

Why partial discharge testing makes good sense – with the MPD 600

PD measurement and analysis have proven to be reliable for detecting defects in the insulation system of electrical assets before major damage or a breakdown occurs.

Introduction

The constant availability of medium- and high-voltage electrical assets used in the generation, transmission and distribution is important for a reliable power supply at both utilities and also industrial plants. These assets include generators and motors, instrument and power transformers, switchgear and power cables.

Research conducted by IEEE (IEEE Gold Book, Table 36) indicates that these assets experience the greatest losses from insulation failure. Insulation breakdown can lead to dangerous situations, severe damage and ultimately huge economic costs. Therefore it is crucial that insulation condition be verified throughout an asset's lifecycle.

Partial discharge (PD) is considered to be one of the major contributors to the degradation and failure of insulation systems in electrical assets.

This white paper aims to familiarize you with PD basics, including its consequences, how it is measured, and which criteria are important for selecting a PD measurement device. If you currently measure and analyze PD in your electrical assets, you are then already familiar with its importance to ensure asset availability.

Regardless of your experience level with PD testing, having the right PD measurement device is key to accurate detection in all types of testing environments. This paper provides you with eight beneficial reasons why hundreds of electrical equipment manufacturers, test engineers at utilities and industrial plants, as well as service providers all over the world have chosen the MPD 600 for their PD testing needs.

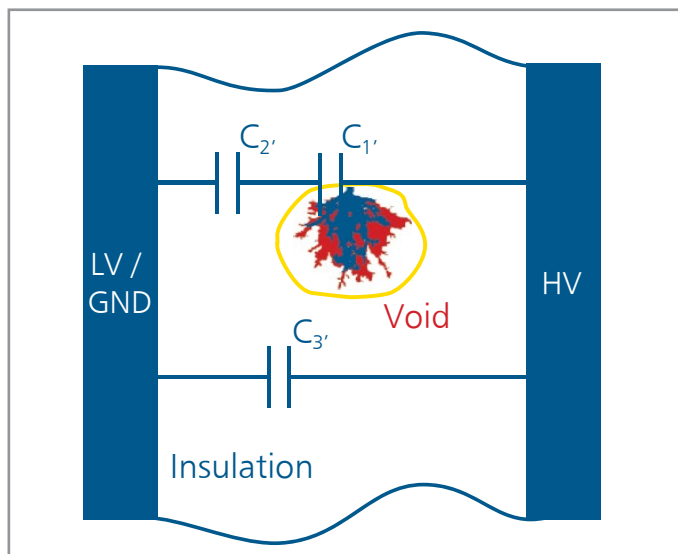
What is partial discharge?

According to the IEC 60270 standard, partial discharges are "localized electrical discharges that only partially bridge the insulation between conductors and which can or cannot occur adjacent to a conductor. Partial discharges are in general a consequence of local electrical stress concentrations in the insulation or on the surface of the insulation."

PD can occur in gaseous, liquid and solid insulating mediums used in assets that are subjected to high electrical fields. It can be initiated by voids, cracks, or inclusions within a solid dielectric, at interfaces within solid or liquid dielectrics, in bubbles within liquid dielectrics, or along the boundary of different insulation materials.



Exploded bushings due to aging insulation on a power transformer



PD occurs when the local electric field stress exceeds the local electrical strength. Here is an example of a void.

PD can cause progressive and irreversible damage to liquid and solid insulation systems. With time, PD activity becomes more intense and dangerous. The process of deterioration can propagate and develop until the insulation is unable to withstand the electrical stress, leading to a flashover.

Why measure PD?

PD measurement is a reliable and non-intrusive method that can be used anytime to diagnose the insulation condition of an electrical asset.

Compared with other dielectric diagnostic methods, PD measurement provides you with very sensitive information to help you to effectively detect localized weak points in the insulation system.

Because PD activity is often present well in advance of insulation failure, asset managers can assess it over time and make informed strategic decisions regarding the timely repair or replacement of the equipment before an unexpected outage occurs.

PD prevention and detection are therefore essential to ensure the reliable, long-term operation of your electrical equipment.

When should PD be measured?

