ELECTRIC PROPERTIES OF XLPE MODEL CABLES UNDER AC AND DC FIELD AT VARIOUS TEMPERATURES

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ABSTRACT

Two types of model cables made by different cross-linked polyethylene (XLPE) materials are investigated in this paper. One material is a standard XLPE homopolymer, the other is high productivity XLPE compound. Electric properties of these cables were studied and compared under AC and DC field. In particular, AC voltage endurance was evaluated by means of an experimental set up developed for ageing and life tests in dry conditions. Additional information on the charge trapping phenomenology under DC field was obtained from the space charge measurements.

KEYWORDS

XLPE cable; AC voltage endurance; space charge; Inverse Power Law.

INTRODUCTION

Extruded polymeric cables have almost entirely substituted paper-oil AC cables in extra-high-voltage AC applications since the 1990s. Extruded cables are widely used because of their high reliability, low cost, low maintenance and environment impact with respect to paper-oil cables. However, under DC field, polymeric cables have not entirely substituted paper-oil cables in extra high voltages, due to space charge accumulation which can reduce considerably the reliability of polymeric insulation, particularly in the presence of voltage polarity inversions. In this paper, we studied the electric properties of two types of extruded XLPE model cables under AC and DC field at various temperatures. Their insulation is made of classic grade XLPE or high productivity XLPE compound. Their voltage endurance properties under AC field and space charge accumulation properties under DC field were investigated and compared.

CABLE SPECIMENS

The two types of model cables were labelled as type A (made of classic XLPE material) and type B (made of high productivity material). AC voltage endurance tests and DC space charge measurements were performed on both types of insulation. The specimens consist of model cables having the same cross-section dimensions as shown in Figure 1. They have a three-layer construction with inner and outer semi-conductive screens. They are produced on a 26 meter long laboratory-scale CCV nitrogen curing line comparable to full-scale cable lines. The main differences to a full-scale line are the use of a separate head for the inner semicon extruder (instead of triple-extrusion) and by performing the extrusion and crosslinking in two separate steps.

The total length of the cable specimen used for voltage endurance tests is 3.5m, with 1.5m outer semicon in the central area. The total length of the cable used for space charge measurement is 1.1m, with 0.1m outer semicon in the central area. All cable specimens were thermally pretreated for 180 hours at 80℃ in order to expel most of the cross-linking by-product.

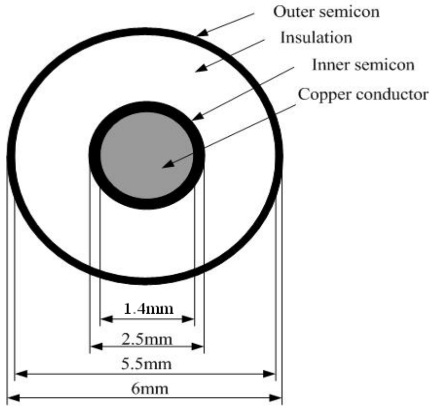

Figure 1. A sketch of the cable cross-section
Conductor diameter = 1.4mm, inner semicon thickness = 0.5mm, insulation thickness = 1.5mm, outer semicon layer thickness = 0.25mm

EXPERIMENTAL PROCEDURE

Voltage endurance tests

The voltage endurance tests were performed under AC voltage at two temperatures, 20℃ and 90℃. At 20℃, three voltages levels, i.e. 56kV, 65kV and 74kV (RMS values), were used for both types of cable specimens. The maximum Laplacian electric field values, E_{max}, at the inner semicon/insulation interface) are 57kV/mm, 67kV/mm and 76kV/mm, respectively.

At 90℃, 50kV, 56kV and 65kV (RMS values) were used for type A cables. 56kV. 60kV and 65kV were used for type B cables. Five cable specimens were tested under each voltage level at 20℃ and 90℃. The failure ti mes were processed using Weibull probability distribution [1].

The terminal parts of the cable (the parts without outer semicon) were immerged in deionized water in order to avoid surface discharges and flashover. The active part (the area covered with outer semicon) was wrapped by copper shield connected to the ground lead. The failure occurs in the active part. During the ageing, the deionized water was driven by a pump and kept flowing in the plastic tubes. The water temperature was stabilized at ~35°C by the cooling unit.