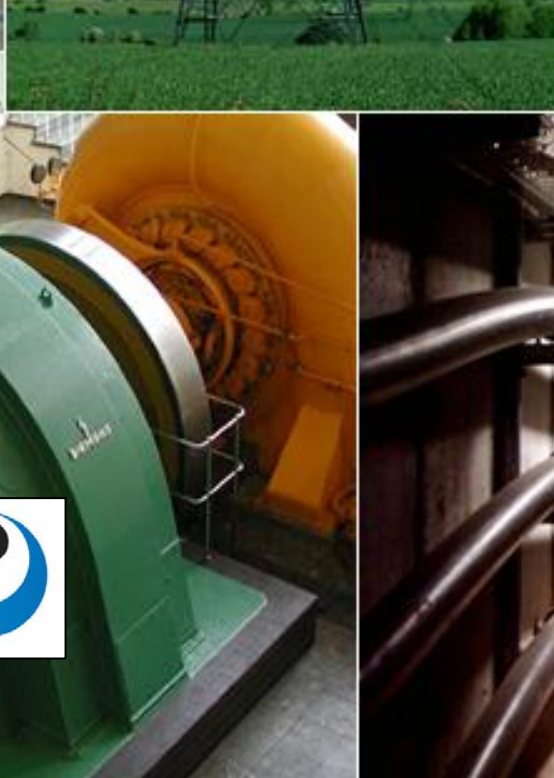


PD Diagnostic Applications and TechImp solutions

Condition Assessment Solutions for Electrical Systems.

PD based innovative tools for
the Condition Based Maintenance.

MD-04.05.004 - rev. 00 - 29/08/2006



TECHIMP
SYSTEMS S.R.L.

High Voltage Cable Systems



PD highlights the presence of several types of on-going local degradation processes.

- For **Extruded Cables**, the presence of PD within the cable system is to be avoided, in fact most of the internal activities within polymeric insulation systems lead to electrical treeing formation and, therefore, to failure.

- **Oil-filled Cables** can better withstand PD activities, but several failures have been reported, particularly in accessories, which might have presented a great deal of partial discharge causing accelerated degradation processes.

Noise rejection. In any case, for an effective diagnosis, it is vital to distinguish between PD internal to the cable system and external PD phenomena (disturbances or noise).

In-Factory Quality Control

Quality control PD tests in factory are nowadays a well assessed practice to make sure that the cable and/or accessory is not affected by manufacturing imperfections.

After Laying tests & Condition Assessment tests

After laying tests (voltage and PD tests carried out through e.g. a variable frequency mobile resonant test set) can be considered an effective quality control test of cable system installation. In fact, particularly for accessories, which are assembled on site, PD tests can highlight the presence of installation mistakes, as well as transportation or laying damages. The same type of test can be carried out again after some time to check for the possible inception of local degradation mechanisms.

- Off-line tests are particularly effective because of the high performances in terms of measurement sensitivity, noise rejection capabilities, and possibility to test at voltage higher than the rated one and a single phase at a time.

- On-line tests are feasible as well, provided that appropriate sensors are employed. These tests are particularly interesting since they can spotlight partial discharge behaviour at different loading (i.e. cable temperature) conditions.

Source Location. Several techniques are associated with PD detection to derive information about the position of the possible partial discharge source, so that the defect can be localized and removed.

Short length Cables. If the cable length is not too long, measurements from terminations can allow a complete picture of the cable conditions to be derived.

On-line Monitoring

Trending of PD phenomena during cable system life can be a very effective method to keep the degradation processes under observation and control, particularly if also quantities other than PD are monitored as well (e.g. temperature, current), so that correlation of PD possible inceptions with load and thermal cycling can be derived.

Sensors

There are several ways to derive PD signals from a cable system, mainly: external inductive sensors, external capacitive sensors, built-in capacitive sensors (embedded capacitive taps). Several methods have been devised in order to achieve PD measurements free of noise. Most of them are tailored for specific applications and fail in the presence of unusual disturbances.

PDBase acquisition philosophy provides efficient noise rejection in most cases without adding any hardware filter or suppression device.

As a matter of fact, noise signals have been observed to be very different from PD signals; therefore the classification system of PDBase succeeds in separating the contributions of PD and disturbances.

In the following an example of noise rejection is reported.

Motors & Generators



PD assessment is an accepted practice to evaluate rotating machine conditions.

The presence of PD in organic insulation systems calls for immediate maintenance actions. For inorganic insulation systems, instead, it is fundamental to distinguish among the different categories of PD. In fact, machines will have a different withstanding degree to different PD degradation mechanisms. In this case, therefore, the recognition of the type of PD source is vital to be able to support properly maintenance actions and planning. In any case, it is always fundamental to be able to get rid of all the signals relevant to noise and disturbances.

When dealing with motors fed by PWM systems, PD detection is an issue than can be faced by appropriate noise rejection devices.

In-Factory Quality Control

Quality control PD tests in factory can be a very effective tool to test the quality of VPI impregnation processes, as well as of manufacturing processes of the single bars or coils (resin-rich technique). It is always a good practice to characterize the PD behaviour of a new machine in factory, also to be able to compare the results obtained on site after some time with this fundamental reference. Statistical databases can be developed aimed at checking production quality and typical flaws.

Off-line and on-line PD tests

- On-line PD monitoring or periodic assessment is commonly accepted as an effective method to check for the possible presence of localized degradation mechanisms and to evaluate their evolution with time. Correlation with the main operation parameters (e.g. load, voltage, ecc.) and with the response from other monitoring systems (e.g., ozone and vibration monitoring) can be exploited to improve diagnosis and to develop maintenance strategies.

