Non-destructive after laying test with PD localization

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ABSTRACT

The paper describes the insights and thoughts to gain more knowledge from the after laying test of high voltage cable circuits. Based on own experience and (practical) knowledge non-destructive testing with partial discharge localization gives added value towards availability and reliability of the high voltage cable circuits. In the near future policy rules will be drawn up to substantiate this philosophy.
In this paper more clarification is given on basis of a practical case study. Finally conclusions will be drawn from the obtained insights.

KEYWORDS

Non-destructive, after laying testing, partial discharges, localization, damped ac testing, ac resonant testing, grid reliability and availability.

INTRODUCTION

It is known that a high voltage (HV) cable network represents a large investment and can be time consuming in planning and installation. For the transmission system owner important tasks are to operate a safe and reliable grid. Faults originating from jointing or during cable installation should be detected before operating the cable circuit, i.e. after laying tests must be done. The main goal of the after laying test and analysis is to detect, localize and recognize possible insulation coordination failures in cables and accessories at an early stage. As a result the repair strategy and/or maintenance can be planned to prevent unexpected discontinuities in the operation of a cable system. Furthermore making fingerprints over the life time of a cable circuit results in a more predictable cable grid. Differentiation between the different fingerprints will also help to develop knowledge rules for the asset management policy for preservation and remaining life time.

We are convinced that the traditional voltage withstand test with use of the AC resonance test (ACRT), without additional (temporary) partial discharge (PD) sensoring techniques, can only give a binary test result 'break-down' or 'no break-down'. With use of a practical case this paper shows the added value of non-destructive testing with PD localization.

BACKGROUND OF AFTER LAYING TESTING IN THE NETHERLANDS

In the Netherlands there is a broad variance with respect to the HV cable systems in operation by the Transmission System Owner (TSO). The voltage classes of the cable systems are 110, 150, 220 and 380 kV. Whereas the main insulation can be of low pressure fluid filled (LPFF), external gas pressure (EGP) or extruded polyethylene (XLPE) type.

Historically, in the Netherlands, after installation testing of HV cable systems is done in line with the recommendations of the Dutch cable standards. For the XLPE cable systems from 36 kV up to a maximum voltage of 170 kV the national Dutch standard HD-632 [1] is used as guidance. This standard consists of a generic part and more specific parts related to cable types.

In figure 1 the general overview of electrical tests after installation of the main insulation is shown. In figure 2 this overview is given for the XLPE type of cable with a smooth aluminium sheath.

8.3 Electrical test after installation, insulation

8.3.1 A.C. voltage test with 2,5 U_o

The test voltage should be gradually increased to 2,5 U_o and then maintained for 10 min between the conductor and the metal screening. If a resonant test circuit is used, the frequency may vary between 25 Hz and 200 Hz.

8.3.2 A.C. voltage test with √3 Uo

This test is performed by earthing in rotation one phase of a network not being earthed in 'star' configuration, and applying √3 U_o to the other two phases. For this test, the voltage on each core should be maintained for twice one hour.

8.3.3 Tests with oscillating voltage

For this test, the cable connection is charged with direct current to 3 U_o and then discharged to earth by way of a coil.

The oscillation frequency will in general exceed 200 Hz and be less than 5 kHz. The test should be performed 50 times on each phase.

Figure 1: overview of after laying test according to part 2 of HD-632 – additional test methods

Clause	Test	Test requirements *)	Test method
7.	**Electrical tests after installation**		
7.1	Insulation - 2 possibilities, in sequence of preference, are given	No breakdown	HD 632, Part 2, subclauses 8.3.1 and 8.3.2
	Note: In case of re-routing or extension of existing cable circuit the following test voltages shall be used:		
	- existing XLPE circuit	80% of the AC testing voltage of a new circuit	
	- existing circuit, other than XLPE	Subjected to agreement between owner and supplier	

Figure 2: overview of after laying test according to part 3 of HD-632 on cables with smooth aluminium metallic screen

A discrepancy is found between both parts of the HD-632 standard. Part 2 mentions the test with oscillating voltage as after laying test but part 3 lacks reference to this particular test. We do want to indicate that the stated principles for testing with an oscillating wave are outdated and needs to be adjusted to the current state of the art. In any case, nothing is written about the measurement and localization of partial PD during the voltage withstand test.

In the Dutch medium voltage grid of the Distribution System Owners (DSO's) testing with a damped oscillating wave is used for a longer period of time. One of the biggest DSO's in Netherlands is using the Damped Alternating Current (DAC) test method for withstand testing combined with PD localization and mapping for both older and new cable circuits.