The integrity of the insulation in MV and HV equipment should be confirmed with PD measurement and analysis during manufacturing, commissioning and, depending on the asset type, during the operation of electrical equipment so that it stays in good condition and is safe to operate.

The high amount of manual work at the manufacturing stage of an asset increases the likelihood of production errors that can lead to its premature failure. As a result, there is a disproportionately high percentage of insulation failures being observed within the first one to three years of service compared to the rest of the asset's working life. PD testing is therefore initially used for routine and factory acceptance testing to identify production quality issues.

After the asset leaves the manufacturer, improper handling during transport and installation can lead to internal mechanical damage. Off-line PD measurement is then often used to commission new equipment prior to energization as a final quality control check.

Once in operation, strategic decisions about maintenance must be made to ensure maximum asset availability. Periodic PD measurement and analysis provide you with the required data to develop an overall test plan that ensures focus on the right assets and minimizes unnecessary maintenance outages and costs.

The frequency of PD testing for in-service equipment is determined by the type and importance of the equipment and prior service experience.

"It is important for us to identify any developing PD defects early on, so that we can take the necessary corrective action."

James Hill, Chief Test Engineer
Seabank Power Station

How is PD measured?

The particular tests and test set-ups are determined by the type of asset being measured and by the standard to which the PD measurements are performed. For example, the IEC 60270 standard specifies how to perform an off-line PD measurement on electrical equipment using a separate voltage source, the PD measurement device, a coupling capacitor and measuring impedances.

For three-phase assets, PD measurements can either be performed off-line, by energizing each phase successively during standstill, or on-line during regular load service operation. You can perform single-phase measurements with the other phases grounded, or three-phase measurements to identify phase-to-phase activity.

PD pulses are of short duration and have rise times in the nanosecond range. The most important criteria for evaluating PD are:

- > Charge level, measured in either picocoulombs (pC) or nanocoulombs (nC)
- > Voltage magnitude, measured in mV
- > Pulse repetition rate

Should any of these criteria increase, so does the risk of insulation breakdown. PD limit values for electrical assets are defined in various international standards.

PD intensity is often displayed versus phase angle of the applied voltage in a Phase-Resolved Partial Discharge Diagram (PRPD). If available, advanced noise suppression techniques can be deployed in high-interference environments to minimize irrelevant data.

PD testing is performed on electrical assets to:

- > Verify the condition of the insulation
- > Detect critical defects and assess risk
- > Indicate the need for timely maintenance and repair
- > Determine the requirement for continuous PD monitoring

What are the measurement challenges?

Since signals emitted from PD activity may be of low magnitude, it is crucial to use highly sensitive PD measurement equipment. This however results in a higher susceptibility to interference from electronic noise. These conditions can render the detection and location of PD signals difficult or even impossible. The elimination of this interference where possible is therefore critical for successful PD detection.

Additionally, while some partial discharges can be extremely dangerous to the health of the insulation system, other types of PD may have a slower degradation effect. For example in rotating electrical machines (motors and generators), several different PD sources are present and active within the stator winding insulation at the same time.

These overlapping signal sources can be classified as either harmful PD, normal PD occurrences or external noise. So therefore, an additional criterion for successful PD diagnostic testing is to be able to separate and differentiate between different PD sources.



The integrity of the insulation should be confirmed with PD measurement and analysis at all stages of an asset's lifetime.



Noise from surrounding substation or electronic equipment can compromise the reliability of PD measurements.

What type of PD testing device do you need?

The PD testing instrument selected must be able to provide reliable measurements – even under the most demanding circumstances.

The measurement challenges described in the previous section can be overcome when the PD measurement device is able to measure PD with high sensitivity, identify external sources of interference and filter or suppress them where possible. The user should also be able to differentiate between multiple PD sources.

Lastly, since each type of electrical asset has its own PD measurement requirements, the chosen PD testing device should provide you with the modular flexibility to easily add components tailored to PD measurements on specific assets in various testing environments.

“The MPD 600 represents the third generation of our market-proven PD measuring technology based on years of customer experience in a number of industries.”

