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THE USE OF MODEL CABLES FOR EVALUATION OF DC ELECTRICAL PROPERTIES OF POLYMERIC CABLE MATERIALS

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ABSTRACT

The possibility to use model cables with 1.5 mm insulation thickness for characterization of dc electrical properties of polymeric materials has been studied. Results from space charge measurements are presented and compared to those obtained from plaques (0.5 mm insulation) and full-sized cables (4.5 mm insulation). It is evident from PEA-measurements that the shape of the space charge distribution and the relative ranking of different insulation systems are basically equivalent among the different types of test specimens.

KEYWORDS

HVDC, power cables, polyethylene

INTRODUCTION

Model cables with insulation thickness 1.5 mm have been extensively used for evaluation of the wet ageing properties of insulating and semiconductive materials intended for crosslinked polyethylene (XLPE) ac power cables [1]. The main advantages with model cables compared to plaques and full-sized cables are ease of preparation, production (extrusion) under similar conditions as for full-sized cables, and the possibility to easily apply high stress levels.

The intention of the present study is to explore the possibilities to use model cables for characterization of the dc electrical properties. The focus of the paper is evaluation of the space charge accumulation process in XLPE insulation systems subjected to high dc electric stress. Will reproducible results be obtained in model cable measurements? Will the ranking of materials with respect to dc electrical performance be the same as in studies using plaques and full-sized cables?

SAMPLES

Three-layer model cables with insulation thickness 1.5 mm were extruded and dry-cured on a 1+2 pilot cable line, figure 1. The cables were thermally treated at 80°C and atmospheric pressure for five days to enable full comparison between the different material systems. This treatment ensured almost complete removal of the peroxide by-products: the levels were all below 100 ppm after the degassing step. However, one model cable and one full-sized cable were tested without previous degassing (figures 9 and 13).

The cables were cut into 1 meter long samples with 10 cm active length (with outer semicon) in the middle.

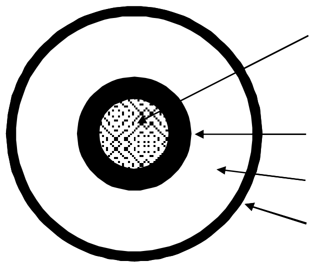

Figure 1: Three-layer model cables with insulation thickness 1.5 mm

The model cable results were compared to those obtained with plaque samples comprising a 0.50 mm insulation layer and a semiconductive layer on one side. Aluminium foil was used as electrode on the other side, this electrode was grounded during the measurements.

In addition, measurements were carried out on full-sized cables with insulation thickness 4.5 mm, a thickness corresponding to 15 kV ac power cables. A 50 mm^2 Al conductor was used in these cables.

Several different peroxide crosslinkable insulating and semiconductive materials were selected based on expected performance in dc electric field. The insulations were labeled INS1, INS2, INS3, and the semiconductive materials SC1 and SC2.

TEST METHODS

Space charge measurements were performed by the pulsed electro acoustic (PEA) technique in a controlled humidity and temperature environment. The model cables were submitted to dc poling voltages of 20 and 60 kV, corresponding to approximately 20 and 60 kV/mm electric field at conductor screen, while heated to 20 and 70°C uniform temperature in an oven. The space charge profiles were recorded regularly during the poling lasting for 10 000 s (3 hours) followed by a depolarization period lasting 2000 s (33 min) with the sample grounded. The voltage-on measurements shown here were obtained at the end of the poling, while the voltage-off profiles were recorded directly after removal of the high voltage.

Comparative space charge measurements were carried out on the plaque samples by applying electric fields in the range