Degradation rates in high voltage subsea cables with polymeric water barrier designs

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Water treeing is one of the main degradation mechanisms in high voltage cross-linked polyethylene (XLPE) cables exposed to water. High voltage subsea cables are normally equipped with a metallic water barrier to keep the insulation dry. In some cases this may not be advantageous e.g. when the cable is subjected to substantial dynamic mechanical stress. In the absence of metallic water barriers, the moisture content in the insulation will rapidly increase as water diffuses into the system. Water tree initiation does normally not occur at relative humidity values (RH) lower than approximately 70%. However, the water tree growth rate is affected by the RH above this level. Therefore, limiting the rate of increase of the relative humidity in the insulation by a smart designed polymeric sheath system, the lifetime of a cable will be significantly extended due to reduced water tree growth. The main purpose of this paper is to demonstrate this model by presenting numerical calculations of water ingress in a semi-conductive wet submarine cable design and results from water tree growth rate experiments at different RH in extruded 12kV model XLPE cables.

The first part of the paper presents results from numerical calculations of water ingress in subsea XLPE cable with a two-layered polymer sheath design. The polymeric outer sheath system was found to increase the time to 70% RH by over eighteen years at 20°C compared to the same cable without any sheaths. This means that no water tree initiation will occur during this time. In addition, the time to 99% RH was increased by over eighty years by including the outer sheath system. The water tree growth rate is likely inhibited during this period, causing an additional lifetime expectancy increase. The effect of the reduced RH on water tree growth rate is studied in the second part of the paper using 12kV model XLPE cables. The cables were aged for 6 months at 3U0 (18kV), in a controlled humid air atmosphere. In total, five different levels of relative humidity were used. The samples were pre-conditioned for 5 months in order to ensure a constant distribution of moisture in the insulation.