Ole Kessler, MPD 600 product manager

8 reasons why the MPD 600 system enhances PD testing

With its fully digital data processing and its advanced measurement and analysis tools, our MPD 600 is capable of separating even the smallest PD pulses from interference for the highest measurement accuracy. It ensures reliable and repeatable IEC 60270-compliant PD measurements in both test laboratories and in the field.

Thousands of MPD 600 PD measurement and analysis systems are already in use worldwide in the following areas:

- > Factory testing and production quality checks by major cable, transformer and rotating machine manufacturers
- > Regular assessments of insulation condition in industrial and utility applications
- > Research at laboratories and universities

Here are eight good reasons why:

1 Modular design for easy setup

The modular plug-and-play MPD 600 system enables fast and flexible setup for a variety of PD measurement applications. The system consists of a PD data acquisition unit, a USB controller and measurement and analysis software. You can easily add a variety of our PD measurement accessories to support diverse PD testing on various electrical assets, such as application-specific charge calibrators, measurement impedances and PD sensors.

In addition, one MPD 600 acquisition unit can be effortlessly combined with multiple other MPD 600 acquisition units for synchronous multi-channel PD measurements. It is currently the only system worldwide that records and analyzes the signals of all connected measurement points at the same time.



MPD 600 – Modular, plug-and-play design

2 Long battery life for uninterrupted testing

Each MPD 600 acquisition unit is powered by a rechargeable battery. Due to the low power consumption of the acquisition unit, an uninterrupted battery operation is ensured for more than 20 hours. This enables you to cover a complete day of testing without having to recharge the battery. Another advantage of the battery power supply is that it can be operated at high-voltage potential without being affected by disturbances which would normally result from a mains power supply.

3 Fiber optics for improved safety & sensitivity

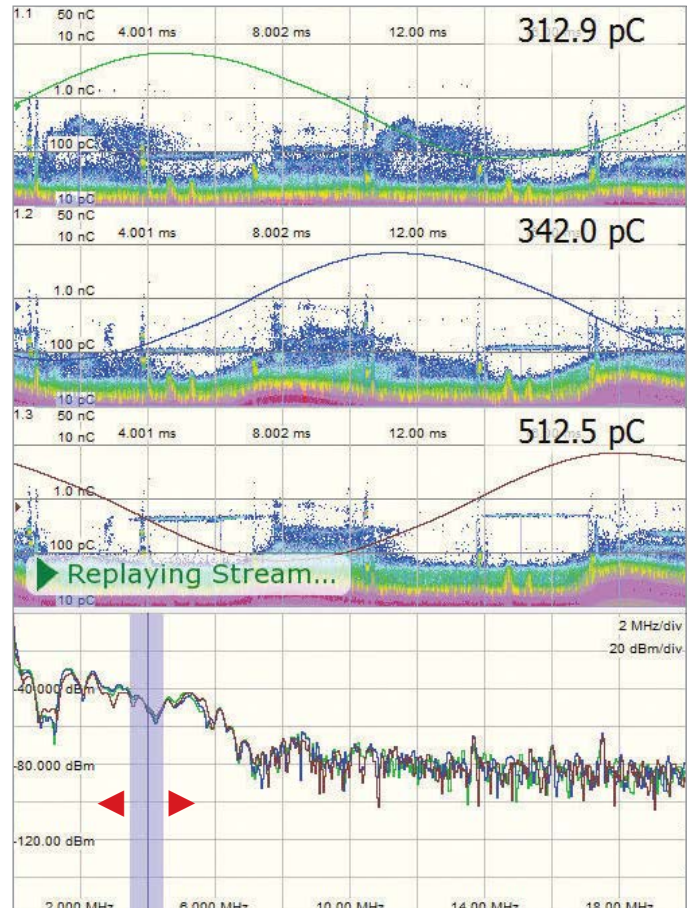
Fiber optic connections are used for the communication between each MPD 600 data acquisition unit and the PC/laptop controller to provide you with complete galvanic isolation. This not only protects you from high-voltage hazards, it also minimizes ground loops and therefore interference to achieve higher system sensitivity through the improved signal-to-noise ratio.

4 Adjustable frequencies for noise suppression

The MPD 600 PD measurement and analysis system offers several methods of electrical noise suppression in challenging on-site conditions. With freely-selectable filtering options, you can adjust the center frequency and bandwidth to achieve a high signal-to-noise ratio and low background noise level for reliable PD analysis.

