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ELECTRICAL AND PHYSICO-CHEMICAL ANALYSIS OF BELGIUM MEDIUM VOLTAGE CABLES DATA BANK

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ABSTRACT

The Belgian Medium Voltage "MV" distribution network consists of a great diversity of under ground cables coming from many manufacturers. This results in a variety of cables executions due to manufacturing processes and used materials.

In service, these various cables, in particular their polymeric insulation can react differently under the effect of the applied combined constraints. It is well known that the electrical constraints applied to insulation strongly influence its electrical properties, in particular its condition in time (ageing).

In this work, we studied the electrical behaviour of cables resulting or intended to use in the Belgian MV network. The ageing markers are the space charge whose harmful effects on the electrical behaviour on the cable insulations are well known. The measurement technique to detect these space charges on cable samples is the Thermal Step Method "TSM" installed at LABORELEC. We have studied the influence of the electrical and thermal constraints applied to various MV cables on the appearance and the development phenomena of space charges in the insulation. The observed phenomena: space charge injection from the electrodes and/or polarization phenomenon have been studied and discussed. These observed phenomena have been also consolidated by some physicochemical characterizations (DSC , FTIR, XRF) performed on each insulating and semiconductor materials used in the analyzed cables.

The final analysis of the results of this work and their interpretation confirms the influence of the couple material insulator-semiconductor in the injection and polarization phenomenon.

KEYWORDS

Medium voltage cable insulation, space charge, polarisation, injection, morphology.

INTRODUCTION

Electrical and physicochemical properties of insulating materials used in high or medium voltage applications can evolve in time. This phenomenon, called « ageing », is strongly related to the external factors acting upon the materials (electric field, temperature, humidity etc.) and to the manufacturing process. Thus, considerable efforts have been made to understand, to interpret and to prevent ageing.

Considering the electrical properties, an insulating material is supposed electrically neutral; however, electric charges (space charges) can penetrate or can be already present within the insulating material [1]. These space charges can be related to several phenomena such as injection and /or polarization. It has been shown that these electric charges trapped in insulations, could play a significant role on ageing, by creating a supplementary internal field [2-5]. Indeed, it seems that the more the insulation stores space charge, the more its ageing is accelerated by the global electric field increasing (sum of the applied field and the supplementary internal field). Sometimes, these charges can cause significant field distortion to affect the insulation performance and to reduce its lifetime. In this work, the space charge measurements have been performed by using the Thermal Step Method "TSM" [5]. A physicochemical analysis by microscopy, infrared spectroscopy (FT-IR) and differential scanning calorimetry of the insulating materials and semiconductor materials has also been performed to explain and/or consolidate the observed phenomena [6].

This study has been carried out on several cables (with several dates of manufacturing) quoted above in order to control their faculty to accumulate the space charges when they are subjected to combined constraints (electric field, temperature, duration).

- Cable 1A (1978), used in network (with water treeing)
- Cable 1C (1978), used in network (with water treeing)
- Cable 2A (1998), electrical lightning tests
- Cable 5C (1992), unknown historic
- Cable 21D (1994), used in network (thermal annealing 120°C)
- Cable 22B (1992), various tests

EVOLUTION OF THE SPACE CHARGES VERSUS THE APPLIED CONSTRAINTS

The various samples of the Belgium medium voltage cable bank were analyzed after having undergone various electrical, thermal and temporal constraints. We present here the evolutions of the space charge profiles according to the applied constraints.

Note: All the distributions presented in this paper present space charge density profiles according to the cable radius. The anode (electrode submitted to the plus of the poling voltage - cable core) is at the left, and the cathode is at the right of figures. The highlighted phenomena, namely polarization and injection will give:

- For charge injection: the presence of homocharges (same