- Off-line periodic assessments are often used for a deep machine analysis. This kind of test is generally more accurate than an on-line one, but it must be emphasized that the testing conditions may vary with respect to those of an on-line test. In fact, some degradation mechanisms can be active just while the machine is under the real operating conditions (mainly those related to vibration or load). When feasible, visual inspection can be carried out to reinforce diagnosis.

Sensors

Typically, the rotating machine is equipped with external capacitive couplers to derive PD and synchronization signals in order to enable on-line investigations. In alternative, High Frequency Current Transformers (HFCT) can be connected to the cable grounding leads or the grounding leads of the machine itself.

Primary & Secondary Distribution Networks MV Switchgears



PD activity in Medium Voltage Switchgears (both gas and air insulated), cables, transformers and other equipments which constitute a power distribution system can be originated at cable accessories, at bushings and post-insulators due to conductive pollution, at gas-insulated lines/switchgears due to, e.g., loose connections and SF6 leakages or floating metal particles, at cast resin transformers due to bad impregnation, at oil-filled transformers, etc..

In-Factory Quality Control

Quality control PD tests in factory can be a very effective tool to test the quality of impregnation processes, as well as of manufacturing processes and can be mandatory for some of the sub-components (resin insulators, voltage and current transformers).

Off-line and on-line PD tests

- On-line PD monitoring or periodic assessment is commonly accepted as an effective method to check for the possible presence of localized degradation mechanisms and to evaluate their evolution with time and correlation with the other main operation parameters (e.g. load). For complete distribution systems, PD source identification and localization may require a comprehensive investigation (i.e., testing at different sites, using different sensors as, e.g., antennae and acoustic detectors, etc.)

Sensors

Typically, dividers used for voltage detection in switchgears can be used. In alternative, High Frequency Current Transformers (HFCT) can be connected to the cable grounding leads or other grounding connections, finally Capacitive Couplers can be installed in the switchgears to derive both PD and synchronization signals. Corona PD and PD on bushing creepage surfaces can be possibly detected and localized through acoustic sensors.

Power & Instrument Transformers



Oil filled transformers are inherently affected by PD phenomena. For this equipment it is of primary importance to distinguish between discharges in oil and discharges affecting paper and pressboard. The latter, in fact, may lead to a fast degradation process and, possibly, breakdown. A combined use of DGA, humidity and temperature monitoring and PD analysis can lead to a thorough overview of transformer conditions.

Cast Resin transformers should be free of PD, since the presence of PD can indicate bad impregnation and/or the existence of heavy degradation processes.

In-Factory Quality Control

Transformers are generally tested in factory for PD at the end of the manufacturing process. In the provision of checking transformer conditions during the asset life, the PD signature obtained at the beginning of the asset life might be considered necessary.

Off-line and on-line PD tests

- Off-line periodic assessments can be carried out to evaluate transformer behaviour in terms of PD. However, it is often difficult to provide a suitable mobile power source to carry out induced-voltage tests on large transformers. Moreover, the service interruption required to carry out an off-line investigation can be a problem for the asset manager.

- On-line PD monitoring or on-line periodic assessment is becoming a better alternative to off-line tests. The combined use of different monitoring systems (e.g. PD, DGA, current, temperature etc...) allows a complete and reliable picture of the transformer conditions to be derived and observed over time.

Sensors

Typically, to perform measurements with adequate sensitivity, large power transformers are equipped with bushing taps from which both PD and synchronization signals can be derived. HFCT on grounding lead of cables connected to the transformers is an alternative. For single-phase measurement transformers inductive sensors wrapped around the grounding leads of the transformers, as well as capacitive couplers installed around the metallic support poles, can be used as PD sensors.

HV outdoor insulators for overhead lines



PD can be a fundamental tool to assess the pollution condition of HV overhead insulators. Especially in salt-humid climates and polluted areas, insulators must be cleaned from time to time to avoid flashovers. Usually this operation is carried out at fixed time intervals and is very expensive. By monitoring the PD activity in the insulators it is possible to assess the pollution level of the insulators, and hence determine the right moment for washing, thus allowing the utility to plan a condition based maintenance procedure.

On-line monitoring aimed at trending PD features related to insulator pollution can alert the asset manager about the need to carry out the cleaning activity.

TechImp Solutions for PD Diagnosis

Electrical system/apparatus	Application	TechImp Solution
HV Cable Systems	Quality control	PDBase (with automatic GO/NO_GO tool)
	On site (on/off-line) measurement service	TechImp portable systems and accessories
	On-line monitoring	<i>Distributed monitoring system based on PDscope set, which is installed on each joint/terminal bay. All PDscopes are connected together through an Ethernet systems which allows also a full remote control of the monitoring system</i>
Motors & Generators	Quality control	PDBase (with automatic GO/NO_GO tool)
	On site (on/off-line) measurement service	TechImp portable systems and accessories
	On-line monitoring	PDcheck or PDASD for machines fed by frequency drives
Medium Voltage Switchgears (GIS, AIS) Distribution networks	Quality control	PDBase (with automatic GO/NO_GO tool)
	On site (on/off-line) measurement service	TechImp portable systems and accessories
	On-line monitoring	PDscope based monitoring systems
High Voltage Switchgears (GIS)	Quality control	PDBase (with automatic GO/NO_GO tool)
	On site (on/off-line) measurement service	TechImp portable systems and accessories
	On-line monitoring	PDpeak or PDcheck
Power & Instrument Transformers	Quality control	PDBase (with automatic GO/NO_GO tool)
	On site (on/off-line) measurement service	TechImp portable systems and accessories
	On-line monitoring	PDcheck (possibly integrated with DGA tool)
Overhead Insulators	On-line monitoring for pollution assessment	<i>Stand-alone set based on the PDcheck with solar cell and GSM communication facilities for remote control</i>