

## 270 kV DC Extruded Land Cable Systems for LCC Power Transmission

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### ABSTRACT

*Although HVDC projects in underground link have led to use the extruded cable combined with the VSC converter, the recent DC Technology milestones have shown that Extruded Cable Systems have been developed and tested successfully up to 400 kV for LCC technology where the power flow change requires polarity reversal.*

*This study describes the new 270kV DC LCC link based on XLPE cable systems used on a land section of the existing interconnection IFA 2000 between the North of France and UK. It is the first worldwide reference using extruded insulation cable at this voltage level for LCC application.*

*The authors describe the development process and the main characteristics of the cable system with the results of an extensive performance tests qualification for the envisioned project.*

*Testing was carried out according to CIGRE TB 496 and relevant IEC 62895 standard*

### KEYWORDS

HVDC, XLPE, Space charge, VSC, LCC, CIGRE TB 496

### INTRODUCTION

For many years, there has been a strong attraction in the use of submarine and underground interconnections for High Voltage Direct Current (HVDC) cables. This request involves the qualification of cables and accessories whose voltage level rises gradually with market demand. The choice of extruded cable reinforces this growing interest in achieving high voltage links without maintenance and with low impact on the environment [1].

Prysmian Group namely Silec has started DC studies on 270 kV extruded cable systems in the 90's [2]. The knowledge acquired during previous years gave us confidence about use of cross-linked extruded cables with polarity reversals. The type test qualification of the HVDC cross-linking based cable systems at 270kV level has been achieved on LCC (Line Commutated Converter) type, where polarity reversals were applied during heat cycling [3].

Such Technology strategy has been continuing to reach the voltage level up to 345kV DC LCC.

Experience in operational lines is extremely limited for LCC converter system.

In the recent past years, French TSO has made its decision regarding the replacement of a section of the underground cable system for the existing IFA 2000 link between the North of France and UK. This cable route portion had been built initially with oil-filled insulation technology (1986). The decision has consisted in the use of a new 270kV DC LCC link based on Extruded XLPE cable systems in two bipoles on a land section of the existing interconnection.

It is the first worldwide reference using extruded insulation cable technology at 270 kV voltage level for LCC Converter Technology. The two 270kV DC LCC XLPE Extruded Land Cable Systems have been energized in 2016 and 2017 respectively.

Before implementing the project, the main DC characteristics in XLPE cable and EPDM premolded accessories have been investigated. In particular, the space charge properties on EPDM as main insulation for accessories have been explored.

The report addresses the development and the qualification process of DC XLPE cable systems with polarity reversals. The successful milestone achieved is the result of permanent intensive Research and Development Program in Extruded HVDC technology since the 90's.

The authors describe the main characteristics of the land cable system equipped with premolded joints and composite outdoor terminations subjected to enhanced electrical tests. To demonstrate the reliability margin of the Extruded Cable Systems, additional performances tests including  $-/+100$  Impulses superimposed to DC voltage with opposite polarity have been performed successfully.

The electrical tests have been carried out according to CIGRE TB 496 [4] and relevant IEC 62895 standard with the combination of both VSC and LCC protocols.

### BASIC DC PROPERTIES

#### DC space charge properties

Space charge measurements have been performed on plaques of XLPE with a thickness of about 500  $\mu\text{m}$  and on model cable with insulation thickness 4,5 mm using the pulsed acoustic method PEA method [3].

The PEA method has been also investigated to measure space charge distribution in premolded accessories.

The samples were submitted to DC poling voltages, corresponding approximately to applied fields in the range 10 to 40 kV/mm. A polarity reversal is performed after the