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

Andreas **WEINLEIN**, Ulrich **PETERS**, Gero **SCHRÖDER**, Dominik **HÄRING**; Südkabel GmbH, Mannheim (Germany),
andreas.weinlein@suedkabel.com, ulrich.peters@suedkabel.com, gero.schroeder@suedkabel.com, dominik.haering@suedkabel.com

ABSTRACT

The experience of about 2400 tested EHV accessories during commissioning or system assessments in about 170 assignments all around the word was cumulated over the last 12 years. The relevant standards for high-voltage cable systems (IEC 60840 [12] / 62067 [11]) recommend 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 applied. 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.

KEYWORDS

online, offline, PD measurement, on-site, commissioning, system assessment, quality assurance

INTRODUCTION

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 system 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 momentary operating reliability. The solution for such a sensitive test method is the PD measurement [5, 13, 14, 15].

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 62067) for 1 hour or U_0 for 24 hours ('soak-test') is carried out.

(1) U [kV] rated voltage / IEC 62067 phase-to-phase	(2) U_m [kV] maximal voltage phase-to-phase	(3) U_0 [kV] phase-to-ground	(4) U_{test} [kV] U_0 (24h) / IEC 62067 phase-to-ground	(5) U_{test} [kV] table 10 (1h) / IEC 62067 phase-to-ground	(6) U_{test} [kV] 1,7 U_0 (1h) / IEC 62067 phase-to-ground	(7) $U_{test\ PD}$ [KV] recommended by manufacturer's philosophy phase-to-ground
220 – 230	245	127	127	180	216	127 – 180
275 – 287	300	160	160	210	272	160 – 210
330 – 345	362	190	190	250	323	190 – 250
380 – 400	420	220	220	260	374	220 – 260
500	550	290	290	320	493	290 – 320

Fig. 1: on-site test voltages acc. to IEC 62067

In addition to the tests specified in IEC 62067 the manufacturer recommends and practises with own projects 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 over the last 12 years. Ideally the test is carried out using an AC resonant test set [1, 2, 3, 4]. 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 [6]. 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 110-115 % 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.

MANUFACTURER'S TEST PHILOSOPHY

The PD measurement is a valuable tool to evaluate the quality of an insulation. Inside factory all components of the cable system which can be checked in advance will be routine tested with a voltage $U_{test} \geq 2 \cdot U_0$. Thereto belongs the cable itself and all pre-moulded field control parts of accessories (100% routine test). With a simultaneous PD measurement during voltage tests weak spots inside the insulation can be detected at an early stage. On principle each company should only supplying system components absolute free of PD on-site. Above all, installation faults which can appear during the assembly works should be detected by use of an on-site after installation PD measurement. The transport chain of the components like cable drum, epoxy resin insulator or field control element should be surveilled by suitable methods e.g. shock indicators or similar from routine test inside factory to installation place