneous monitoring of all channels for precedence based fault location
- Remote reporting via SCADA, WEB, SMS as well as a local HMI.

- User configurable reporting and graphing as well as individually settable alarm points.
- Be backed by a company with the technical know-how to design, install, and commission the system and if desired, evaluate the data.