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Electrical Treeing Phenomenon under Rippled Fields in HVDC Cable Insulation

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Power cables are exposed to various stresses in their service lifetime due to loading and transient effects that appear in the system. These stresses degrade the insulation in the long term and can even result in premature failure depending on the severity of the deterioration. Electrical treeing is closely related with partial discharge (PD) and in some stages of its growth it can be monitored through PD measurement. Regarding the treeing phenomena under pure sinusoidal high voltage alternating current (HVAC) voltages and harmonic AC waveforms well established research work has been conducted and the knowledge is in maturate stage. Harmonics have been reported to have undesirable effects both on insulation integrity and on the diagnostic process. However, less has been devoted under the condition of distorted or rippled high voltage direct current (HVDC) voltages. In this paper, artificial test samples of polymeric material have been developed in which the needle electrodes are embedded in polymeric insulation slabs in order to artificially initiate tree phenomenon. DC voltages superimposed with harmonic components that commonly appear on the output terminals of HVDC converters were simulated using a high voltage amplifier in the laboratory, and applied to the test samples and the growth of the developing trees recorded at different stages by digital microscope and also the corresponding PD pulses were acquired simultaneously using a wide-band HFCT sensor and high bandwidth sampling hardware. Results show that the superimposed abrupt waveforms result in rapid initiation and growth of treeing process in the samples with respect to pure DC waveform. Since treeing is one of the primary causes of failure in polymeric insulation, correlation of its features with simultaneously acquired PD data will have key implications for HVDC network operators, facilitating on-line monitoring and assessment of cable degradation and allowing preventative maintenance.

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