JICABLE '03

B.1.6

20 years of experience with copolymer power cable insulation

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Abstract: Copolymer modified crosslinkable polyethylene for power cable insulation was introduced in the early 1980s. This compound concept was developed to overcome the high failure rate of polyethylene insulated cables reported in the late 1970s in the USA and to bring more confidence in the MV XLPE market. The origin of this high failure rate was attributed to poor cable construction and inadequate installation practices leading to extensive water tree degradation of the first generation insulations.
The copolymer XLPE concept has over the years evolved in formulation optimisation and compound quality to become a robust technology meeting today's industry requirements of electrical performance and processing economics. This material family is now the preferred power cable insulation technology in MV bonded cable constructions.

Keywords: Power cable, insulation, copolymer, wet ageing

Résumé: Le PRC modifié par l'adjonction de copolymères fut introduit dans les années 80 comme isolant des câbles d'énergie. Leur développement a été motivé par le besoin d'améliorer la résistance aux arborescences d'eau du PRC sur base PEBD en vue d'en assurer son acceptabilité comme isolant MT. L'expérience aux USA à la fin des années 70 avait en effet identifié ce phénomène de dégradation électrochimique comme une des raisons primordiales du claquage prématuré des câbles de la première génération isolés au polyéthylène.
La performance des PRC-copolymères a évolué au cours des ans pour répondre aux besoins de l'industrie à la recherche d'une technologie robuste et compétitive économiquement. Le PRC-copolymère est aujourd'hui devenu le matériau d'isolation de référence pour les câbles MT à écran semiconducteur adhérent.

Mots clés: Câble d'énergie, isolation, copolymère, arborescences

1. Introduction

Due to its intrinsic electrical properties, low density polyethylene (LDPE) had already by the 1950s established itself as a superior insulation material for power cables compared to the then commonly used rubber and polyvinyl chloride (PVC). A major advantage of extruded polyethylene insulation over oil filled paper cables is the absence of a dielectric fluid. Consequently, operating and maintenance activities are significantly reduced; leakage problems are eliminated leading to a simpler cable design. Initially the thermoplastic polyethylene insulation was the most popular choice in for example Germany, France and the USA. However, the LDPE cable insulation technology evolved quickly to its peroxide crosslinked version (XLPE). Among the advantages of XLPE are the improved heat deformation characteristics allowing higher carrying capacities of the cable, essential for overload conditions.
XLPE cables have been installed in Japan since 1965 and today all cables in Japan up to 69 kV are made of this material. The Scandinavian countries introduced XLPE in the early 1970s and have installed many thousands of kilometers of XLPE cable in the voltage range 12 – 420 kV. The American experience has been well documented and published in the surveys conducted by Thue (1). A later survey (2) reported that 60 000 km of PE cable and 116 000 km of XLPE cable had been installed in the USA by the end of 1983.
However, the service experience in the USA was found to be unsatisfactory compared to that in Europe. The susceptibility of both PE and XLPE cables to premature failures arising from electrical discharge and water trees had been overlooked. Early American designs utilised a semiconducting tape screen applied helically over the conductor. This construction was later superseded by an extruded layer of semiconducting material. The absence of an extruded polymeric jacket and the often wet laying conditions of the cable were identified for reasons for early electrical breakdown. Also insufficient care was taken to avoid