

Performance of a Polypropylene-insulated MVAC cable for ± 50 kV MVDC

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ABSTRACT

Polypropylene (PP) has been used as an innovative and, in particular, environmentally friendly base material for cable insulation in medium-voltage and high-voltage technology, with comparable or better technical properties than XLPE. PP cables are nowadays in service for voltages up to 150 kV at AC and are available for operating voltages up to ± 600 kV at DC. However, the medium-voltage direct current (MVDC) technology is a promising approach to meeting the upcoming challenges in the distribution system of tomorrow due to the growing use of decentralized renewable energy sources and to enable the required energy transition. In this context, eco-friendly MVDC cables are of great importance. In this report, an overview of the general technical characteristics and environmental aspects of PP-insulated medium-voltage cables and an investigation of a MVAC PP-insulated cable for MVDC transmission are presented and discussed in detail.

KEYWORDS

Polypropylene, eco-friendly, MVAC cable, MVDC cable, CO₂ reduction, conductivity, PQ test, space charge

INTRODUCTION

For decades, cross-linked polyethylene (XLPE) has been used almost exclusively as an insulating material for extruded medium-voltage and high-voltage cables. XLPE cables have significant technical and ecological advantages over the earlier mass-impregnated or oil/paper-insulated cables, such as lower dielectric losses, higher permissible operating temperature, simpler accessories technology and the elimination of oil-impregnated paper insulation. The corresponding XLPE insulation systems, cable designs and test specifications have been continuously improved in the past to eliminate faults, inhomogeneities and water treeing. XLPE cables are now available for operating voltages up to 550 kV for AC and ± 640 kV for DC, with a maximum operating temperature of 90 °C [1 - 3]. From today's point of view, the disadvantages of XLPE cables are the high energy consumption during production and the limited recyclability.

For some years now, polypropylene (PP) has been used as an innovative and, in particular, environmentally friendly material for cable insulation in high-voltage technology, with comparable or better technical characteristics than XLPE, a significant reduction in CO₂ emissions during cable production and very good recyclability of the insulation material [4 - 6]. Polypropylene is a thermoplastic material that allows simplified cable production compared to XLPE cables, does not require cross-linking of the insulation and thus no energy-intensive degassing of the cross-linking by-products, and allows a maximum operating temperature of 110 °C. PP-insulated cables were initially

developed by one company and are now available on the market under the general term HPTE (High Performance Thermoplastic Elastomer) insulated cables from various manufacturers.

Due to the historical development and the associated status of standardization, PP-insulated cables are currently mainly used in the medium-voltage range in Italy and the Netherlands [7, 8]. PP cables are currently in service for voltages of up to 150 kV at AC and are available for operating voltages of up to ± 600 kV at DC [9, 10]. PP-insulated cables will be used in Germany in the HVDC corridor cable projects A-Nord and SüdOstLink [11]. Against the background described above, there are indications of a change from XLPE to PP, especially for medium-voltage cables (Fig. 1).

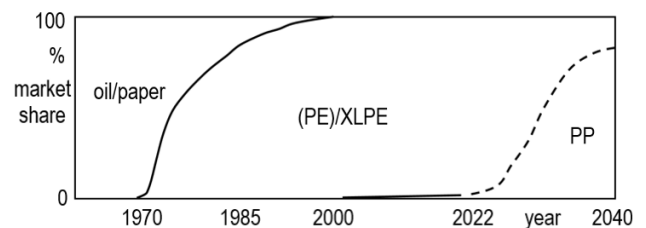


Fig. 1: Development of cable insulation materials (oil/paper and (PE)/XLPE according to [12], PP: estimation)

TECHNICAL CHARACTERISTICS

Polypropylene as cable insulation material

With a production capacity of approximately 75.6 Mill tons PP is the second most produced plastic in the world. Till 1953 it was thought that it is impossible to produce this material. Then G. Natta produced the first polypropylene in Milan, which was an isotactic polypropylene.

Polypropylene is produced by chain polymerization of propene and belongs to the group of thermoplastic elastomers. In contrast to XLPE, PP is harder and more heat-resistant (Fig. 2).

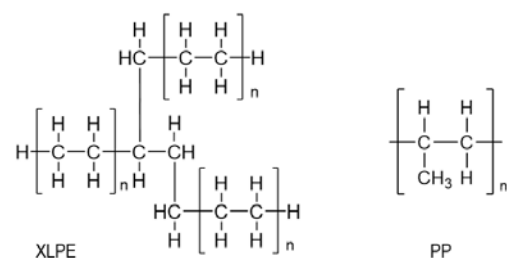


Fig. 2: Structure of XLPE and PP