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Evaluation of insulation degradation of stressed XLPE cables

GARROS B., Alcatel CIT, Marcoussis, France
AUDRY C., SAFT, Marcoussis, France
SCHADLICH H., Alcatel Kabel, Hannover, Germany
MONTANARI G.C., BENCIVENNI L., DIE, University of Bologna, Italy

Résumé

Une nouvelle technique de diagnostic de vieillissement pour isolant de câble soumis a une contrainte thermo-électrique est présentée. Cette technique, destinée à la prédiction du seuil électrique en courant continu, s'appuie sur des mesures conventionnelles de courant de charge et de charges d'espace. Nous supposons que la variation du seuil électrique avec le temps d'application de la contrainte est associée à la dégradation de l'isolant, et que le vieillissement est d'autant plus important que cette variation est grande. Des informations sur le vieillissement sont également tirées à partir de la forme des courbes de courant de charge à différentes valeurs du champ électrique. Les résultats obtenus par cette nouvelle technique sont confirmés par des mesures de taille de submicrocavités avec la méthode SAXS.

Abstract

A new method for the diagnosis of ageing of cable insulation subjected to electrothermal stress is described in this paper. The method relies upon conventional charging-current measurements and space-charge observations, but focuses on the use of these techniques for DC electrical threshold inference. It is assumed, indeed, that the variation with stress time of the electrical threshold is associated to insulation degradation, and the larger the variation, the more significant is ageing. In addition, also the shape of the charging-current characteristics at various electrical field values gives information about ageing. The results obtained by this method are supported by SAXS observations.

1. Introduction

The problem of timely evaluation of insulation degradation of polymeric cables in service is still widely open. Various techniques have been proposed, from the classic dielectric permittivity and losses measurements, to partial discharge investigation and, more recently, space-charge observation. However, often indications on insulation degradation are achieved when ageing is already significant, as it occurs, for example, when partial discharges associated to electrical tree growth are detected.

Another intriguing problem is that of the evaluation of the level of electrical and thermal stress above which insulation degradation can proceed with significant speed (i.e. identification of ageing threshold). Besides techniques for short-term threshold inference, methods for an early detection of insulation degradation should be investigated, since conventional accelerated life tests, prolonged until electrical breakdown, cannot be used at stresses close to the design one (requiring too long times before any information can be achieved). This aspect is directly related to the first item raised above, i.e. timely evaluation of insulation degradation.

XLPE insulated cables for AC applications, subjected to electro-thermal stress for long times (more than 4 years), were investigated, [1], searching for insulation ageing evidence. The examined indicators were electric strength, loss factor, mechanical properties, oxidative stability, water content, conductivity, potential decay and space-charge observation. Only the two last properties seemed to provide indications on some occurred ageing. Following that work, a new approach based on charging current measurements has been investigated, and the results thereby obtained are here presented.

Since ageing means irreversible degradation of insulation, it can be assumed that an early diagnosis of ageing can be achieved by measuring properties sensitive to morphological changes of insulation. In this paper, a procedure consisting of DC charging-current measurements at fields above and below the unaged-material threshold is proposed as a tool to detect early stage of insulation degradation. The measurements are performed on specimens peeled from cables either