AN ENHANCED TR-XLPE INSULATION FOR LONG LIFE POWER CABLES

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ABSTRACT (<100 WORDS)

With its excellent insulating properties in dry and wet environments, water tree retardant crosslinked polyethylene (TR-XLPE) is the insulation material of choice for achieving long life power cables. An enhanced water tree retardant crosslinked polyethylene (EnTR-XLPE) has been developed that will further improve the longevity and reliability of insulated cables. The EnTR-XLPE compound technology builds upon the field proven technology of TR-XLPE and incorporates careful selection and optimization of additional functional elements to provide a balance of performance in terms of resistance to water treeing, improved performance in accelerated wet electrical testing, crosslinking efficiency and scorch retardancy.

KEYWORDS

Polyethylene insulation, water tree retardant, long life

INTRODUCTION

Over 50 years ago, electric power cables began being insulated with polyethylene. Polyethylene's inherent characteristics of toughness, resistance to chemicals and moisture, flexibility at low temperatures and excellent electrical properties, along with low cost and easy processability, make it a very desirable material for insulating electric cables. Polyethylene insulated cables supported utility companies' efforts to reduce the life cycle costs of their power transmission and distribution systems by utilizing a low dielectric loss insulation.

In the 1970s, underground cables insulated with crosslinked polyethylene which were used in wet environments began failing prematurely due to a phenomena known as water treeing.[1,2] Though the mechanism of water treeing is still being researched, there is agreement that water trees result from the combined influence of water, ions and electrical stress. Specifically, water trees tend to initiate and grow from regions of particularly high local electrical stress, such as at defects in the insulation and at its interfaces.[3] Developments in polyethylene material technology have minimized this water-treeing problem. A revolutionary development that resulted in dramatic improvements in cable life was the use of a novel additive formulation approach that imparted water treeing resistance to polyethylene. This insulation product called TR-XLPE was introduced in the early 1980's and has shown excellent field service performance.

This TR-XLPE insulation was designed and has been demonstrated to retard significantly the growth of water trees, and thus extend the service life of power cables. The use of TR-XLPE insulation has allowed utilities to achieve long service life under severe conditions leading to improved life cycle economics and minimizing social and environmental issues resulting from cable replacement activities. Since its commercial introduction, TR-XLPE insulation has demonstrated the capability to significantly extend the service life of power distribution cables. Medium voltage cables insulated with TR-XLPE have shown higher retention of dielectric strength after aging in accelerated wet testing conducted in numerous global electrical laboratories. Additionally, field aged cables insulated with TR-XLPE have shown excellent retention of dielectric performance.[4,5,6]

There is continual interest from utilities to further advance the reliability and efficiency of their power distribution system. Utility engineers have expressed interest in further loading the electrical power system without increasing cable dimensions, to explore ways to reduce cable costs without impacting cable performance or further advance the service life of the current cable designs. Based on this utility interest, advances in TR-XLPE material performance were explored. These material studies included enhanced resistance to the initiation and growth of both water and electrical trees as well as features to improve cable manufacturing robustness.

Though water trees are associated with cable failures, it is accepted that the failure of cables is due to electrical treeing. The electrical treeing occurs when the water tree grows sufficiently large that the electrical stress across the remaining insulation is high enough to cause failure of the insulation.[4] Therefore, enhanced (water and electrical) tree retardancy of TR-XLPE is expected to provide utilities the opportunity to further improve cable system efficiency. However, product technology enhancements need to maintain the performance attributes and robustness of a well-designed material system.

Today's high performing crosslinked cables are produced via a continuous extrusion and vulcanization process that has been practiced for over fifty years. It is desirable to extrude the insulation at high rates with long runs in order to maximize process economics. Operating at high rates will require the use of a fast-acting crosslinking chemistry. However, the crosslinking chemistry must not occur in the extrusion equipment at the normal processing temperatures of cable manufacturing. Such crosslinking in the extrusion equipment at low temperatures is referred to as scorch and it can result in serious product defects.