Copolymer WTR XLPE solution for inter-array wet design enable offshore wind growth acceleration: a full life cycle perspective

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ABSTRACT

This study compares the performance of two model cable cores insulated with two different insulation materials, copolymer WTR and additive WTR, in the CIGRE TB 722 salt water wet ageing test using the 2 years wet ageing time. A model cable core insulated with a modified insulation material, balancing wet ageing performance and dielectric losses, and modelling applications above the range of CIGRE TB 722, has been tested as well using a higher ageing stress. Breakdown values are presented and reviewed. Sustainability aspects are discussed as well.

KEYWORDS

Copolymer, CIGRE TB 722, salt water, 50 Hz, wet ageing, water treeing, wet design, life cycle

INTRODUCTION

Given the high interest and need from the offshore and cable industries to implement solutions which can lower the cost per GW, while still preserving the highest reliability and sustainability in operation, wet design cables can play a pivotal role to accelerate offshore wind growth.

Thanks to its superior wet ageing and productivity properties, the crosslinkable copolymer water tree retardant (WTR) solution is the leading proven technology platform for wet or semi-wet inter-array cables, bringing consistent benefits in terms of reliability, sustainability, and total cost of ownership. This paper discusses the benefits of this technology platform in regard of sustainability, adding new interesting insights to possible developments of wet inter-array solutions for voltage levels beyond 66 kV, and for floating wind applications.

High voltage (HV) subsea cables are normally of a dry design, which means that they include moisture impervious barriers, for example lead, to keep the insulation dry. In absence of this layer, moisture is allowed to enter the insulation and water trees can start to grow. However, studies on initiation of water trees and water tree growth have shown that this is affected to a large extent by availability of water in the insulation. In [1] it has been shown that if the relative humidity (RH) is below about 70% there is no initiation of water trees. When the RH is between 70 to 100% water trees grow at a reduced rate and above 100% RH water trees will grow with full rate [2].

Cables installed in the sea will be surrounded by salt water. This means that the insulation layer in a cable with wet or semi-wet design may also be exposed to ions originating from the salt. There are numerous experimental studies demonstrating that ions play an important role in the initiation and propagation of water trees on small-scale samples [3]. This is also the reason why small-scale laboratory test methods, where the insulation is directly exposed to water, like the ASTM D 6097 water needle test, are normally using a saline water electrolyte. There are however, less studies exploring the effects of ions on wet ageing characteristics of full-scale samples. The evidence of ionic diffusion through the cable materials has been reviewed in [4], and the conclusion is that, although there is experimental support of ionic (sodium and chloride) diffusion through cable materials from laboratory tests on plaques, there is no such evidence from measurements on cable samples. The potential effect of ionic diffusion into the insulating layer of full cables remains unclear.

Crosslinkable copolymer WTR insulation compounds have been used for wet designs in medium voltage (MV) land applications for several decades with excellent results. For this application, wet ageing properties are assessed via testing according to the CENELEC HD 605 in tap water. On the other hand, technical brochure (TB) 722 prepared by CIGRE SC B1, “Recommendations for additional testing for submarine cables from 6 kV (Um=7.2 kV) up to 60 kV (Um=72.5 kV)” [5] is now available to evaluate the wet ageing performance of insulation compounds intended for existing 66 kV applications under marine environments. In this study two peroxide crosslinkable insulation grades have been tested using a model cable core with 5.5 mm insulation thickness (20 kV cable construction), using a design stress of 6 kV/mm as a model for current 66 kV array cable design. Another model cable core with a design stress of 8 kV/mm, corresponding to higher service voltage levels was also included in the test program. In the absence of other guidelines for testing high voltage cables in salt water environment, CIGRE TB 722 was used as the basis for that testing as well.

EXPERIMENTAL

Samples

Materials

WTR-C – copolymer water tree retardant insulation material.

WTR-A – additive water tree retardant insulation material.

WTR-C-HV – a material based on the copolymer water tree retardant technology optimised for use at higher stress levels.

All three materials listed above are peroxide crosslinkable insulation compounds.

For all model cable cores tested in this work, the same peroxide crosslinkable semiconductive material was used,