PARTIAL DISCHARGE MECHANISM

Partial Discharge prevention and detection are essential to insure reliable, long-term operation of high voltage equipment.

Partial Discharge (PD) generally begins within voids, cracks, at conductor-dielectric interfaces within a solid insulation system, or in bubbles within liquid dielectrics. Since discharges are limited to only a portion of the insulation, the discharges only partially bridge the distance between electrodes. PD can also occur along the boundary between different insulating materials.

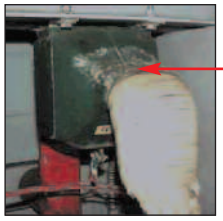
Partial discharges within an insulating material are usually initiated within gas-filled voids within the dielectric. Because the dielectric constant of the void is considerably less than the surrounding dielectric, the electric field (and the voltage stress) appearing across the void is significantly higher than across an equivalent distance of dielectric. If the voltage stress across the void is increased above the corona inception voltage (CIV) for the gas within the void, then PD activity will start within the void.

Once begun, PD causes progressive deterioration of insulating materials, ultimately leading to electrical breakdown. PD can be prevented through careful design and material selection. In critical high voltage equipment, the integrity of the insulation is confirmed using PD detection equipment during the manufacturing stage as well as periodically through the equipment's useful life using On-Line Partial Discharge surveys.

PD prevention and detection are essential to insure reliable, long-term operation of high voltage equipment as used by high voltage clients such as airports/refineries/industry/ and network operators. i.e. any client that cannot afford an unplanned outage.

Examples of PD found in switchgear while in-service

Bus-bar clamp that was tracking (Due to pollution caused by an unrelated fire in a cable trench within the same substation)



Discharge path

Rear view of a current transformer

CASE STUDY

Background

A network operator experienced random, insulation-based, switchgear failures over a 10-year period. The primary cause of the failures was surface tracking caused by the dirty environment and a change in maintenance practices.

Though the customer did not share specifics, it indicated the lost productivity figures – in terms of dollars – were significant. The nature of the operation and the design of the switchgear basically preclude even more traditional forms of insulation testing. Thus, the customer was particularly vulnerable to unplanned outages.

Problem

How to ascertain (while on-line and without loss of productivity) the insulation integrity of the switchgear in order to avoid a forced outage?

SOLUTION

The customer used regular On-Line Partial Discharge surveys [conducted by High Voltage Solution Ltd (HVS)] to monitor all switchgear on a 2 yearly cycle. The detailed report graded each substation to provide the client with the following information:

1. Identified problems within each substation.
   (Was it a bus chamber problem/feeder/VT/cable termination problem, etc?)
2. Report on each feeder concerned.
   Showing levels of discharge if these were present and a rating is applied.) This allows the client to plan the order of repairs based upon the rating provided.
3. By revisiting the substations every 2 years, HVS was also able to check the substations that had maintenance work carried out to ensure the work that was done did, in fact, correct the discharge problem.
   (In some cases the problem was not corrected due to misunderstanding. It is important that the report HVS prepare giving recommendations on how to carry out repairs gets to the field staff, rather than being a general instruction).
   Example: Please service Circuit Breaker.
   Servicing a circuit breaker and correcting a Partial Discharge problem is completely different to normal maintenance procedures and requires experience in this area.
   Again, HVS can provide on-site training to staff to show them where to look/how to repair or replace the faulty part, depending upon degree of damage that has occurred.
4. The report is provided in Excel format to allow for other fields to be entered (rather than a specific program that prevents this)

By approaching the problem in this manner it allowed for:

- No more substation/feeder failures
- Able to target substations that needed more work than others
- Able to bring in the right resource to attend to specfic problems
- Allowed ***one*** planned shutdown to be organized in conjunction with other work on the same feeder, without having to negotiate a "second" shutdown to clients.
- Where it was deemed not economical to repair switchgear due to age/fault clearing capacity/nature/level of partial discharge, a proper financial case can be prepared in advance (for director approval etc), rather than having an unplanned expenditure.

CONCLUSIONS

Using On-Line Partial Discharge surveys will provide partial discharge information while the switchgear is energized. More importantly, it monitors the insulation condition of the main bus. Typically, the only way to examine the main bus properly is to take a complete outage.

Conducting a visual inspection of the main bus requires both an outage and major disassembly. Using regular On-Line Partial Discharge surveys, the customer will always know the status of his equipment's insulation without having to take an outage. Thus, productivity is maximized while knowledge of the conditions that can lead to a forced outage is also maximized.

Levels (magnitude and pulse rate) of partial discharge are a well known indicator of insulation quality and can provide information as to the expected life of the switchgear.

The measurements will also allow the customer to plan an outage; he can order spare parts and allocate manpower in advance.