HV Cables
Testing & Monitoring

Take advantage of Techimp GLOBAL Monitoring System “diagnostics all in one”
Introduction

The measurement of Partial Discharges (PD) can be a fundamental tool to evaluate the “state of health” of HV Cable Systems.

PD measurements highlight and localize on-going degradation processes that could lead to the damage of the electrical apparatus insulation and, unavoidably, to sudden breakdowns.

PD measurement analysis and consequent diagnosis allow Condition Based Maintenance (CBM) program and best practices to be set up.

Electrical asset state is usually checked by submitting them to Time Based Maintenance (TBM) programs, carried out at fixed intervals. However, for the most critical equipments, a Condition Based Maintenance (CBM) program is much more advisable. Applying a CBM program means keeping the electrical state of the equipment under continuous control. Potential sources of problems are detected at a very early stage, allowing relevant countermeasures to be taken before harmful and irreversible events happen. By means of CBM, failure rate can be kept at a constant level chosen by the asset manager. Therefore, unexpected breakdowns, causing long forced stops, can be avoided, thus limiting infrastructure maintenance costs due to loss of revenues and repair after failure.

As a matter of fact, Techimp monitoring systems represent the ideal and ultimate solution for the CBM of electrical apparatus.
For **Extruded Polymeric Cables**, the presence of PD within a cable system is to be avoided, because PD activity within polymeric insulation systems can lead quickly to electrical treeing formation and, eventually, to failure.

**Oil-filled Cables** can better withstand PD activities, but several failures have been reported, particularly in accessories, which have been associated with PD activity.

Although PD are one of the major failure causes of cables and accessories, a complete and modern cable diagnostic system must give solutions also for **tan-delta** monitoring, in order to cover other possible degradation agents like watertrees. Techimp provides a proprietary and innovative solution for tan-delta measurement, integrated with PD monitoring for a better diagnostic coverage at lower Customer costs.

Techimp Systems has now moved further on the edge of the technical excellence and innovation in diagnostics applied to cable applications, by developing the first **PD-DTS** (Distributed Temperature Sensing) integrated system exploiting fiber optics and PD sensors to monitor temperature and discharges along a cable, and integrating RTTR (Real Time thermal Rating) and PD in a unique system, representing the ideal solution for **Global Power Cable and Transmission Line Monitoring**.

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**Techimp Services provides asset managers with high-value added services to enhance the effectiveness of maintenance operation of power apparatus, establishing CBM policies.**

- ✓ Commissioning of new installations to secure that the assembly work has been carried out properly and to take reference PD fingerprints;
- ✓ Uncertainty on a critical/important asset condition;
- ✓ Decision making on equipment replacement;
- ✓ Repeated failures of a specific equipment type/model/technology;
- ✓ Scheduled outage of a plant;
- ✓ Evaluation of ageing and residual life extension.

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**A worldwide experience:**

300 and more commissioning, assessments and PD testing services carried out over the last 4 years
Techimp monitoring system layout and installation

The **on line PD monitoring system** is made up essentially of the following components:

- Sensors (one for each joint/terminal);
- PD detection unit: PDScope (one for each set of joints/terminals);
- Supervision & Control System (one for each complete circuit);
- Ethernet links between the PD detection units and the Supervision & Control System.

Sensors should be installed in proximity of each cable accessory, i.e. terminations and joints of each phase, depending on cable length. In case the cable is provided with **embedded sensors** (capacitive taps), this devices can be used for PD detection purposes. Whenever the cable is not provided with embedded sensors, Techimp can provide special **external sensors (HFCT or FMC)**, which can be easily installed, in proximity of the joint or termination, with a suitable protection against mechanical stress and water ingress.

Each PD detection unit is provided with 3 input channels, therefore it can detect PD signals from the sensors installed onto a set of joints or terminations, keeping the three phases under control. The unit is also provided with another input channel for the power frequency reference (synchronisation).

The overall power consumption of the equipment installed in each bay is extremely low. Whenever, for technical or economical reasons, it is not convenient to provide and lay down a LV power distribution cable, each joint/terminal bay can be easily equipped with:

- a pole mounted small solar photovoltaic panel (approx. 0.25 m²) and the relevant battery and charger;
- a **Techimp PPS (Permanent Power Supply)**, which gets the required energy from the Hi-Voltage power line under test by means of a toroidal unit clamped on the power cable.

Other customised solutions are available on request.
Connectivity & data management

All the monitoring units installed along the cable route form a Local Area Network and are connected together by means of a redundant Ethernet fibre optic link (suitably protected from mechanical and environmental stresses). The data stream from all units is conveyed to a SCADA (Supervisory Control And Data Acquisition) system, aimed at extracting relevant information to assess cable condition. PD data are stored in and managed by a built-in Database, which enables the system to carry out a real-time diagnosis and give alarms in case PD parameters go beyond the set thresholds.

