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Space charge in AC-poled XLPE for HV cables

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Résumé

Ce travail porte sur les charges d'espace et le vieillissement du polyéthylène réticulé chimiquement (PRC) soumis à un fort champ alternatif (50 Hz).
A l'aide de la sensible méthode de l'onde thermique, nous apportons des preuves expérimentales concernant l'influence des charges d'espace dans le vieillissement sous contrainte alternative. Nous montrons, par des mesures de charges d'espace, que ces charges sont bien présentes dans le PRC conditionné en alternatif et nous suivons leur évolution dans le temps. En corrélant les mesures de charges d'espace avec des expériences de courants de décharge thermostimulés et des mesures de pertes diélectriques, nous analysons le vieillissement du PRC sous champ alternatif, en mettant en évidence l'augmentation des pertes diélectriques en parallèle avec le contenu en charges d'espace.

Abstract

In this paper, space charge and AC ageing of cross-linked polyethylene for high voltage cable insulation are studied.
Using the sensitive thermal step method (TSM), we bring experimental proofs concerning the involvement of space charge in AC ageing. By TSM, we reveal the presence of steady space charge in AC-poled XLPE samples and we observe the space charge dynamics.
Dielectric loss measurements and experiments of thermally stimulated discharge currents (TSDC) are also performed on the samples. A correlation between space charge and increase of dielectric loss is attempted. The probable effects of space charge on the degradation of the electrical properties of XLPE in AC are brought in sharper focus.

Introduction

The remarkable properties of polyethylenes make them widely used as insulators for power cables. However, the electrical properties of polyethylene-based insulations diminish in time irreversibly when submitted to combined electrical and thermal stress. This phenomenon, called "ageing", results in detrimental effects for the cables, as increase of dielectric loss and decrease of the breakdown strength. Over the last decades, considerable efforts have been made to understand polymer ageing. The physical and chemical processes involved are still poorly understood. Several theories have been proposed [1], but none of them allows to make satisfactory predictions on the long term behaviour of a HV insulator.

An insulating material is supposed electrically neutral; however, electric charges can penetrate and accumulate within the material (*space charge*). It is strongly believed that space charge is one of the factors involved in the ageing process, as it creates a supplementary internal field (*remnant electric field*) and it increases the internal energy of the dielectric [2, 3, 4]. Indeed, it seems that the more an insulation stores space charge, the more its ageing is accelerated. Moreover, charge transport [5] can produce molecular chain distortion, which creates energy traps and can favour accumulation of other charges. Over the last ten years, the set up of non destructive methods for space charge measurement [6] resulted in various studies on space charge.

The role of the *space charge in AC ageing* is poorly understood, since there is very few