345kV DC XLPE Extruded Cable Systems Development

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ABSTRACT

The recent projects in HVDC underground link have led to use the extruded cable combined with the VSC converter technology.

This study describes the DC extruded cable systems development for voltage level ranging from 270kV up to 320kV. In addition, the authors explore the reliability of the cable systems up to 345 kV where the tests of qualification have performed according to both VSC and LCC technology.

The behaviours of space charge accumulation of the main insulation system for cable and premoulded accessories under DC stresses have been investigated.

This paper describes the development process DC XLPE cable systems with the results of an extensive performance tests qualification.

KEYWORDS

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

INTRODUCTION

For many years, there is a strong attraction in the used of submarine and underground for high voltage direct current (HVDC) cables. This request involves the cable and accessories qualification 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 low impact for environment [1].

General Cable has started DC study on 270 kV extruded cable systems in 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 system on the 270 kV level is focused on LCC (Line Commutated Converter) converter type, where polarity reversals were applied during heat cycling [3].

Such strategy has been continuing to reach the voltage level ranging from 320 kV up to 345 kV. The DC development approach has been articulated on the assessment of the cross-linking based cable system and better understanding of space charge behavior in those materials under DC stress. Space charges formation under DC stress is certainly the major concern for such a material. The space charges build up may modify the electric field distribution inside the insulation and leads to local overstresses unsuitable to long-run ability. In addition the introduction of VSC technology where the power flow reversal occurs without changing polarity of the cable encourages the use of synthetic insulated cables and both long submarine and underground links are being considered and actively implemented.

In this paper the behaviour of the space charge accumulation in XLPE cable and EPDM as main insulation for premoulded accessories under DC stresses has been investigated. Measurement techniques are now available and the spatial distribution of space charge was deeply investigated, applying PEA (Pulsed Electro Acoustic) technology. Further information about the technique is given in [4, 5].

In this study both premoulded and extruded moulded jointing technology to the HVDC system has been demonstrated. The concept of premoulded joints has several attractive features including the ability to fully test before installation. In contrast extrusion moulded joints offer an important route to ensuring compatibility of the jointing and cable materials and offer a long term prospect of systems with the highest reliability. In parallel this paper introduces the newest technology based on the development of the premoulded joint which has sufficient reliability for currently envisioned HVDC systems.

The focus of the paper is to assess the reliability of XLPE insulation cable system equipped with moulded field joint and premoulded joint subjected to high DC electric stress. The authors describe the development process DC XLPE cable systems with the results of the type tests qualification according to CIGRE TB 496 recommendations [6].

The electrical test has been performed with the combination of both VSC and LCC protocols.

BASIC DC PROPERTIES

DC insulation resistance and space charge properties

DC insulation resistance (ρ) properties and the space charge properties are explored on EPDM material which is the main insulating material of the premoulded accessories. The DC insulation resistance (ρ) is generally known to depend on the electric field and temperature. Its characteristics are important for the assessment of the electric field in the accessories. Figure 1 shows an example of the measurement results based on temperature dependence. The tests are conducted under an appropriate electric field where the samples are submitted to 8 hours withstand voltage conditions.