The degassing process of HV XLPE cables and its influence on selected electrical properties

Annika **SMEDBERG**, Jan-Ove **BOSTRÖM**; BOREALIS AB, Stenungsund, Sweden, annika.smedberg@borealisgroup.com, jan-ove.bostrom@borealisgroup.com

Pekka **HUOTARI**, Maillefer Extrusion Oy, Vantaa, Finland, Pekka.Huotari@maillefer.net

Magnus **BENGTSSON**, Nexans Norway AS, Halden, Norway, karl_magnus.bengtsson@nexans.com

ABSTRACT

Degassing of high voltage (HV) and extra high voltage (EHV) XLPE cables is a widely established practice in the industry where the prime reason is to reduce the content of methane for safety and operation reasons. As degassing is a capacity demanding and time consuming process access to a methane diffusion calculation model would provide a helpful guide for an optimisation of the degassing process. The paper presents a calculation tool and experimental work made on samples from commercial high voltage cables. In addition the influence of different contents of polar peroxide decomposition products on selected electrical properties is also presented.

KEYWORDS

crosslinking, methane, degassing, modelling, electrical properties

INTRODUCTION

Today crosslinked polyethylene (XLPE) is the preferred insulation material for use in distribution and transmission cables rated up to 500 kV. The crosslinking of the polyethylene chains is accomplished by peroxides of which dicumylperoxide (DCP) is the most frequently used type. Each decomposed peroxide molecule, whether it provides a crosslink or not, gives at least three peroxide decomposition products, methane, cumylalcohol (CA) and acetophenone (AP), which are contained within the crosslinked polyethylene. The ratio between CA and AP is determined by the actual temperature in the polymer matrix during the crosslinking reaction. An increase of the crosslinking temperature normally results in a higher content of acetophenone and thereby in a higher content of methane as well [1]. Thus the composition of the peroxide decomposition products will depend on the cable type, production technology and the processing conditions used.

Degassing of high voltage and extra high voltage XLPE cables is a widely established practice in the industry. The prime reason is to reduce the content of methane due to its flammability and related health and safety issues. In addition, related internal pressure and influence on accessories has also been addressed. This is because HV/EHV cables typically have a metal barrier to prevent water ingress into the insulation system. The metal barrier prevents methane residues to diffuse out and the gas can thus travel along the cable during operation and exert an undesired mechanical pressure on accessories leading to issues in service [2].

Degassing of cables has to take place in special degassing chambers. The planning of the conditions to be used has to take factors such as time, temperature, cable construction and amount of cables into account. An important parameter for the degassing is the actual design of the cable core, where both the thickness of the XLPE insulation and the conductor design have a considerable influence. Typically the conductor can be unfilled, filled or solid. The degassing time is much shorter for an unfilled conductor compared to a filled/solid conductor. Typically subsea cables are filled with water blocking compound in order to prevent axial water penetration into the conductor in the case of a failure during installation or operation. The use of a filled conductor in combination with long cable lengths gives rise to a considerably longer degassing time compared to underground land cables that often has an unfilled conductor and shorter cable lengths. As degassing is a capacity demanding and time consuming process, it would be valuable to find means of decreasing the present degassing time without jeopardizing the technical features of the cables. For this reason a practical calculation model would provide valuable support. This, in combination with reliable and specific methods for the analysis of methane, would form a basis for cable manufactures to combine optimised degassing conditions with maintained safe limit of methane. Today a curing calculation program is used to determine the correct line speed and heating zone profile for a certain cable construction and it is the aim with this work to present how a methane calculation model can be combined with this program.

The cumylalcohol and acetophenone, referred to as polar by-products or polar decomposition products, have a considerably lower diffusion rate than methane and will remain in the cable over very long times. The influence of these polar decomposition products on various electrical properties have been discussed in the literature with somewhat conflicting results. Both AP and CA are reported to increase the alternate current (AC) breakdown (BD) strength when added separately in controlled amounts to crosslinked degassed plaques [3]. When tested in the same way but with both components present still an improvement is reported but not to the same extent as when added as separate components [3]. On the other hand the impulse BD strength is found to be lowered in samples with CA and AP added separately [3]. The tree inception voltage is reported to increase in the presence of AP [4]. Nakatsuka *el al* [5] identified that tan δ is increased when AP and CA respectively are added to crosslinked degassed thin plaque samples, especially at high temperature and high stress.