Long-term experiences and review with offline and online PD measurements on-site on EHV XLPE cable systems 330kV to 500kV

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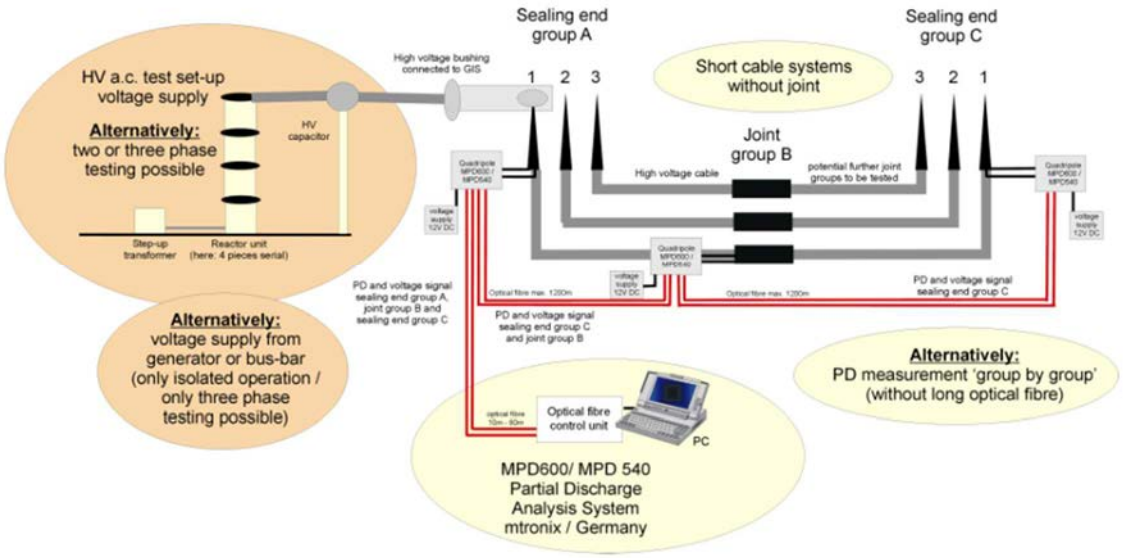
A high voltage cable is tested to demonstrate the guaranteed properties, to show the compliance with standards and to secure the operating reliability. For an XLPE cable the essential tests are the AC voltage test and a partial discharge (PD) measurement. A solitary voltage test has the shortcoming of not detecting all irregularities which may harm the operating reliability by causing a breakdown during voltage test time while at the same time not initiating pre-damages at irregularities which otherwise would not harm operating reliability. The solution for such a sensitive test method is the PD measurement.

Commissioning tests are carried out on the assembled cable system once the installation is completed. There are very few tests that can be carried out that will prove the long term life of cable and accessory. The relevant standards for high-voltage cable systems (IEC 60840 / 62067) recommend two possible after installation tests: As all prefabricated components are factory tested, a DC measurement of the outer sheath together with a quality assurance procedure during installation. In reality, this possibility is not taken into consideration by customers. De facto an AC voltage test of the main insulation with a specified value ($1.7 \cdot U_0$ or values acc. to table 4 column 11 in IEC 60840 / 62067) for 1 hour or U_0 for 24 hours ('soak-test') is carried out. In addition to the tests specified in IEC 62067 the manufacturer recommends and practises a PD measurement of all accessories after installation for voltage levels $U_m \geq 362$kV.



The experience of about 2400 tested EHV accessories during commissioning or system assessments in about 170 assignments all around the word was cumulated the last 12 years. Summing up it can be evaluate that for a reasonably commissioned EHV cable system including PD measurement no further monitoring facilities are necessary like for example a continuous PD measurement system. Considering the costs of such systems of up to 15% - 20% of the supply share of cables and accessories this expenses should be invested in a well done PD measurement during commissioning, not yet taking into account the flood of data and the necessary fast and qualified response on actual occurrence of PD detected by such a monitoring system.

Ideally the test is carried out using an AC resonant test set. This allows the cable system to be energised offline and at low energy and so there is a minimised risk of breakdown. It is also possible to carry out an AC test by energising the system with system voltage and using online partial discharge monitoring. This is not ideal, as noise from the system can mask discharge activity occurring within the accessory. In addition, if a breakdown does occur this will lead to a disruptive failure of the accessory and may lead to an outage and power disruption. Very often for new installations as well as for system assessments it is possible to carry out online measurements in isolated operation with the feasibility of increasing the voltage up to 110% via the generator. For these measurements a huge expert knowledge on-site is necessary to be able to compare and evaluate the accessories vertically and horizontally inside a system.

The requirement to carry out such online measurements globally by the cable system manufacturer is the availability of a modern, robust and finally compact PD measurement equipment for on-site use which can be carried along by the test engineer worldwide.

Current considerations using alternative voltage types for high voltage commissioning tests of EHV and HV cable systems are regarded as very critical. DC voltage tests must be considered with respect to a potential risk of damaging the insulation system. For example DAC (damped AC) or VLF (very low frequency) are non-standard-compliant test methods. These test methods are not comparable to power-frequency voltage tests or operation similar frequencies (10-300 Hz). In the overall context these methods do not correspond to the state of the art and knowledge and have to be rated accordingly.

On the other hand the behaviour of some breakdowns during operation indicates a gap in today's testing philosophy that does not seem to be filled out with the diagnostic methods available today.