# Partial Discharge testing of XLPE cables for HVDC: Challenges and opportunities

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## *ABSTRACT*

This paper reports preliminary results of an investigation on the meaning of testing HVDC cables using AC voltages. Cables with artificial defects are tested under AC (50 Hz and 0.1 Hz) and DC (room temperature or conductor at 70 °C). To carry out this investigation, a technique for measuring PD with high sensitivity under DC has been devised, and is reported. Preliminary results on a cable with misplaced grading system (a typical defect due to bad assembly in the field) indicate that AC tests provide conservative result (PDIV is lower under AC compared to DC). VLF (0.1 Hz) provides results (PDIV and PD magnitude) that are closer to those observed in DC. The behavior trend of PDIV is confirmed by FEM simulations.

Keywords: HVDC, partial discharges, diagnosis.

## INTRODUCTION

HVDC connections are becoming an important part of the electrical system, making network reliability increasingly depending on HVDC equipment. Focusing on HVDC cables, manufacturers have dealt at a design level with the issues of space charge accumulation and its detrimental effects at polarity reversal. To date, this does not pose severe threats. However, this concerns primarily cable design and manufacturing. Issues might be introduced during cable system assembly, where human errors can affect joint and termination assembly.

Since tests under DC are difficult to carry out, to assess the quality of cable systems and rule out the presence of these defects, partial discharge (PD) testing under AC is being used. However, doubts arise concern the feasibility of this approach, in that PD tests using AC waveforms might:

\Highlight the presence of defects that do not affect the reliability of the cable system in operation (since the field distribution is different under DC). We shall refer to this type of error as false positive.

Opposite to the former case, PD tests might miss defects that have a negative influence on cable reliability. This type of error will be referred to as false negative.

Nexans and the University of Bologna have established a joint research program aimed at determining the influence of the most typical accessory installation defects on HVDC cable reliability. The research resorts to the following steps:

1. PD testing using 50 Hz AC sinusoidal voltages
2. PD testing using 0.1 Hz AC sinusoidal voltages
3. PD testing under DC voltages with the cable at ambient temperature
4. PD testing under DC voltages with the cable under thermal gradient
5. FEM modeling of the defect site
6. Breakdown under ramped DC voltages

The results presented here are only preliminary and concern a single cable loop. Unfortunately, testing was stopped due to a fire in the lab of the University of Bologna and the need to sanitize the area. More results will be presented in future papers.

## CABLE TYPE AND CABLE DEFECTS

The cables used in this investigation were provided by Nexans and are, properly, XLPE cable models that Nexans uses to qualify HVDC cables. Cable loops of 10 m are used for each test. The radius of the conductor is 95 mm², the thickness of the insulation is 4.9 mm. The grading system consists of a 300 mm-long resistive mastic.

The considered defects for the investigations were:

1. Incorrect alignment of the grading system, with a 10 mm gap left between the cable screen and the beginning of the grading tube.
2. Knife cut left by improper stripping of the screen

The geometry of the defects is sketched in Fig. 1.

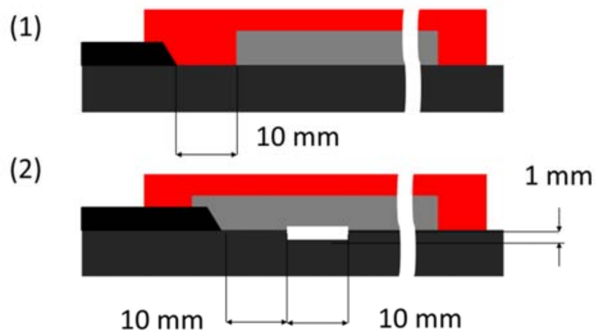


**Fig. 1: Geometry of the defects.**