B.6.5.

The effect of voltage reversal and elevated temperature on space charge behaviour in XLPE cable

FU M., CHEN G., University of Southampton, UK

Abstract: Space charge accumulation in XLPE power cable insulation under dc electric stress and polarity reversal was experimentally studied. It has been found that once space charge appears in the insulation of high voltage dc (HVDC) cable, polarity reversal becomes a crucial operation to cable insulation. The space charge accumulated prior to polarity reversal is fairly stable and can lead to a severe distortion of electric stress through cable insulation immediately after the reversal. To mimic loaded dc cables in service, space charge distribution in a cable with a temperature gradient was also reported.

Keywords: Space charge, dc XLPE cable, temperature gradient and voltage reversal.

Résumé: L'accumulation de charges d'espace dans les isolants (XLPE) de cables à haute tension, soumis à des contraintes électriques en courant continu et à polarité inversée, a fait l'objet d'une étude expérimentale. Nous avons déterminé qu'une inversion de polarité devient une opération cruciale à l'égard de l'isolation offerte par le cable transportant un courant continu (HVDC), une fois que les charges d'espace apparaissent au niveau des isolants du câble. Les charges d'espace accumulées avant l'inversion de polarité restent globalement en place, et peuvent mener à de sévères distorsions des contraintes électriques le long de la couche isolante du cable, à effet immédiat suivant la-dite inversion. Afin de reproduire la situation de câbles supportant des courants continus en service, une distribution de charges d'espace dans un câble soumis à un gradient de température a également fait l'objet d'un rapport.

Mots clés : Charge d'espace, cable de transport d'un courant continu (XLPE), gradient de température, inversion de polarité.

1. Introduction

The renewed interest in HVDC transmission has led to many manufacturers worldwide investing in polymer insulated dc power cables. The advantages of these materials, such as cross-linked polyethylene (XLPE) are their excellent electrical properties in combination with good physical and mechanical properties. However, under certain high electric stress, trapped or low mobility electrical charge within the bulk insulation can give rise to space charge, resulting in localised electric stress enhancement which may lead to premature failure of the cable well below the anticipated and designed values. This issue had fascinated many researchers over the world to investigate space charge accumulating mechanism, and some fruitful results have been achieved from the researches carried out on film and plaque samples [1-6]. However, less attention has been paid to space charge dynamics in full sized cables presumably due to limited cable system. From the view point of practical interests, the latter is more important as the production process of the insulation, electric stress and temperature profile are fully reflected [7-10].

Bi-directional power flow capability is a necessary and a quite common operating mode in most dc transmission systems. The power flow direction is controlled by exchanging roles of rectifier (sending end) and inverter (receiving end), thus, the voltage polarity is reversed. In the case of presence of space charge as mentioned previously high electric stresses within the insulation may be created in this manoeuvre due to low charge carrier mobility. This could pose a major threat to the cable insulation in service.

Additionally, the temperature gradient existing in the insulation of a fully loaded dc cable will make the space charge distribution more complex. The electric field distribution is affected by the conductivity of polymer insulation which is dependent on temperature as well as electric field. The research on space charge at elevated temperature is expected to