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Material solutions for extruded HVDC cables

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Abstract: The paper describes the performance of insulating and semiconductive crosslinked polyethylene compounds developed for extruded HVDC power cables. The focus is placed on the critical issues controlling the reliability of the cables. The ageing characteristics of laboratory samples and full size cables are discussed, as well as electrical conduction and space charge effects influencing the electrical field distribution. However, not only the electrical properties have to be optimised, but also e.g. the processing properties such as resistance to pre-crosslinking.

Keywords: HVDC, power cables, polyethylene

Résumé: L'article décrit les performances de composés isolants et semi-conducteurs en polyéthylène réticulé destinés aux câbles à courant continu à isolation extrudée. Il met l'accent sur les aspects critiques influençant le contrôle de la fiabilité des câbles. Les auteurs abordent les caractéristiques de vieillissement d'échantillons de laboratoire et de câbles complets, ainsi que la conduction électrique et les effets de charge d'espace susceptibles d'influencer la distribution du champ électrique. L'optimisation des matériaux ne doit pas porter uniquement sur les propriétés électriques mais également sur les propriétés de mise en oeuvre et notamment la résistanceau grillage.

Mots clés: Courant continu, câbles de transport, polyéthylène

1. Introduction

In recent years special materials (insulations and semicons) have been developed to enable the manufacture of extruded DC transmission cables [1,2]. These materials have been engineered to have a unique set of properties. They combine the cleanliness, extrudability and high temperature performance now expected of crosslinked materials with the specific electrical properties required for operation under HVDC conditions. The correct combination of critical material properties has been achieved through a detailed development, which has considered the specific requirements of both cable manufacture and cable operation. Since 1999 these bespoke crosslinked DC materials have been proven in a number of practical applications around the world [2-6], which now account for >900 km of installed cables.

This paper will further describe how the development of insulation and screening materials has supported the commercial evolution of extruded HVDC cable technology. Particular focus will be placed on the protocols that have been used to assure the longevity of crosslinked DC cable technology. The influence of some of the challenging aspects of DC technology on the material solutions (insulations and semicons) will be explored in detail.

The technological drivers behind the development of DC transmission systems have been:

- No capacitive current making long distance (>100 km) power transmission with cables possible
- Lower dielectric losses
- Better control of power flow

A number of major advantages with polymeric DC cables compared to fluid-filled systems have been identified:

- Lower environmental impact (contains no fluid phase)
- Higher operating temperature
- Reduced maintenance

Tests with early polymeric insulations showed weaknesses due to space charges leading to limited performance and life [7]. Therefore, extensive work has been needed to develop specific crosslinked PE insulating and semiconductive materials for HVDC cables.