On-line partial discharge screening of MV and HV cables: feasibility and potential

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ABSTRACT

While the health conditions of the HV and MV cable assets of utilities and industrial plants are becoming a problem, due to the increased mean age and the lack of proper commissioning tests, there is a lack of testing procedure allowing for a rapid and effective screening of the cable system conditions. Most often, off-line partial discharge tests are carried out, which are a reliable source of information for the presence of PD and the way to localize them along a cable. However, they are expensive in terms of time and owing to the need of supplying cables by external power sources.

On the contrary, on-line PD screening could be and effective procedure, provided that noise can be rejected efficiently.

This paper shows results of on-line PD testing of HV cables, where PD phenomena are separated from noise thanks to the time-frequency map technique. Cases regarding polymeric cables, rated between 88 and 220 kV, are presented and discussed, showing clear presence of partial discharges of amplitude above or below the external noise. The usefulness of on-line PD testing approach for diagnostic purposes and CBM procedures of cable systems is thus supported.

INTRODUCTION

Cable commissioning tests have been based mostly on off-line voltage withstand tests. In MV most often commissioning tests are not performed due to their cost. In HV, the use of a testing overvoltage compared to the nominal one (sometimes 1.7 times) is meant to be a pass/failure criterion which would ensure reliable operation for the design life (e.g. 30 years with failure probability 1%) [1]. Specifically,IEC62067 Par.16.3 (AC voltage test of the insulation) [2] establishes Dielectric Withstand Tests, DWT, as mandatory for HV and EHV cables. Testing waveform should be substantially sinusoidal, with frequency between 20 Hz and 300 Hz. A voltage according either to Table I or to 1.7 U0 (depending on practical operational conditions) shall be applied for 1 hour. The suggested UTEST values were determined considering the technical limitations of testing equipment, usually Resonant Test Sets (RTS). The value 1.7 U0 ($\approx \sqrt{3}\,U_0$) is the maximum voltage at which the cable can be energized.

Alternatively, a voltage of U0 can be applied for 24 hours directly from the network, and this is the so-called “soak test”. Note that the standard does not mention the PD test, even if the importance of such test is worldwide known. It is quite recent, indeed, the use of PD for cable condition assessment, and the technology dynamics in such a delicate field as HV cables are generally quite slow.

Tab. 1.Voltages used for AC withstand insulation Test

Cable Rated Voltage	Nominal U_0 (for U_{TEST} determination)	Suggested U_{TEST}	Ratio U_{TEST}/U_0
220 to 230 kV	127 kV	180 kV	1.39
275 to 287 kV	160 kV	210 kV	1.32
330 to 345 kV	190 kV	250 kV	1.26
380 to 400 kV	220 kV	260 kV	1.13
500 kV	290 kV	320 kV	1.11

The choice of voltage levels during HVAC test is still debated widely. Clearly, the main purpose of the test is aiming at highlighting major defects in the insulation system, which would lead to failure before the end of the design life. However, testing at too high voltage level (as 1.7 U_0) may cause breakdown of the cable due to defects that would never be activated under whole design life under nominal working conditions. Alternatively, it could create a permanent damage that is able to trigger PD under nominal operating conditions, bringing the cable to premature failure. Therefore, testing at much higher voltages than the maximum sustained overvoltage the cable can experience during its life, should be considered carefully.

The practice of associating PD measurements to DWT can help considerably in detecting defects without going to too high test voltage levels, and is even more important in soak tests, where the existence of even small defects which will never break the cable in a short time at nominal voltage can be spot out.

However, cable system condition can change during life under thermo-electrical stress, e.g. due to thermal cycling which can cause the appearance of cavities-delaminations especially in accessories, so that not only commissioning should be considered to ensure the design service life to a cable, but also spot measurements at regular times during life.

As temperature plays an important role in PD phenomenology, cable condition assessment during life should be done properly on-line (better using permanent monitoring, but at least through periodic measurements), under various load conditions.

The convenience of on-line commissioning tests and, in general, cable condition assessment, compared to off-line testing is discussed in the next sections.