Electric field distribution in polyethylene insulation used in the electric cables affected by water trees in the presence of space charges.

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The extruded polymeric materials are largely used as insulation of electric cables. However, in a wet environment, the penetration of water inside the insulation can have an important role in the formation of the water trees. These defects represent a significant factor in the process of the electric degradation of polymeric insulation, induced by the modification of the permittivity of the insulation. The association of space charges to these defects can be the principal cause of the electric tree initiation, and then, the rupture of the polymeric insulation. So, many studies have been carried out for a better comprehension of the space charges generation in the polymeric insulations. This work was directed so far towards the study of the space charge characteristics under D.C current, while the study of the dynamics of the space charge and its impacts on the electric defects under AC current caused only one limited attention. Indeed the behavior of space charge in the water tree under AC current is still badly understood. To understand the mechanism of displacement of this space charge in the presence of defects in polymer, an evaluation of the electric distribution of field is essential.

The aim of this work is to determine the distribution of the field in polyethylene insulation used in the medium and high voltage cables, affected by water trees in the presence of space charges. In our study, we chose the model of vented tree, with homogeneous electric properties (permittivity and conductivity). We considered the case where these trees develop starting from the two semiconductor layers, interior and exterior of the polymer insulation. The results of investigation showed that the distribution of the field is uniform in the insulation in absence of any defect. However, when the insulation is affected by water tree, the field and the equipotential lines show more divergence compared with the case of pure dielectric. This non uniform variation of the field and equipotential lines which becomes apparent on the insulation-defect interface depends on the length as well as the position of the water tree compared to the conductor. Furthermore, the accumulation of the space charges induces a significant variation of the electric field close to the two semiconductor layers. Consequently, the electric field decreases in a remarkable way in the vicinity of the interior semiconductor layer while it increases significantly in the vicinity of the external semiconductor layer. Moreover, we noticed a considerable decrease of the equipotential lines in the volume of the insulation compared to the case where there are no space charges. We also noted that this distribution of the field depends on the quantity of space charges accumulated and their dynamic movement in the insulation with defects.

Key words: Electric cables, polyethylene insulation, water trees, electric field, space charges.