Close and Return

LONG-LIFE XLPE INSULATED POWER CABLE

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ABSTRACT

Crosslinked polyethylene (XLPE) has become the globally preferred insulation for power cables, both for distribution and transmission system applications. This insulation system provides cost efficiency in operation and procurement, as well as lower environmental and maintenance requirements when compared to older impregnated paper systems.

The purpose of this paper is to outline some of the developments that have led to this position. Understanding these developments will assist utilities to continue sourcing, and installing, the reliable underground assets that they require for the future.

KEYWORDS

QUALITY, MEDIUM VOLTAGE, AGEING

INTRODUCTION

When medium voltage (MV) XLPE insulated cables were first installed in the late 1960's, cable manufacturers and electric utilities expected them to perform reliably for 20 or even 30 years. History has shown that the service life of some of these early cables was far shorter than expected. At that time, cable engineers and material scientists were not aware that moisture, voltage stress, omitting jackets and imperfections within the cable structure would combine to accelerate the corrosion of neutral wires / tapes and cause water trees. These defects degraded the cable performance so severely that many cables failed after only 10 to 15 years in service.

The consequences of this lack of understanding were profound. It has been estimated that for every dollar that utilities spent installing the cable, they had to spend at least 10 dollars to replace it. Resources that could have been used to build new infrastructure were now diverted to replace cables that were less than 20 years old. This had an impact on operating costs that electric utilities are still dealing with today [1].

Engineers and scientists now know what went wrong. They discovered that voids and contamination in the insulation, combined with ionic contamination in the semiconducting shields, as well as other design and manufacturing deficiencies, led to voltage stress concentrations within the cables. These elevated voltage stresses, combined with moisture ingress into the cable structure created what are known today as water trees. These dendritic growths of microscopic cavities degraded the insulation over time, ultimately causing the cables to fail.

Today there are XLPE insulations that can be designed to inhibit the growth of water trees, allowing for even greater reliability for distribution class cables. Semiconducting screens that are free of excessive ionic contamination are also available. Manufacturers have also learned how to produce cable with insulations that are free of voids and with smooth interfaces between the semiconducting screens and the insulation.

Cables must also be specified, designed, manufactured, tested and installed such that the desired life is delivered. It is clear that a high level of symbiosis is required by academics, cable manufacturers, compound suppliers and utilities. This paper sets out to provide the foundations for this by identifying the critical developments and understanding. Many of the comments are relevant for all cable voltages (LV to EHV). However we will focus on the MV arena in this paper and address the higher voltage issues in a subsequent publication.

CABLE STRUCTURE AND MATERIALS

The structure of underground power cables appears deceptively simple. However, each component has an important purpose and must be selected carefully to assure that the composite cable structure will perform reliably in service. The critical structural elements of underground power cables are discussed in the following sections.

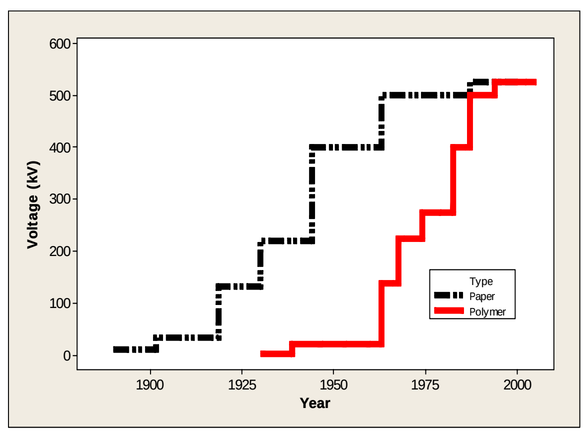

Figure 1 Evolution of the Highest AC Cable Voltage

Insulation materials used in MV power cables have long included the mature technology of fluid-impregnated Kraft paper. They have been successfully used for over 100 years. Today, extruded crosslinked polymer insulations are