ASSESSMENT OF WATER TREED CABLE INSULATION CONDITION BY MICROSCOPY AND SPACE CHARGE MEASUREMENTS

Cristina **STANCU,** INCDIE ICPE CA, 313 Splaiul Unirii (Romania), cstancu@icpe-ca.ro
Mihai G. **PLOPEANU,** Politehnica Univ. of Bucharest, 313 Splaiul Independentei (Romania), mgplopeanu@elmat.pub.ro
Petru **NOTINGHER jr,** Université Montpellier 2, Place E. Bataillon, Montpelllier (France), petru@univ-montp2.fr
Petru V. **NOTINGHER,** Politehnica University of Bucharest, 313 Splaiul Independentei (Romania), petrunot@elmat.pub.ro

ABSTRACT

In this work, the ageing condition of water treed cable insulation was assessed by optical microscopy and space charge measurements (thermal step method). Model cables were aged in the presence of water and ac electric field, during various times and at different frequencies. The dimensions and densities of grown water trees were determined in each case, and thermal step currents (images of the electric charge and polarization in the sample) were measured after a brief low dc poling of the samples. It has been found that the current amplitude increases with the growth of the water treed regions in the samples (dimensions and concentration of water trees), showing the potentiality of this quantity as a non destructive marker for the state of water-treed cables.

INTRODUCTION

Under the combined action of electric field and water the polyethylene insulations of power cables suffers degradations known as water trees [1].

Water tress represent very thin micro-channels filled with water, which develop in high electric field areas respectively in regions where defects (like impurities, micro-cavities) are presented or in the semiconductor layers vicinity [2].

Water trees contribute to the local enhancing of the electric field [3] and electric strength of insulations [4], having as consequence their premature breakdown. According to the available statistics, water trees represent more than 30 % of total causes of medium voltage cables breakdown [5].

Water trees development is influenced by a series of factors like ions inside the insulations [6]. On the other hand the charge related to the ions, leads to a local enhancement of the electric field [7], leading to the reduction of partial discharge and electric trees inception voltage. In order to estimate the space charge and electric field repartition in flat samples several methods are available [8]. In cylindrical samples (cables), the thermal step method is often used [9].

Determination of resistance to water trees is an important test for lifetime estimation of insulations. The achievement of such attempts at 50 Hz implies long periods, of months order. In order to reduce these periods, electric fields or frequencies higher than the service ones are used to accelerate water trees development [10]. In this case, it is important to know the influence of these parameters on the trees development and characteristics, respectively the space charge related to water trees [3].

This paper concerns an experimental study made on low density polyethylene-insulated model cables. The condition of the cables (aged at frequencies comprised between 50 Hz and 3 kHz) is analyzed in terms of water tree characteristics (dimensions, densities, volumes) and space charge, with the aim of evaluating the possibility of using a space-charge based methodology for assessing non-destructively the insulation state.

EXPERIMENTS

Samples

Commercially-available low density polyethylene-insulated cables have been used. The insulating thickness was 0.8 mm, and the copper conductor diameter was 1.1 mm. The experiments were performed on 50 cm-long samples cut from cable rolls.

Development of water trees

In order to develop water trees in the studied samples, the setup presented in Figure 1 was used. Groups of 2 samples were introduced in a PMMA cell filled with NaCl solution (concentration: 0.1 mol/l). A sinusoidal voltage of RMS voltage U = 5 kV has been applied to the samples. Three ageing frequencies have been used on several samples: 50 Hz (ageing time: 55 days), 2 kHz and 3 kHz (ageing time: 24 to 96 hours).

For a fast development of water trees, superficial defects have been made with abrasive paper on the outer surface of insulation, by using a special device. The water trees were visualized and their dimensions were measured after ageing by using the setup presented in [9].

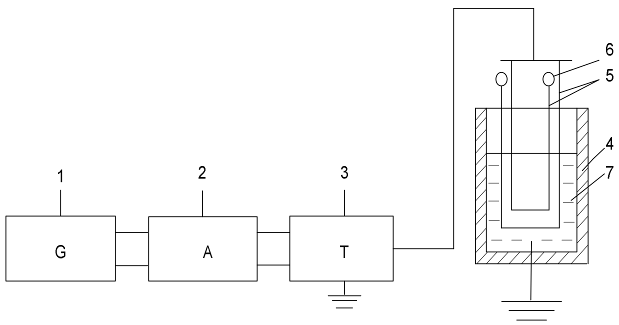

Fig. 1: Setup used for water trees development: 1- Tektronix CFG 253 voltage generator, 2- Amplifier, 3- High frequency transformer, 4- Ageing cell, 5- Samples, 6- Metal balls to avoid discharges, 7- Water/NaCl solution