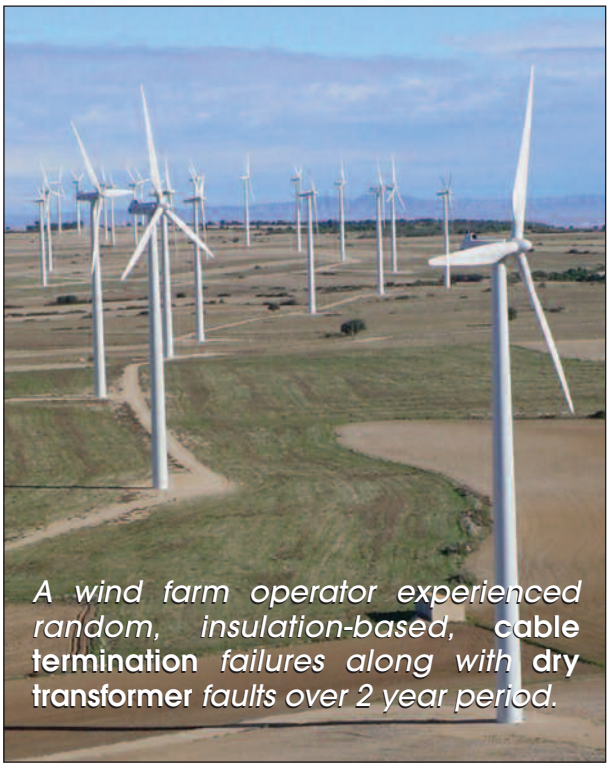
IMPROVING WIND FARM RELIABILITY using on-line partial discharge



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.

DIELECTRIC CONSTANT OF THE VOID

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.

WIND FARM MAINTENANCE

Wind Farms are relatively new which means in regard to maintenance, the asset owner needs to think outside the square. The nature of the design of the installation basically precludes even more traditional forms of insulation testing. Thus, the customer is particularly vulnerable to unplanned outages.

CASE STUDY

Background

A wind farm operator experienced random, insulation-based, cable termination failures along with dry transformer faults over a 2 year period.

Problem

How to ascertain (while on-line and without loss of productivity) the insulation integrity of the Strings and Dry transformers in order to avoid a forced outage.

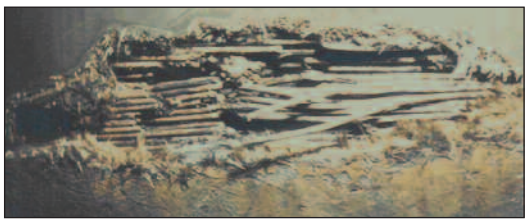
Dealing with Cable Strings

In wind farms the cables from the main substation are connected in *strings* where at least 5 wind turbines are connected in series. When a cable fault occurs, it affects that entire *string*. By using On-Line Partial Discharge it is possible to determine which *string* and where within the *string* a potential fault is developing. Once located repairs can be planned at the next outage thus ensuring increased reliability.

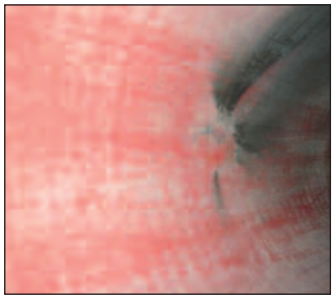
Dealing with the Dry Transformer

At the base of each wind turbine a step up Dry type transformer is installed. The problem is that most transformers are located adjacent to the access service door where the transformer is exposed to dust and dirt – a difficult problem to overcome. It was not surprising therefore, to discover that the primary cause of the failures was surface tracking caused by the dirty environment which required a change in maintenance practices.

Though the customer did not share specifics, it indicated the lost productivity figures – in terms of dollars – were significant.



Example of a failed dry type transformer winding



Winding of a dry type transformer destroyed by winding short due to PD.

By using state-of-the-art Partial Discharge testing equipment it is possible to selectively determine which dry transformer should be taken out of service for inspection / maintenance prior to a serious problem leading to an outage.

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UNPLANNED OUTAGE SOLUTION

In this instance, the customer used regular On-Line Partial Discharge surveys undertaken by High Voltage Solution (HVS) to monitor all cables / switchgear and cables (22kV) on a 3 yearly cycle. The detailed report graded each wind turbine dry transformer / section of *string* and SF_6 termination providing the client with the following information:

1. Identified problems within each wind turbine dry transformer i.e. which coil the maintenance crew needed to look at more closely. (Loose laminations / coil packing over compressed / excess build up of dirt between the internal primary – secondary windings etc.

2. Report on each *string* concerned. (Showing levels of discharge where present). A rating is applied that allows the client to plan the order of repairs based upon the rating provided.

3. Report on each HV termination concerned i.e. on the dry transformer and SF_6 circuit breaker. (Showing levels of discharge where present) and a rating is applied that allows the client to plan the order of repairs based upon the rating provided.

4. By re-visiting the substations every 3 years, HVS was also able to revisit the wind turbines 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 prepared report giving recommendations on how to carry out repairs gets to the field staff.)

5 Correcting a Partial Discharge problem requires experience in this area. Again, HVS can provide on-site training to your staff to show them where to look and/or how to repair or replace faulty part (depending upon degree of damage that has occurred).

6. The report is provided in Excel that allows for further data fields to be entered and also allows the report to be easily inputted into other dedicated asset management systems.

By approaching the problem in this manner it allowed for:

1. Targeted maintenance within a complex string of wind turbines.
2. Able to target which dry transformer needed more work than others.
3. Able to bring in the right resource to attend to specfic problems.
4. Allowed ***one*** planned shutdown to be organized in conjunction with other work on the same feeder, without having to readvertise a second shutdown to clients.

CONCLUSIONS

Using On-Line Partial Discharge surveys will provide partial discharge information while the wind farm is energized. Typically, the only way to examine insulation is to have a complete outage.

Using regular On-Line Partial Discharge surveys enables the customer to 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 insulation.

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