EVALUATION OF INSULATING SYSTEMS QUALITY FOR HVDC POWER CABLE DESIGN TOWARD SPACE CHARGE CRITERION

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ABSTRACT

This paper deals with the evaluation of the quality of different insulation systems suitable for HVDC applications. The considered systems are insulation/semi-conductor couples used in model cable designs. The criterion used is space charge build-up: Indeed, it is now accepted that the electric field distortions resulting from space charge build-up in the insulation thickness is closely linked to the cable performance, more than ever in HVDC conditions. Our work contributes both to reveal the suitable insulating system and to control the longitudinal homogeneity of the system in regard with space charge build-up. The outcome of this experimental campaign was found to be of great interest and led to decisive orientations for insulation selection and design.

KEYWORDS

Insulation/Semicon Systems, HVDC, Power Cables, Space Charge, Electric Field

INTRODUCTION

In this collaboration, we have studied the dielectric properties of polymer materials. These materials are used for making high voltage power cables. The study of dielectric properties of these materials has been carried out on miniature cables, called here "model cables". Three different model cables (with three different couples insulation/semicon materials) have been analysed: HVDCM0-1, HVDCM0-2 and HVDCM0-4.

The purpose of this study was to characterize the dielectric behaviour of materials submitted to combined constraints and to assess the suitability of the insulating systems to accumulate and release space charges. We have thus evaluated, by using a space charge measurement method, the ability of the three model cables to store space charges when they are submitted to an electrical and thermal stress: 20kVdcduring 4hours at70℃. Indeed, it is now accepted that the electri c field distortions resulting from space charge build-up in the insulation thickness is closely linked to the cable performance, more than ever in HVDC conditions [1-3].

The space charge measurements were performed using the Thermal Step Method (TSM). A brief description of the TSM is done in the following section.

THE THERMAL STEP METHOD

This investigation was carried out using the thermal step method (TSM), a non-destructive space charge measurement technique. It involves applying a temperature step to a short-circuited insulating sample and measuring the capacitive current response (with a magnitude order of 10^{-12} to 10^{-9} A). The response reflects the amount of charge trapped in the insulation; then the internal charge distribution can be calculated. The TSM can be applied to flat specimens [4], short pieces of cable or cable loops several meters long [5-6].

Two variants of the TSM can be used: the Inner Heating Technique (IHT) and the Outer Cooling Technique (OCT). The IHT, which does not require any specific preparation of the cable prior to the measurements, follows the evolution of the mean electrical state of the whole cable insulation (several meters long) in relation to applied ageing electro-thermal stresses.

The OCT aims at a local analysis of the cable (20 to 40 cm lengths). A cooling exchanger is moved along the cable to detect possible longitudinal differences in space charge build-up in the insulation. Thus, cutting the cable into pieces is not required, and measurements can be performed without prior dc poling.

The cable was short-circuited via a current amplifier, and a thermal step of -30℃ was applied to the outer s emicon during some tens of seconds by circulating a cold liquid(Fig. 1). The thermal step current was measured during cooling. The cable was then reheated during several minutes by circulating a liquid at room temperature. Each experiment was repeated three times in order to confirm the repeatability of the results.

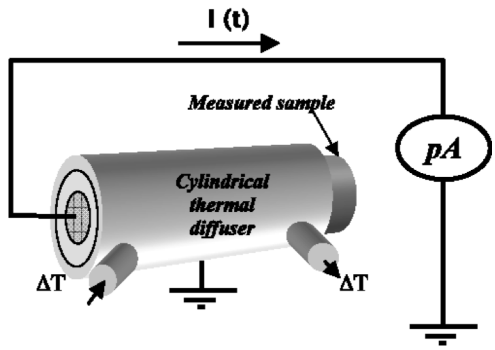

Fig. 1: Principle of the TSM applied to a cable using the outer cooling technique in short-circuit conditions

The thermal step was applied to the samples using a cylindrical radiator (thermal diffuser). A radiator with improved thermal transfer was designed for this purpose. (Fig. 1). The liquid flows directly on the external semicon. By this way, the sensitivity of the measurements has been significantly increased, allowing to measure space charge densities of ~1 m.C/m^3 on 1 mm thick samples.

The capacitive thermal step current I(t), measured by the current amplifier, is generated by changes in the induced charge on the electrodes by the space charge in the