The software has a user-friendly graphic interface, which enables the user to set parameters, trigger levels, alarms and visualise the situation in a mimic diagram in which all joints and terminations along the cable route are represented.

In case a potentially harmful defect is detected, the system management software in the control room will show and displace alerts. A special tool for the PD source location available in the PDCheck software, based on the amplitude/frequency analysis and time domain reflectometry, can be then used.

Furthermore, the system also has a remote communication facility, so that even if the substation is unmanned, the system can be easily managed via the internet.

In such a way, the team of expert analysts from the Techimp head office, can retrieve data, analyse them and provide the circuit owner with a periodic report with the assessment of the whole circuit.

Techimp Assets & Services

Techimp support to Customer:

- Data analysis service
- Supervision of PDM system
- Warning alert customization
- Database for all asset components

Techimp Asset Database, Your asset at a glance:

- Data management
- EUT and detection management
- Systems parts inventory
- Sensors system configurations and detection
- Identification and classification management
- Advanced query
Techimp off-line cable testing

After laying tests (voltage and PD tests carried out through e.g. a 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 installation faults, as well as damages due to transportation or inaccurate laying. The same test can be carried out again after some time to check the possible inception of local degradation mechanisms.
Off-line tests are particularly effective because of high measurement sensitivity, low noise level, and possibility to test at voltage higher than the rated one and a single phase at a time.

Source Location
Several techniques (e.g. simultaneous measurements) 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 (e.g. 1 or 2 Km), measurements from one termination only (or both terminations) can allow a complete picture of the cable conditions to be derived.

Measurement configuration
The working setup of an HV cable system is different from the test configuration needed during off-line PD test, when only one phase at a time can be tested.
Techimp offers a wide range of proven measurement configurations (provision of Resonant Test Set included) in order to achieve the best measurement performance even in complex setups.
**Four steps to get the answer**

**Techimp Services** provides diagnostic assessment for cables systems, applying ultimate diagnostic technologies. In particular, Techimp is a leading world company for Partial Discharge (PD) technology. PD detection and analysis is a fundamental tool to assess the condition of Electrical Systems which allows CBM practices to be established.

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**Four steps to get the answer**

The process to get the diagnosis for a Cable can be summarised in four steps.

1. **contact**: in this stage the customer and Techimp discuss about the technical characteristics of the site and the equipment to be submitted to diagnostic investigation.

2. **planning**: Techimp Services engineers analyse the technical aspects and share with the Customer a diagnostic action plan.

3. **service**: Techimp Services sets up and implement on-site testing based on Techimp technology.

4. **reporting**: Data analysis and reporting are issued by Techimp with clear indication of the asset status, the required maintenance activity and prevention actions to be taken.
Techimp provides a complete solution for electrical subsystems representing the utmost state of the art of the technology commercially available. Techimp technology is based on global monitoring unit PDCheck, with Sensors and accessories covering all the possible ranges of applications and measurements for HVAC cables.

**Techimp PDCheck** (patented) is the ultimate solution for industrial monitoring; it is a compact, stand alone and portable global diagnostic system for the condition assessment of medium and high voltage electrical systems.

Techimp provides PDCheck with the most advanced software tools for noise rejection and PD data analysis and Identification. These tools are based upon the **SID (Separation, Identification, Diagnosis)** strategy, which allows noise and disturbance rejection, PD source separation and identification, risk assessment to be achieved.

Techimp technology enables Partial Discharge (PD) phenomena to be classified on the basis of TF map* and statistical indicators, so that further analysis can be carried out on each dataset, separately, by artificial intelligence techniques. This enhances the likelihood of PD source identification, even for non skilled operators.
Sensors

**Techimp Clamp HFCT** *(High Frequency Current Transformer)* is an inductive sensor for partial discharge measurements. One of the main advantage of the Clamp HFCT is that it can be clamped on the cable to be tested without disconnecting it.

**Techimp FMC** *(Flexible Magnetic Coupler)* is a partial discharge sensor whose working principle is based on a direct magnetic coupling with the cable conductor and shield. His compact and robust design (passive sensor) make the FMC the optimal sensor for direct installation on cables.

**Techimp derivation box** allows (permanently or temporarily) an acquisition unit to be connected to sensors permanently installed in an electrical system. The operator can connect the acquisition unit any time, on line, and carry out the measurements without any outage of the equipment to be tested.

Devices

**Techimp PD-DTS** Techimp Systems has now moved further on the edge of the technical excellence and innovation in diagnostics applied to cable applications, by developing the first **PD-DTS** *(Distributed Temperature Sensing)* integrated system exploiting fiber optics and PD sensors to monitor temperature and discharges along a cable, and integrating RTTR and PD in a unique powerful system.