A number of gating methods are available to effectively eliminate the effect of disturbances, such as:

- > **Amplitude-phase gating:** Signals with certain amplitude and fixed phase position are suppressed.
- > **Antenna gating:** Disturbance effects are eliminated by comparing measured events between an external gating unit (e.g. additional MPD 600) and the measurement unit.



Adjustable center frequency and bandwidth

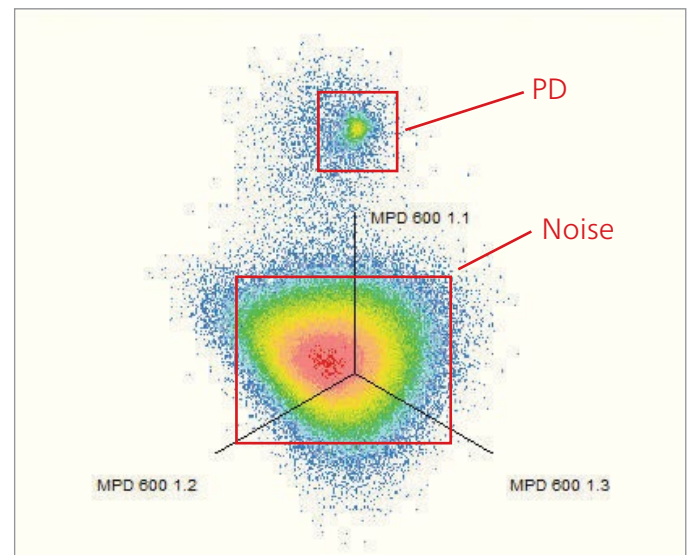
5 Synchronous multi-channel measurement for accurate PD source separation

When using three or more acquisition units, the MPD 600 ensures a fully digital, synchronous multi-channel PD measurement. This not only minimizes the time for which the test voltage has to be applied and speeds up measurement time, it also enables you to take advantage of our unique separation tools, such as 3PARD (3-Phase Amplitude Relation Diagram), to simplify the differentiation of various PD sources and interferences.

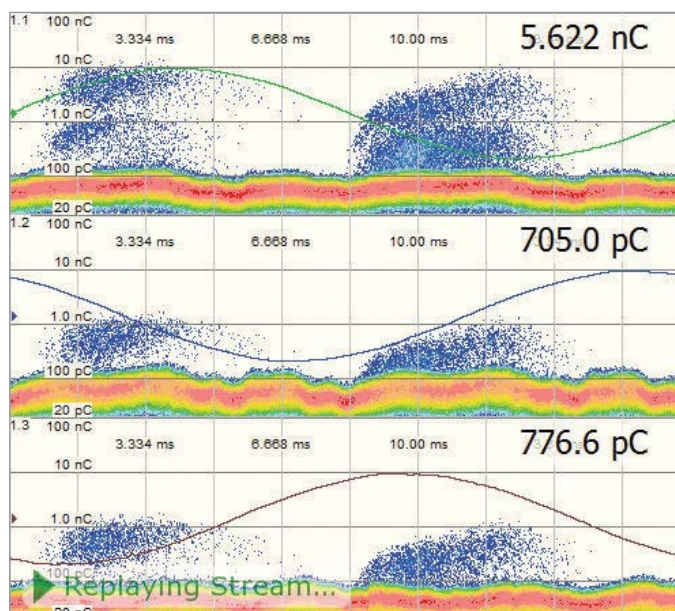
PD signals originating from sources of different type and/or location appear in different parts of the 3PARD and can be analyzed separately in real-time. This enables an effective de-noising as well as an easy separation of overlapping PD signals in the corresponding Phase Resolved Partial Discharge Diagram (PRPD). If you are using only one measurement channel, the multi-spectral PD measurement, called the 3-Center Frequency Relation Diagram (3CFRD), can be used to separate different PD sources.

“The MPD 600’s synchronous, multi-channel measurement capability reliably separates internal PD sources from each other and from outer noise signals common in industrial environments.”

