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A new test method to evaluate the water treeing resistance of polymers for cable insulation

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Tests on real cables being expensive and time consuming, laboratory tests are usually performed prior to cable tests to evaluate the water tree resistance of materials. Two classes of laboratory tests can be distinguished: (i) tests in uniform or quasi-uniform field geometry with plate-like specimens or miniature cables, in which the essential criterion is the breakdown voltage after ageing; (ii) tests in divergent field geometry with plates containing sharp, water-filled indentations, so-called water needles, where the criterion is the water tree size after ageing, sometimes combined with the water tree opacity [1].

A better knowledge of the causes of insulation breakdown induced by water treeing leads us to propose a new method, belonging to the second class of laboratory tests in which the criterion is the breakdown voltage of specimens containing an unique water tree.

The new test method is based on the breakdown model briefly described below: since a water tree can be considered as a dielectric medium of permittivity higher than that of the surrounding material, the a.c. electric field distribution in the insulation is modified by the presence of the water tree: the field is lowered inside the water tree and is enhanced at its front and ahead of it. If a defect of the insulating material – e.g. a small conducting inclusion – is present in the zone of enhanced field, the local field, already amplified by the defect shape, undergoes an extra amplification which can initiate an electrical tree and cause breakdown [2].

The laboratory model proposed for the test consists of two facing needles: the first one is the usual water needle, the second one, located in the axis of the first, is a metal needle which simulates a defect of the material. Typical dimensions are: curvature radii of the tips of the needles, 10 micrometers ; distance between the tips, 1 mm.

Material testing includes ageing and breakdown stages. During the ageing stage a large enough number of specimens are put under voltage for a given time in accelerating conditions, for example 7 kV and 1500 Hz for 300 hours, thus giving water trees of a length in the order of 0.1 mm. Then each specimen is transferred to a breakdown test bench to measure the partial discharge inception voltage and the breakdown voltage during the application of a 50 Hz voltage ramp. A statistical presentation of the results allows us to characterize the materials by one or two breakdown parameters and to compare their water treeing resistance.

The pertinence of the method was proved by experiments which will be presented in detail in the paper. The main results are: (1) breakdown is initiated by an electrical tree growing at the metal needle tip ; (2) breakdown voltage is a decreasing function of the water tree length ; (3) for water trees of given length the most opaque give the lowest breakdown voltage. The result of a comparison between two compounds with and without WTR additives will be given.

The new method combines the advantages of the water needle test in which individual water trees are grown in controlled conditions and those of the breakdown tests which are aimed at measuring the deciding property of the material.

References:

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