**Techimp ***(tan delta)* system is composed by the following sub-units:

- **Current Sensor**: Current Capacitive sensor, installed upon the monitored asset.
- **Voltage sensor**: installed upon the monitored asset.
- **Current Unbalance and Monitoring unit**: is the pre-processing unit with multiple functionalities: signals conditioning from sensors, digital conversion, data communication and power management (Voltage regulation, power supply, battery recharge).
HV cables testing and quality control, Techimp PDBase II

Quality control and reliability assessment on electrical systems are essential requirements for power system apparatus. As a consequence, the demand of non-destructive diagnostic tests on electrical devices is constantly increasing.

Nowadays, digital systems for PD measurements permit diagnostic indications to be obtained about the insulating systems degradation. Various procedures are being developed in order to interpret PD data and providing diagnostic indicators related to each different type of insulating system. In order to apply artificial intelligence processing techniques, a selection of stochastic quantities is provided among the parameters that can be extracted from digital PD measurements.

**Techimp Quality Control system** has been designed purposely as a system able to collect a large number of PD pulses and separate them according to their waveform. In order to accomplish this task, the hardware is equipped with an ultra-wide band digitizer and integrated processing capabilities. Thanks to its fast sampling rate (200 MS/s) and its on-board processing capabilities, a very large number of digitized PD pulse waveforms are analyzed and pulse features are stored for a further processing leading to the final PD source identification.

**Techimp Quality Control system** is composed of a standard Techimp measurement instrument (**Techimp PDBase II**) together with a software dedicated to the end of line and factory quality control testing of high and medium voltage devices, such as cables, cables accessories, rotating machines, transformers etc.

**Techimp Quality Control system**

**PDsmartBRIDGE**

Techimp offers a special option expressly developed for measurements performed in noisy environments, denoted by severe electromagnetic pollution condition.

**PDsmartBRIDGE** option implements advanced filtering algorithms based on digital differential measurements, complying with the IEC 60270 frequency bandwith.

Hence, **PDsmartBRIDGE** ensures your PDBase best performances in any operating condition!
Localization tools

Localization of PD sources represents one of the most challenging tasks for the diagnostic procedure. Techimp PDCheck acquisition unit implements **multiple and powerful localization techniques**:

- **AFC**—Amplitude/Frequency characteristics of PD pulses
- **TDR**—Time Domain Reflectometry
- **ATA**—Arrival Time Analysis, GPS assisted (see picture)

All these techniques provide a complete and unrivaled set of tools giving the wider coverage for HV and MV cable monitoring applications and spot measurements.

ATA—Arrival Time Analysis, GPS assisted

It is based on arrival time analysis performed by simultaneous measurements.

On-line PD measurements on HV and MV cables provide key information regarding failure risk under operating conditions, but some technical problems shall be solved. First of all, an adequate voltage reference signal must be available in order to build up the (phase resolved) PD pattern and achieve an effective diagnostic. Moreover, PD source localization should be made available from online measurements, without the need of performing additional investigations.

The problems above can be solved by **time synchronized (TS)** measurements, i.e., measurements where PD arrival times are expressed in the same absolute time frame and where at least one unit is provided with a reference voltage signal.

The Global Positioning Systems (GPS) with its array of 24 satellites visible almost everywhere on our planet provides a convenient way, especially where synchronization by fiber optic link is unavailable (mainly in metropolitan areas), to achieve a time reference signal accurate to a few nanoseconds.

ATA technique is applicable for off-line measurements, as well.
Case Studies

**EUT: HV Cable, 8 joints and 2 terminations for each phase**

Insulation technology of terminations:
**EPR** stress cone immersed in oil

1. **First PD measurement Results:**
   - **PD activities detected** at one side terminations of yellow and blue phase

2. **Second PD measurement Results:**
   - Again **PD activities detected** at the same terminations of yellow and blue phase
   - Taken action: **replace terminations!!!**

3. **Third PD measurement Results:**
   - **PD FREE!!**
   - PD inference resulted to be effective:
     - during inspection a defect was found in the stress cone immersed in oil
Case Studies

a worldwide experience!
our vision

**Apparatus**
- Multiple subsystems
- Multiple failure modes

**Approach**
- One apparatus where multiple sensors provide information on any electrical apparatus
- Shrink monitoring costs
- Exploit synergies between information provided by different diagnostic techniques
- Enhance diagnostic capability and apparatus reliability
- Reduce overall maintenance costs
Headquarter & International Subsidiaries

Bologna | Abu Dhabi | Beijing | São Paulo | Buenos Aires