The Effect of Water Ingress on Dielectric Properties of Polyethylene Cable Insulation

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PE based insulation has been introduced in underground distribution cable systems up to 40 years ago. For this type of insulation, long term aging is a concern since it is well known that water treeing gradually develops when the insulation is exposed simultaneously to water ingress and service electric stress. As a growing proportion of XLPE extruded cables are considered to be reaching the end of their design service life, there is a need to develop diagnostic methods able to provide an accurate assessment of their insulation. Considering the correlation between dielectric losses and the general degradation of the insulation, a Time Domain Spectroscopy (TDS) device was developed at Hydro-Québec (IREQ) as a diagnostic tool to assess the health of the cable insulation. For cables showing a high level of degradation as well as for most of the accessories, dielectric loss measured by TDS has been shown to fit well with those measured with very low frequency (VLF) systems.

A recent study has revealed that water ingress in the PE based insulation can have a strong influence on the dielectric loss measured by TDS. Especially for the early stage of water tree (WT) aging, this influence can make it very difficult to separate the WT contribution to the losses from that of water. This study was performed on miniatures PE based cables as WT in this type of cables can grow at an higher rate compared to that occurring in the XLPE based insulation used for MV cables. Also, these miniature cables present the advantage of being easy to handle for being subjected to various water exposition and accelerated aging procedures.

This paper reports on dielectric loss measurement features (absolute values, voltage dependence, etc.) and residual breakdown voltages obtained on miniature cables as a function of water absorption and electrical aging by WT under $5kV_{AC}$ voltage. The dielectric losses were measured in polarization and depolarization using Time Domain Spectroscopy (TDS) and compared with those measured at VLF, using a sine wave VLF generator. Dielectric losses measured at voltages up to 5kV are presented and discussed for different degrees of water ingress and WT aging. The corresponding residual AC breakdown voltage will be analysed as a function of water content and WT aging, using Weibull analysis.

Key words : Insulation, Dielectric, Water tree; TDS, VLF, Breakdown voltage, Weibull