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B.8.1. Une revue des résultats de vieillissement électrique accéléré des câbles extrudés

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Résumé

Une étude bibliographique des principaux modèles de vieillissement électrique a montré que la loi de puissance inversée ne peut pas décrire l'ensemble des résultats de vieillissement accéléré des câbles extrudés HT. Le modèle de Crine *et al* est celui qui décrit le mieux les résultats de câbles isolés au PE, PRC et EPR. Ce modèle dépend de deux paramètres physiques ΔG_o, l'énergie d'activation et λ_{max}, la largeur de la barrière limitant le vieillissement. Comme prédit par le modèle, le champ électrique de rupture décroît exponentiellement avec le temps pour des champs supérieurs au champ critique, F_c. Ce paramètre peut être calculé à partir de l'énergie de cohésion du diélectrique et de l'épaisseur de sa phase amorphe. À bas champ, le champ de rupture varie très lentement avec le temps donnant l'impression d'un seuil en dessous duquel il n'y a pas de vieillissement. Les résultats obtenus avec des câbles dans plus de 200 expériences différentes de vieillissement accéléré dans l'air ou dans l'eau sont analysés en fonction de notre modèle. Il apparaît entre autres, que les résultats obtenus avec des câbles miniature sont différents de ceux obtenus avec des câbles pleine grandeur.

B.8.1. A review of electrical accelerated ageing data for extruded dielectric cables

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Abstract

From a review of existing theories and experimental data, it is deduced that the rate theory, modified to take into account some elements of the Zhurkov and Zeller theories, could describe the electrical aging of extruded cables. The proposed model relies on two physical parameters: ΔG_o and λ_{max}, the free energy and the width of the barrier controlling aging. The model predicts that at high fields there is a linear relation between electric field and the log of time-to-breakdown. Below a given critical field, the breakdown field does not vary linearly with the log of time-to-breakdown. In its present form, the model allows the determination of the value of the critical field. Various materials can also be compared from the values of ΔG_o and λ_{max} determined from high field endurance results. It was verified that the proposed model describes the published voltage endurance results for PE, XLPE and EPR cables aged in air or water. The influence of air, water, temperature and polymer nature on the values of ΔG and λ_{max} was briefly discussed. Miniature cables give slightly different results than actual cables.

Introduction

Despite the huge amount of data on the so-called electrical aging of extruded high-voltage cables, the fundamental phenomena responsible for it or evolving with aging time are still far from well understood. It is therefore not surprising why it is so difficult to predict reliable cable lifetimes in service from accelerated-aging experiments in the laboratory. The objective of this paper is to critically review the existing theories of electrical aging of solid dielectric materials. A relatively large number of models and theories exist but none of the most often used is known to yield reliable life predictions. One conclusion is that there is a need for a more comprehensive model of electrical aging of extruded dielectric cables. In order to develop this model, an extensive review of existing literature data was undertaken. More than 200 papers on aging of PE, XLPE and EPR cables were retrieved and their data was analyzed.

The next section of this paper is a rapid review of existing theories and models; more details may be found in Refs [1, 2]. The section on the review of existing data is more extensive, although details and a more complete analysis are given in Ref. [1]. Finally, this paper ends with a summary of the most important findings drawn from these reviews. Note that none of the experimental results discussed in this paper were obtained by us and, to the best of our knowledge, they represent all the data published between 1962 and 1989 and some (but not all)