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Microspectral analysis in UV-VIS range as a tool for power cable insulation diagnosis

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Materials used as power cable dielectrics typically may be characterized by absorbance, fluorescence and diffuse reflection spectra in visible (VIS) and ultraviolet (UV) range and these spectra tend to change during ageing. Localized degradation phenomena like treeing as well as many technological defects, i.e. foreign particles, also possess specific spectra. Spectral properties often are distributed inside the insulation essentially heterogeneously and sometimes a small amount of material is available for analysis. All this permits to apply microspectrophotometry and microspectrofluorometry (MSF) for power cables examination. This statement is illustrated by the following examples.

Thermal aging of peroxide cross-linked PE. This process is accompanied by an increase and a shift of fluorescence and absorbance to longer wavelengths due to polyenes accumulation. The desorption of mobile substances together with the diffusion of impurities into insulation from semicons are controlled by means of MSF with the aid of scanning technique.

Water treeing in XLPE. Water trees in the course of their growth gain UV or VIS absorbance which increases with ageing time. The tree optical density may serve as an additional quantitative parameter for the diagnosis due to its correlation with the dielectric strength. The water tree absorption vs. time dependence is in satisfactory agreement with our theoretical model presented at JICABLE'99. Local oxidation in water trees is well illustrated by secondary fluorescence due to sample treatment with dansyl hydrazine. In case of morphological similarity of electrical and water trees the type of a tree may be recognized by primary fluorescence spectra.

Thermal ageing of impregnated paper insulation. The intensity of VIS diffusive reflectance of *paper* decreases with aging while its absorbance grows; fluorescence exhibits more complex behaviour. The electronic spectra of paper also show a shift to larger wavelengths similar to that of XLPE. The variation of paper optical properties may be described in terms of Arrhenius 1st or zero order kinetics thus providing a useful approach for the remaining lifetime estimation. Fluorescence and absorbance of impregnating *oils* increase during thermal aging. Changes in optical properties of the insulation components correlate with the polymerization degree and power factor values.

In case of *electric degradation* under the action of intensive partial discharges the fluorescence of oil containing aromatic hydrocarbons decreases and dark fluorescence-free spots appear on paper surface.

Ageing of different materials exhibit some common features in terms of their spectra evolution. This permits to derive a kind of general approach for the diagnosis and the residual lifespan evaluation, in particular when normalized spectra are treated as probability distribution functions.

Recognition of foreign particles. This problem, rather complicated in the general case, may be successfully solved by a combined application of MSF and other microscopic methods. Some examples are as follows: identification of 'gel' in XLPE, emery particle in cable termination and contamination of one impregnating compound with the other.

The above given applications permit to regard microspectrophotometry and microspectrofluorometry in visible and ultraviolet range as effective tools for solving many specific problems in power cable insulation quality control and diagnosis.