JICABLE '99

C2.7

Correlation between conduction and space charge studies on laminar dielectrics under DC stress

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Résumé

Beaucoup de défis technologiques doivent être abordés lorsqu'on utilise une isolation rubanée en papier pour des applications en courant continu. Un bon isolant doit posséder une distribution de champ électrique stable dans toutes les conditions de fonctionnement, et une rigidité diélectrique élevée (sous tension continue, inversion de polarité et impulsions superposées). Cette communication discute des corrélations entre les propriétés électriques et les effets de la tension appliquée et de la température. Les caractéristiques électriques examinées sont la conductivité, la rigidité diélectrique et les charges d'espace. Les conséquences pour les critères de choix et de fabrication concernant les câbles à isolation rubanée THT à courant continu, sont ainsi soulignées.

Abstract

There are a number of technological challenges that need to be addressed when using a lapped paper insulation for DC applications. A good DC insulation must have a stable electrical stress distribution under all operating conditions, and high breakdown strength (under DC stress, polarity reversal and superposed impulse conditions. This paper discusses how the electrical properties are affected by the applied voltage and temperature. The electrical properties examined here are conductivity, breakdown strength and space charge. The implications for selection and manufacturing criteria for EHV DC power cables using lapped insulation are thus emphasized.

Introduction

There are two methods of transmission of electrical power: Direct Current (DC) and Alternating Current (AC). Electrical cables have been in service for both AC and DC transmission for both land and subsea applications for many years, using impregnated lapped (paper and paper polypropylene laminate) insulations [1,2,3]. However, there are a number of technological challenges that need to be addressed when using a lapped insulation for DC applications. A suitable insulation must provide a stable electrical stress distribution under a wide range of temperature conditions and also as a function of time. It must also possess high breakdown strength under conditions of DC stress, polarity reversal and electrical impulse. This paper investigates how the main factors (applied voltage and temperature) interact with the electrical properties.

Experimental

Samples

This communication reports work performed on traditional paper only; paper polypropylene laminate work will be reported later.

Paper samples with selected densities and thicknesses were tested to investigate the effects of impregnation methods and paper properties. The samples were impregnated with the modern insulating cable fluid, dodecyl benzene, which has a viscosity of $4.2\times10^{-6}m^2s^{-1}$ and a density of $860kg.m^{-3}$. They were either impregnated at room temperature in air, or dried and impregnated at elevated temperature in vacuum. Details of the paper samples tested are listed in table 1.

Table 1: Paper samples tested in this work.

Type	Density ($kg.m^{-3}$)	Thickness (μm)
F	1000	75
G	1050	75
L	700	200
R	900	100

The factors investigated in this study were the number of layers, the impregnation method, and the paper type.

Impregnation

The effect of the impregnation method was believed to be an important factor. To test this