The experience in applying new recovery voltage parameters for the impregnated paper insulation cable condition diagnostics

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The form and volume of recovery voltage (RV) in dielectrics is defined by two simultaneous processes - space charge depolarization and volume conductivity. There were some new RV parameters examined, which allow controlling two relatively independent processes of electric insulation aging: the volume conductivity change and volume charge state change. For the volume charge state control a PIRV polarization indicator on recovery voltage is introduced, for the volume conductivity control a LIRV electric conductivity indicator is introduced. Both these condition indicators are calculated from RV max value. For this purpose the RV curve $U_r(t)$ is approximated by the exponent amount with A_i and τ_i parameters

$$U_r = \sum_{i=1}^{n} A_i \cdot \exp\left(-\frac{t}{\tau_i}\right), \quad (1)$$

where t is time. In the model (1) A_i takes on both positive and negative values. It is customary to assume that RV is of negative polarity, so here the short-lived components are of positive polarity.

PIRV is defined as a ratio of the RV maximum U_{rm} to the amount of intensities of the short-lived positive components A_+:

$$PIRV = 10 \cdot \left|\frac{U_{rm}}{A_+}\right|, \quad (2)$$

and the LIRV indicator is defined as a ratio of U_{rm} to the total area of the short-lived component S_+:

$$LIRV = 100 \cdot \left|\frac{U_{rm}}{S_+}\right|. \quad (3)$$

In both cases the multiplying factor and the modulus sign is introduced for the convenience of applying PIRV and LIRV condition indicators. The division of U_{rm} by A_+ in practice presents normalization of U_{rm} by the volume residual insulation polarization value in the moment of the beginning of RV measurement. Such normalization allows comparing PIRV for industrial insulators of various geometrical sizes and configurations, for example, for insulating cables of various lengths and cross-sections. The division of U_{rm} by S_+ value represents a normalization of U_{rm} by charge value resulting from depolarization currents of the short-lived charge states. Such "internal" normalization allows quantitively evaluating the volume insulation conductivity by the LIRV value regardless of its geometrical sizes and configurations.

The PIRV and LIRV values were used to evaluate technical condition of power cables with impregnated paper insulation (PILC) after a continuous exploitation in the nuclear plant unit rooms. The experimental findings allowed elaborating the criteria for evaluation of PILC cable condition in case of typical defects in this environment.

The joint use of the PIRV and LIRV condition indicators and the parameters of partial discharges registered at oscillating damping voltage allowed both diagnosing the aging degree of PILC cable caused by typical defects, and determining the defect location on cable routings.

Key words

Electric insulation, recovery voltage, condition indicators, volume conductivity, volume charge, polarization, cable, impregnated paper insulation.