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Electroluminescence in XLPE due to impulses superimposed on AC voltage

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Résumé

Les câbles souterrains de haute tension en service sont assujettis par mégarde à des surtensions de commutation et atmosphérique qui se superposent à la tension c.a. à laquelle ils fonctionnent. La technique d'électroluminescence (EL) est utilisée pour étudier l'effet de la charge d'espace du polyéthylène réticulé (XLPE) de qualité câble soumis à des impulsions superposées à la tension c.a. On démontre qu'à la différence des émissions EL dans le XLPE assujetti seulement à une tension c.a., le plus grand nombre d'impulsions EL ne sont pas émises lorsque les impulsions sont superposées avant les crêtes des demi-cycles positifs et négatifs du cycle c.a. De même, plus d'impulsions EL sont émises lorsque des impulsions sont appliquées pendant le demi-cycle négatif plutôt que pendant le demi-cycle positif de la tension c.a. La technique EL peut offrir une meilleure compré hension des divers mécanismes variant chronologiquement en fonction du temps, tels que l'injection de la zone de charge d'espace, le piégeage et la décomposition qui peuvent entraîner une défaillance de l'isolant.

Abstract

Underground high voltage cables in service are inadvertently subjected to switching and lightning surges that are superimposed on the ac voltage at which they operate. The electroluminescence (EL) technique is employed to study the effect of space charge in cable-grade crosslinked polyethylene (XLPE) subjected to impulses superimposed on ac voltage. It is shown that, unlike EL emission in XLPE subjected only to ac voltage, the highest number of EL pulses are not emitted when impulses are superimposed prior to the peaks of the positive and negative half-cycles of the ac cycle. Also, more EL pulses are emitted when impulses are applied during the negative than during the positive half-cycle of the ac voltage. The EL technique can provide a better understanding of the various time dependant mechanisms, such as space charge injection, trapping and decay that can lead to insulation failure.

Introduction

Polymeric insulation is extensively used in power devices such as capacitors, cables and transformers, and cross-linked polyethylene (XLPE) is commonly employed as the insulation material in underground high voltage transmission and distribution class cables. Impulse voltage tests are usually employed to check the integrity of the polymeric insulation prior to cable installation or during service. The effect of impulse voltage on XLPE was recently studied [1] with the electroluminescence (EL) technique which is several orders of magnitude more sensitive than the commonly employed partial discharge detection It was shown that EL emission depends on the number of impulses consecutively applied to the polymer.

During normal operation, due to lightning and switching surges, underground power cables are unexpectedly subjected to impulses that are superimposed on the ac voltage. Such impulses could initiate degradation of the polymeric insulation that can continue under normal operation. This paper describes the characteristics of EL emission in XLPE subjected to positive and negative impulses superimposed on ac voltage. The EL technique is employed to determine the effect of the impulses applied at various phase angles of the ac cycle. It is shown that more EL pulses are emitted when negative impulses are applied to XLPE during the negative half cycle than positive impulses during the positive half cycle of the ac voltage. Also, more EL pulses are emitted when impulses are applied at the peaks of the positive and negative half cycles of the ac voltage than at any other phase angle of the ac cycle. This suggests that the amount of charge injected and trapped into the polymer plays a crucial role for EL emission. The EL technique can provide a better understanding of the various time dependant mechanisms, such as space charge injection, trapping and decay that can lead to insulation failure.

Experimental

XLPE samples with embedded semicon needles were used to simulate defects that could occur in the polymeric insulation of underground power cables. The samples were tested inside a light tight chamber and the sample dimensions and the experimental set-up have been described elsewhere [1].

In the present work, positive and negative impulses (±10 kV) having a rise time of 60 μs and a fall time of 750 μs,