

Predictive Maintenance for Medium Voltage Switchgear above 4kV

Billions of dollars are spent each year on plant and electrical equipment maintenance. Typical maintenance statistics have shown that 80% of the equipment failures occur at a random basis and that they have not been predicted by testing and maintenance. One way to increase detections of future failures in medium voltage equipment is to use partial discharge measurements.

Wikipedia defines partial discharge as a localized dielectric breakdown of a small portion of a solid or fluid electrical insulation system under high voltage stress, which does not bridge the space between two conductors. While a corona discharge is usually revealed by a relatively steady glow or brush discharge in air, partial discharges within solid insulation system are not visible.

PD can occur in a gaseous, liquid, or solid insulating medium. It often starts within gas voids, such as voids in solid epoxy insulation or bubbles in transformer oil. Protracted partial discharge can erode solid insulation and eventually lead to breakdown of insulation measurements. This article will focus on PD in medium voltage switchgear rated equal or greater than 4,000 volts.

The traditional approach to PD is to make periodic (one to four times per year) measurements. Unfortunately, many of the problems occur within a much shorter period of time. Another problem is that if a problem is detected, no one will really know:

- How long has the problem been occurring?
- Is the insulation degradation accelerating or leveling off?
- How fast will the insulation continue to degrade?
- When should the equipment be taken out of service and the problem corrected?

Another issue with PD problems is that they are not always active when the tests are performed. Some of the PD problems are affected by:

- Temperature
- Humidity
- Voltage
- Loading

Performing routine periodic PD readings using testing organizations is expensive and time consuming. Well trained technicians or engineers are required to analyze the results.

Continuous monitoring of PD activity is a much more effective way to monitor the condition of the medium voltage equipment. This method avoids the problems stated above. The advantages include:

- The problems are found early and located quickly. The monitoring device will

- detect which cubicle and phase the problem is located in. This greatly reduces the equipment downtime and labor to locate the problem.
- The monitors are also capable of determining what type of problem is detected. These include:
 - Corona
 - Void types of defects such as insulation delamination or voids in epoxy potential transformers.
 - Loose or corroded arcing connections
 - Conductive tape deterioration
 - PD monitoring will reduce equipment downtime and unnecessary maintenance because the monitor is continually testing, storing the results and creating a history of equipment condition. The equipment does not need to be taken out of service to perform the measurements and tests.
 - The data collected by the PD monitor is more accurate because it is making the measurements during real operating conditions. The effects of loading, humidity and other factors are taken being recorded.
 - The monitor allows the user to program different levels of alarms for various types of problems.
 - The monitoring system will reduce forced outages and increase system reliability and the overall safety of personnel.

Several systems are currently on the market but they all have similar features. The system uses Radio Frequency Voltage Sensors (RFVS), Radio Frequency Current Transformers (RFCT), and RTDs,

Some types of cables can also be monitored using PD tests. Unfortunately the type of cable used will determine the overall effectiveness. All though it can be done, PILC cables are more difficult. The length of the cable that can be monitored is a function of the type of cable and design. The following are the typical lengths that can be monitored.

- PILC, XLPE and HMWPE – 1,000 to 1,500 feet
- EPR – 300 feet

Summary

This paper has presented the advantages and features of PD continuous monitoring systems. A continuous monitoring system can save the owner money and time. These systems will increase the equipment protection and reliability. By continually monitoring and storing the test results, temperature, humidity, and loading information, accurate trending can be created. This will allow the owner to make more accurate and informed decisions on when the equipment will need to be taken out of service and repaired. Some of the advantages of a continuous PD monitoring system include:

- No labor is required to conduct the tests
- The tests are performed while the equipment is energized and under real loading conditions.
- Problems are detected quickly.
- Problems are located faster by showing the user which cubicle and phase has the

- problem.
- Unnecessary maintenance tests are avoided due to the fact that the monitoring system is performing tests 24/7.
 - The test results are stored making it very easy to perform trending and determine (1) when the problem started and (2) is the problem getting worse.

About the Author

Bob Fuhr graduated with a B.S.E.E. from the University of Wisconsin in 1980. Before graduating, Mr. Fuhr worked for Madison Gas and Electric in Madison, WI and Tennessee Valley Authority in Knoxville, TN.

After graduation, he worked for General Electric Company from 1980 to 1986 as a Field Engineer performing commissioning and start up tests on a multitude of power distribution equipment.

From 1986 to 1989 he worked as a Senior Facilities Engineer at the University of Washington. There he re-commissioned the electrical power distribution system for University Hospital.

In 1986, he established Power Systems Engineering (now called PowerStudies, Inc.); a consulting firm that specializes in power systems studies, power quality services, and commissioning services. He also teaches classes in electrical safety, short circuit calculation, protective device coordination, arc flash hazard assessment, power factor correction, and harmonics and filter design.

Mr. Fuhr has Professional Engineer Licenses in the following States and Provinces: Alaska, Arizona, California, Colorado, Delaware, Florida, Hawaii, Idaho, Nevada, New Mexico, New York, New Jersey, Maryland, Oregon, Pennsylvania, Washington, and British Columbia.

Bob has been involved in IEEE and the Industrial Applications Society since 1986. He has served as an officer for IAS from 1988 to 1992. He was the 1991-92 Chairperson of IAS. He was a Member-at-large for the Seattle Section of IEEE for 1992-93. He is an IEEE Senior Member. He is also member of the Electric League of the Pacific Northwest.