HVDC dielectric material comparison from cable characterizations as a mean for material selection

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ABSTRACT

The present paper aims at describing the measurement methods applied to mock-up cables in order to evaluate their dielectrics. The focus is on leakage current and temperature measurements together with the processing based upon them to assist in the selection of the more appropriate material.

KEYWORDS

HVDC cables, dielectric, characterization, material selection.

INTRODUCTION

With increasing operational DC voltages for power transmission, the electric stress in cable dielectrics is increasing, leading to greater influence of Joule losses and space charge dynamics on the cable system ageing. The former may lead to thermal runaway while the latter may induce higher electric field distortion. Both may result in the breakdown of the cable. In this context, it appears important to carefully select the right cable dielectric material for a given DC application.

A first step toward the selection of the optimum dielectric material is to characterize and compare different formulations in the shape of flat samples. The use of such samples is beneficial when compared to cables as it is easier to produce and faster to characterize [1], [2]. On the other hand, in many respects, the structure of flat samples differ from cables: geometry, arrangement of molecular chains due to the manufacturing process, by-product content and distribution and so on. As a consequence, the dielectric materials selected on the basis of flat sample study may produce unexpected behaviors when embedded into a cable.

It appears then that one of the important stages of dielectric material selection is the comparison of their parameters when directly used in cables.

The present paper aims at describing the measurement methods applied to mock-up cables in order to evaluate their dielectrics. The focus is on leakage current and temperature measurements together with the processing based upon them to assist in the selection of the more appropriate material.

SETUP AND TEST PROTOCOL

Test objects

The test setup is composed of two loops. A dummy loop used as thermal reference for the tests at temperatures higher than ambient and a voltage loop on which the different voltages are applied in combination with the temperature. The conductor cross section of the tested object is 95 mm² and the XLPE based insulation thickness is approximately 5 mm. A picture of the test setup is given in Figure 1. The experiments were carried out in the high voltage Faraday's cage at SuperGrid' Institute.

Figure 1: Characterized cable sample.

Measurement setup

Several temperature sensors composed of PT100s and T-type thermocouples were placed both on the dummy loop and on the voltage loop to follow the evolution of the cable conductor and outer sheath temperatures during the experiment. The sampling frequency for the acquisition of the temperature was 1 Hz. A moving average over 30 s was applied prior to display and record.

The leakage current was measured through a shunt resistor located between the voltage loop outer screen and the ground pit of the high voltage laboratory, as shown in Figure 2. The sampling frequency of the for the acquisition was 2 kHz. Special care was taken in order to mitigate the effects of the perturbations emitted by the voltage and heating current generators on the measured leakage current, such as parasitic currents induced by the ripple of the voltage generator. A numerical low pass filter with a cutoff frequency of 0.05 Hz was then applied prior to display and record.