WATER TREEING TEST RESULTS FOR DIFFERENT XLPE COMPOUNDS OBTAINED WITH NEEDLE TECHNIQUES

Mikhail SHUVALOV, VNIIKP, (Russia), shuvalov@vniikp.ru
Vladimir OVSIENKO, VNIIKP (Russia), vniikp@vniikp.ru
Yuri OBRAZTOV, VNIIKP (Russia), vniikp@vniikp.ru
Andrzej URBANCZYK , Borealis u.l , (Poland), andrzej urbanczyk@borealisgroup.com
Jan-Ove BOSTROM, Borealis AB , (Sweden), jan-ove.bostrom@borealisgroup.com

ABSTRACT

This paper presents results from water tree studies based on a water needle test method. Several cables insulated with different XLPE insulation compounds, including peroxide-cured XLPE copolymer, peroxide- cured XLPE homopolymer and silane- cured XLPE have been evaluated.
In addition, the analysis of insulation morphology is presented for all dielectrics under consideration, as revealed by light microscopy.
The results from this study show that water tree growth by the water needle test method exhibits the same ranking of the different materials as seen in model cable tests.
It also shows that superior performance is demonstrated by enhanced copolymer XLPE insulation.

KEYWORDS

Water treeing, Needle test, Morphology, Model cables

INTRODUCTION

A variety of methods has been used to study the water treeing characteristics of polymeric insulations. Experiments in laboratory scale are typically made on press-molded objects. Studies have shown that it is possible to rank the performance of insulation compounds tested on laboratory objects in same order as the performance obtained by accelerated tests of cables [1].
By creating tiny water needles in objects taken directly from cables and subject them to electrical stress in presence of water, it is possible to study the true intrinsic water treeing properties of cable insulations.
This paper describes a water needle test method and results from tests of selected cable specimens with different insulation compounds. Morphology studies made of the cable samples is also reported.

MATERIALS

Crosslinked polyethylene (XLPE) is the most commonly used insulation material for modern MV cables. The XLPE is obtained by either peroxide or silane crosslinking of polyethylene. The peroxide XLPE exists in different compounds formulated to obtain long life and optimum processing and electrical performance. The classic peroxide XLPE is based on polyethylene homopolymer.
A broadly used later developed type is the so called copolymer XLPE that was developed in the 80ies for improved water tree retardant performance. This was obtained by addition of an acrylate copolymer to the polyethylene homopolymer base. A recent development of this category of copolymer XLPE has been made to further enhance the processing and water tree retardant performance.
The modern silane XLPE for power cable insulation is based on a reactor made polymer where the silane groups are attached to the polymer backbone simultaneous with the polymerization, i.e. a co-polymerization process.

For this study, commercially manufactured cables with the following insulation compounds have been selected:

- XLPE 1: Classic (homopolymer) peroxide XLPE
- Copo-XLPE 1:Copolymer modified WTR peroxide XLPE
- Copo-XLPE 2: Copolymer modified enhanced WTR peroxide XLPE
- Si-XLPE: Reactor made silane XLPE

ANALYSIS OF INSULATION MORPHOLOGY

Morphology, i.e. the structural organization of the insulation is one of the factors that determines the dielectric strength and the reliability of medium and high voltage cables, and in doing so morphology in the general case depends on the chemical composition and physical properties of insulation materials, as well as on their processing technology (extrusion equipment design, thermal conditions of extrusion, vulcanization and cooling).
The basic method for morphology analysis used in the present study is the computer-aided video enhanced microscopy, thus the spatial resolution is limited by the potentialities of the light microscope optics. DSC is used as an additional method.

Units of morphology of XLPE insulation in optical respect constitute phase objects, therefore methods which are sensitive to phase shift should be applied in their study. The present work employed the following main methods: dark-field microscopy (at low magnifications) and asymmetric illumination contrast (AIC), according to [2] for medium and large magnifications.

Morphology of homopolymer insulation.

At higher magnifications one can see that the basic large structure elements – clouds – split into separate regions which we will further refer to as “microclouds”. The concentration of microclouds in the cable under consideration is relatively small which means that it is rather homogeneous in terms of morphology. The same is also true for the copolymer and silane copolymer cables.