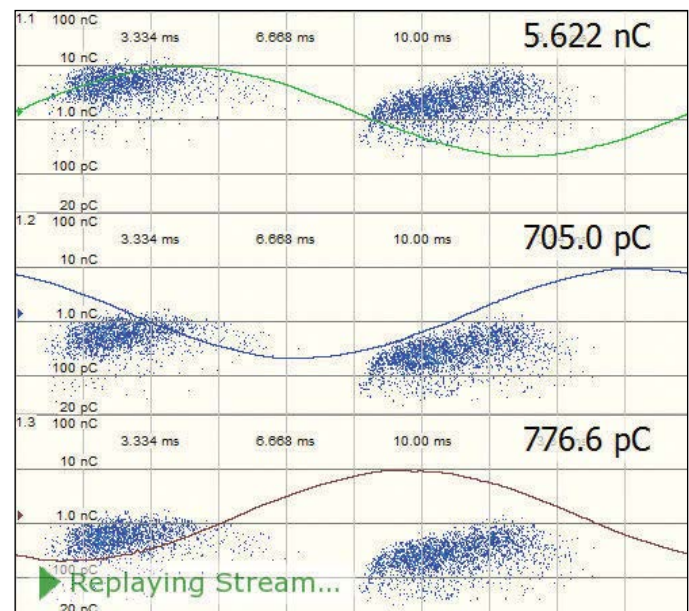
Zsolt Gaal, Managing Director
Gaal Umwelttechnik



3-Phase Amplitude Relation Diagram (3PARD)



Unseparated noise and PD activity



Separated PD activity

Additional disturbance impact reduction

For added noise reduction in high-voltage laboratories with very high interference, the MPD 600 can be used with our MBB1 measurement balanced bridge to perform differential PD measurements during single-phase AC and DC PD testing. It provides you with an improved signal-to-noise-ratio and a significant reduction of disturbance signals.



MBB1 Balanced Measurement Bridge

6 Measures up to the UHF range

The MPD 600 measurement range can be easily expanded up to the ultra-high frequency (UHF) range in combination with a variety of UHF sensors and a special bandwidth converter. This unconventional UHF measurement method ensures a more sensitive detection of PD in environments with high interference levels. It can be used for commissioning tests as well as off-line and on-line diagnostics, especially on liquid-insulated power transformers, gas-insulated switchgear (GIS) and high-voltage cables.

"The biggest advantage of the MPD 600 is that you can record a stream of partial discharge and analyze it later as you are playing it back."

Michael Jay, Chief of Test for Power Transformers
GE Grid Solutions

7 Flexible post analysis of measurement data

The MPD 600 can store PD events with a very high sampling rate during testing. In addition, the test voltages and all other relevant system settings are stored, which can be used as reference for the interpretation of future measurement results. The measured data is stored as unprocessed raw data, so that it can be analysed at any time. The full set of analysis functions, like 3PAR, can be applied to this data without having to repeat the measurement.

Real-time PD measurements can be recorded as data streams for later replay and analysis. These streams can be individually cut to focus on relevant PD events. The playback speed can also be freely selected, enabling sections of data to be played back more slowly and analyzed in greater detail. Should questions arise during analysis, you can send recorded data streams to PD experts for interpretation and advice.

8 Integrated reporting

Using the integrated report function in the MPD 600 software, you can easily create reports with measurement values and screenshots in .xml format and save them as PDF files. With the optional .COM interface, PD data can also be integrated into preferred third-party applications for testing and reporting purposes.

More information is available under:
www.omicronenergy.com/mpd600

Hands-on PD training is available from OMICRON Academy, where you can learn how to use the MPD 600 PD measurement and analysis system on a variety of electrical assets.

OMICRON is an international company serving the electrical power industry with innovative testing and diagnostic solutions. The application of OMICRON products allows users to assess the condition of the primary and secondary equipment on their systems with complete confidence. Services offered in the area of consulting, commissioning, testing, diagnosis and training make the product range complete.

Customers in more than 150 countries rely on the company's ability to supply leading edge technology of excellent quality. Service centers on all continents provide a broad base of knowledge and extraordinary customer support. All of this together with our strong network of sales partners is what has made our company a market leader in the electrical power industry.