Application

Future technology on the test bench

OMS 600 monitors plastic-insulated high-voltage cables

1 A 220 kV cable with modern XLPE insulation runs from Lübeck to Siems. The cable terminations in the Siems substation are monitored by the OMS 600 PD monitoring system. ***2*** The OMICRON sensor MCT 110 captures partial discharge impulses. ***3*** The OMS 600 collects the values captured from the sensors.

Power cables made of cross-linked polyethylene (XLPE)

Plastic cables made of cross-linked polyethylene (XLPE) have been in use alongside classic oil-paper insulated high-voltage cables since the 1970s. In addition to their lower manufacturing costs, easier and time-saving installation and improved operating characteristics (e.g. lower dielectric losses), these cables also offer another important advantage: They are far more environment friendly, as no insulation oil can seep into the soil. However, one of the few disadvantages of completely solid insulation compared to conventional oil-paper insulation is the increased susceptibility to partial discharge (PD) and the consequences associated with it. With XLPE, electrical treeing resulting from PD is irreversible and ultimately destructive.

TenneT TSO GmbH is Europe's first cross-border grid operator. In addition to overhead lines, the company also uses underground high-voltage cables. However, according to German energy agency "dena", XLPE cable technology (see box) is still in the testing phase. Underground cabling in the extra-high-voltage range is only partially implemented in projects in sections classed as pilot projects as defined in the German Power Grid Expansion Act (EnLAG). At the 220 kV level, TenneT is already using underground cabling in the line from Lübeck to Siems, Germany. It not only employs temperature sensor systems, but also the OMS 600 partial discharge monitoring system from OMICRON to monitor the terminations of a 220 kV high-voltage cable. This allows any potential, premature faults on cable sections to be detected in good time based on advancing partial discharge. The PD monitoring system was commissioned in November 2011 for the existing 220 kV cable connection from the town of Lübeck to the town of Siems in Germany.

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This cable was laid in 2005. The cross-bonding technique—whereby the cable screens cross—was used to reduce circulating currents. This approach prevents costly energy losses in the cable screen.

Basic investigation using the Lübeck-Siems cable

Postgraduates at the Technical University of Berlin collaborated with the Berlin-based testing institute IPH, to perform basic investigations into the propagation of potential partial discharge pulses in high-voltage cable systems. In addition to frequency-based attenuation of partial discharge pulses along the high-voltage cable, the researchers were primarily interested in the complex pulse propagation on the branches of the cross-bonding system of the high-voltage joints. The objective here was to clarify whether potential PD pulses from cables, terminations and joints could also be detected and measured in the permanently accessible, relatively safe, cross-bonding sections of the cable system while operating under high voltage. The tests were extremely successful, and PD detection using inductive coupling with cross-bonding cable systems is now almost used as the standard for online PD testing. Such coupling can, for example, be established using OMICRON's MCT 100 sensor.

Inspection of newly laid cables

All components of a cable system, in particular the individual manufactured lengths of the high-voltage cable and the joint boxes, pass through a quality assurance process at the manufacturing facility. PD measurements in line with IEC 60270 and IEC 60885-3 are one of the most useful diagnostic measurements that are capable of detecting and localizing even the slightest faults in the cable insulation. However, important installation work, such as connecting the individual manufactured lengths to create the complete system, is only performed on site. As such, only an on-site diagnostic measurement on the finished object can provide certainty as to whether the installation was successful and free of faults. Since the applicable standards do not class PD measurements as mandatory during commissioning, in many cases only the much cheaper and

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The monitoring server system at the substation in Siems: It captures, logs and provides measured data for the user.

easier voltage tests are performed for system voltages below 400 kV. However, this approach is incapable of detecting potential defects which would cause the cable to fail after it has been in continuous use for some time.

The OMS 600 PD monitoring system

The OMS 600 has been designed for outdoor use. The measured data evaluation for continuous operation is performed differently than the tests performed by the laboratory version, which is already used worldwide by well-known cable manufacturers. At the substation in the German town of Siems, a monitoring server system is used. This system captures and logs the measured data, and then makes it available to users via a database. A large number of prepared charts and diagrams can also be accessed remotely in real-time via a secure remote connection, to specific locations including Bayreuth.

Installation in Lübeck

For safety reasons, it is necessary to disconnect the cable when installing the monitoring system, particularly when attaching the PD sensors close to the terminations. Thanks to the excellent collaboration between TenneT and OMICRON, it was possible to limit the system downtime to just a few hours. TenneT had already laid the fiber-optic cables in advance and then set up the monitoring server and performed the installation of the OMS 600 PD recording unit. The installation team from OMICRON fitted the PD sensors and ultimately connected all of the components to form the complete system.

Operating the monitoring system

The OMS 600 PD monitoring system has been in use in Lübeck since November 2011. Using digital filter algorithms, such as 3PARD (3-Phase Amplitude Relation Diagram), it is possible to differentiate potentially critical partial discharge from the non-critical external discharges which occur in virtually all substations. TenneT performs detailed evaluations of the PD activity itself, supported by OMICRON's monitoring service team.

XLPE cable technology is on its way to becoming an accepted technique thanks to the monitoring of partial discharge in plastic-insulated high-voltage cables.

TenneT TSO GmbH

Following its merger with transpower, TenneT is Europe's first cross-border electrical grid operator. With approximately 20 000 km / 12 500 mi of high-voltage and extra-high-voltage cables and 36 million consumers in the Netherlands and Germany, the company ranks among the top five grid operators in Europe.

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