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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Density (kg.m$^{-3}$)</th>
<th>Thickness (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>1000</td>
<td>75</td>
</tr>
<tr>
<td>G</td>
<td>1050</td>
<td>75</td>
</tr>
<tr>
<td>L</td>
<td>700</td>
<td>200</td>
</tr>
<tr>
<td>R</td>
<td>900</td>
<td>100</td>
</tr>
</tbody>
</table>

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