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Influence of electrochemical effects on vented tree initiation in accelerated tests

BRÜGGEMANN M., KALKNER W., Technische Universität Berlin, Germany
BROMAN C., SMEDBERG A., Borealis AB, Sweden

Abstract: The presence of water in the conductor-area of XLPE-insulated medium voltage cables with an aluminium conductor can in accelerated tests lead to the development of porous channels in the inner semiconductive layer which are able to initiate and promote vented tree growth. The electrochemical mechanism for the development of these channels was investigated by ageing of model insulation systems for different materials and ageing parameters. In this paper different possible electrochemical ageing mechanisms are proposed and discussed.
Keywords: semiconductive layer, vented trees, electrochemical degradation

Résumé: La présence d'eau dans le conducteur aluminium des câbles PRC peut donner naissance, lors d'essais accélérés, à des canaux poreux dans la couche semiconductrice interne du câble et initier des arborescences d'eau ouvertes dans l'isolant. Le méchanisme életrochimique du développement de ces canaux a été étudié en utilisant des systèmes d'isolation modèle et en faisant varier les différents paramètres de vieillissement. Différent mécanismes de vieillissement sont proposés dans cet article.

Mots clés: couche semiconductrice, dégradation électrochimique, arborescence d'eau ouverte

1 Introduction

It is well known that water trees, i.e. bow-tie and vented trees, can develop in extruded PE/XLPE-insulated medium voltage cables in the presence of water and an electric field. Normally bow-tie trees are initiated at contaminants present within the insulation layer while vented trees are initiated at particles or protrusions at the interface between the semiconductive and the insulation layer. The increased field strength or a weakened insulation at the tip of the water tree structure may initiate electrical treeing leading to an electrical breakdown of the insulation system. The extensive work on the water tree phenomena has resulted in improvements in design, manufacture, materials, testing and qualification; these have reduced the impact of water treeing in modern cable systems.

Within the extensive research and development activities, it has been reported by Burns [1] that occasionally vented trees can initiate from an apparently undisturbed semicon/insulation interface. The same observations have also been made by Kalkner et al. [2] as well as by Meurer et al. [3] who both found that in some cases structural changes in the inner semiconductive layer of the laboratory aged XLPE insulated cables could be observed.

Steinfeld et al. [4] have reported porous channel like structures in the semicon layer initiating relatively large vented trees in the insulation layer, see Figure. 1.

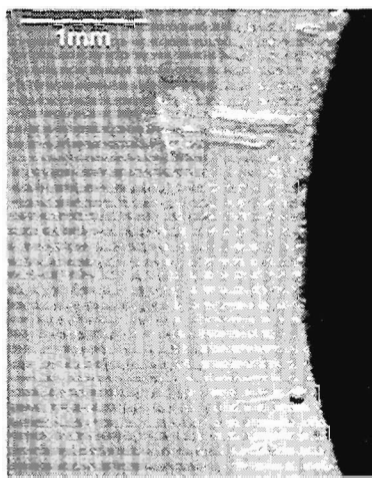

Figure 1. Structures in the inner semiconductive layer of an accelerated wet aged cable.

They proposed that the channels were generated via an electrochemical reaction between the aluminium conductor and the neighbouring semiconductive layer under the influence of mechanical stress. When an electrolyte is present in the conductor area of an insulation system a galvanic cell is formed between