Low emission XLPE – The next generation of Insulation materials for power cables

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ABSTRACT

Peroxide based crosslinked Polyethylene insulation is dominant for MV/HV cables. XLPE is compatible with the cable manufacturing process and generates a robust insulation system. A new generation XLPE has been developed - resulting in a significant reduction in emissions and degassing time, while maintaining the excellent properties of regular XLPE. The performance of the novel insulation compound has been evaluated, on commercially sized MV and HV cables. A comparison was made between Low emission and conventional XLPE, to assess sustainability impacts during cable manufacturing. The results indicates that Low emission XLPE is a more sustainable insulation material for power cables.

KEYWORDS

Low Emission XLPE; Conventional XLPE; XLPE; Headspace; Degassing; Byproducts; Crosslinking; Methane; Equivalent CO_2 Emissions; semi empirical degassing model

INTRODUCTION

Growth in population, urbanization and industrialization of the globe are driving sustainable energy initiatives. Electrification as one of the key levers for decarbonization has been reported in several studies. The transfer of electricity produced from source to efficient delivery at customers, through the use of transmission and distribution power cables hence is important. Polyethylene (PE) based materials are widely used in insulation applications because of their low permittivity, low loss, and good balance of toughness and chemical and moisture resistance. PE based insulation is crosslinked to increase the temperature rating and ampacity of the cable, where peroxide-based crosslinking is the dominant chemistry for medium voltage distribution and high voltage transmission cables. Peroxide crosslinking is highly compatible with the cable manufacturing process, and generates a chemically, mechanically as well as electrically robust insulation system.

Small amounts of undesirable by-products, such as methane, from the efficient peroxide crosslinking reaction, need to be removed prior to completion of the process for making finished cable. A new generation of crosslinked polyethylene (XLPE) has been developed, to provide a significant reduction in peroxide decomposition by-products, that are released to the environment - resulting in a reduction in emissions, as well as in degassing time, while maintaining the excellent mechanical and dielectric properties of a crosslinked polyethylene.

This article investigates the reduction in degassing through the measurement of the methane concentration in the cable. Simulations are completed to run calculations of CO_2 equivalent emissions that arise from the methane generated during crosslinking, and the energy used during degassing. The electrical and mechanical performance of this insulation compound was evaluated on full size medium voltage (MV) cables. A comparison was made between the novel XLPE and conventional XLPE, to assess sustainability impacts during cable manufacturing. Carbon emissions are generated by a cable system at several stages such as raw materials, manufacturing, transportation, installation, use-phase and end of life. A holistic approach is required to assess the sustainability impact of a cable system from cradle to grave. The low emission XLPE is a more sustainable insulation material for the future in power cables.

DEGASSING SIMULATIONS

In order to calculate degassing times, simulations were run using a semi empirical degassing model developed from a slab diffusion model as described by Yue et al. [1]. A diffusion coefficient of 5.2225e-6 cm^2/s was used. Day 0 average methane concentration values were generated through analytical analysis of full size cables produced with low emission XLPE and conventional XLPE as described in “Sampling and degassing measurements”. Simulation results are reported in the “Results and discussion” section. Fig. 1 shows a typical simulation done to compare conventional and low emission XLPE.

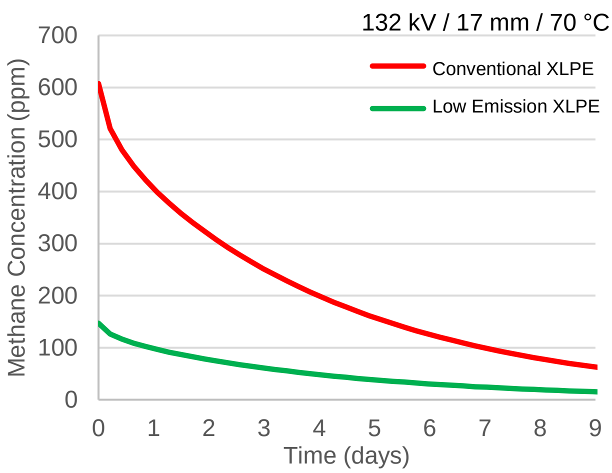

Fig. 1: Simulation comparing conventional and low