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On the derivation of quantities from space charge measurements for the characterization of cable insulation performance

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Résumé

Cet article fournit des grandeurs qui peuvent aider à résumer et interpreter la grande quantité de données obtenues des mesures de charges par les techniques les plus récentes. Ces grandeurs sont associées à l'amplitude et à la mobilité des charges, ainsi qu'au champ électrique. Des exemples de calculs sont reportés; ils font référence à quatre différents matériaux étudiés pour l'isolement de câbles en c. c.. On montre que ces grandeurs peuvent fournir des indications utiles sur le phénomène des charges d'espace, et qu'elles permettent d'extrapoler le comportement des isolants et de confronter différents matériaux. En outre, on propone une procédure pour obtenir une corrélation quantitative entre les grandeurs associées à la charge d'espace et la durée de vie de l'isolation.

Abstract

Quantities are provided in this paper which can help to summarize and interpret the huge amount of data resulting from space-charge measurements performed by means of the most recent techniques. The quantities are associated to space-charge amplitude and mobility, as well as electrical field. Examples of calculation are reported, with reference to four different materials investigated for DC cable insulation. It is shown that the proposed quantities can provide useful indications on space-charge phenomena, allowing inference on insulation behaviour and comparison among materials candidate for cable insulation. In addition, a procedure is proposed to achieve a quantitative correlation between space-charge associated quantities and insulation life.

1. Introduction

Space-charge measurements are becoming a fundamental tool for the investigation of cable-insulation behaviour under DC electrical stress. Accumulation of space charge into insulation is generally associated to increased failure risk of the cable, particularly due to the voltage inversions and surges to which DC cables are subjected during service operation.
However, observation of space charges provides a huge amount of information that may not be easily interpreted or summarized for the purpose of insulation characterization. One can see, for example, how much charge is trapped, the charge dynamic, the electrical field behaviour, but objective quantities that can be, eventually, correlated to insulation endurance under electrical stress are still lacking.
The aim of this paper is, in fact, to single out a few quantities derived from space-charge measurements which could help in the inference of insulation behaviour under electrical DC stress. These quantities encompass charge amount and dynamic, as well as electric field. Applications on different polymeric materials (based on Polyethylene) candidate for DC-cable applications are shown and techniques for correlation with life are proposed.

2. Life tests and space-charge evaluation

The investigation of the electrical performance of insulating materials for DC applications can resort to electric strength and accelerated life tests, as well as on space-charge observation. The advantage of life tests is that a direct information on the consequence of the application of stress (electric field) on insulation, i.e. time to breakdown, can be achieved. The disadvantage is that reasonable test times can be obtained only by very large increase of stress magnitude. Hencefrom, test stresses are, in general, very far from the actual service stress, thus extrapolation from test to service stress can be hazardous.