The Influence of Dielectric Properties of Commercial Vacuum Interrupters

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This paper deals with influence of dielectric properties of commercial vacuum interrupters that have transverse magnetic field C_uC_r. The influence of switching operations 'closing without current/ breaking without current', 'closing without current/ breaking with rated current', 'closing without current/ breaking of rated short-circuit current' on vacuum interrupter dielectric strength, is discussed in this paper. Two types of commercially available vacuum interrupters with transverse magnetic field C_uC_r contacts were tested.

The irreversibility of dielectric strength of commercial vacuum interrupters after a large number of consecutive short-circuit current interruptions is investigated in order to find out how dielectric performance of a vacuum interrupter degrades during its service life.

Experimental procedure included “closing without current/breaking without current”, “closing without current/breaking with rated current” and “closing without current/breaking of rated short-circuit current” influence to breakdown voltage and emission current. Inter-contact gap was varied in these experiments. The corresponding characteristics were determined after conditioning. We applied following voltage shapes: D.C., lightning impulse voltage (1.2/50 μs) and A.C. with 50 Hz. Tests were conducted with three different types of vacuum interrupters. All the interrupters were with CuCr contacts. Type A and type B interrupters were with transverse magnetic field contacts, while type C was with axial magnetic field contacts. Each measurement series consisted of 100 breakdown voltage measurements. Between two successive measurements we paused for 30 seconds. Measured breakdown voltage data were statistically processed by specially developed numerical programs. The aim of statistical processing was to determine if breakdown voltage can be represented in the form of usual distribution functions (normal, Weibull, double-exponential). After taking into account theoretical considerations, it was concluded which physical mechanisms determine the influence of switching operations on the dielectric strength.

It has been found that the dielectric strength strongly depends on the type of the switching operation performed before dielectric testing. For the “breakdown voltage” random variable, after all considered switching operations, it was found that it belongs to Weibull distribution. At the same time, the Weibull distribution with constant parameter shape was obtained approximately for all cases except for the case of switching operation “closing without current/breaking of rated short-circuit current”. It can be concluded that this is the consequence of the same weak insulator points in all cases, i.e. micro tips on cathodes.

By measuring the emission current for conditioned contacts and contacts after switching operation “closing without current/breaking without current” and “closing without current/breaking with rated current”, the existence of correlation between average breakdown voltage and voltage during dielectric tests by impulse voltage has been found. On the contrary, for contacts after switching operation “closing without current/breaking of rated short-circuit current”, it has been found that there is no correlation between average breakdown voltage and voltage during dielectric tests by impulse voltage. It can be concluded that breakdown for conditioned contacts, contacts after switching operation “closing without current/breaking without current” and contacts after switching operation “closing without current/breaking with rated current”, is initiated by the emission mechanism.

However, after the switching operation “closing without current/breaking of rated short - circuit current”, the breakdown is initiated by the micro particles mechanism. Any influence of the type of interrupter on the change of dielectric strength after switching operations “closing without current/breaking with rated current” and “closing without current/breaking without current” has not been observed. It was concluded that the contact material composition and magnetic field type did not influence degradation of dielectric by these switching operations. Higher degradation of dielectric strength by the switching operation “closing without current/breaking of rated short-circuit current” for the type B interrupter in comparison with the type A interrupter was explained by different composition of contact material. Higher degradation of dielectric strength by the switching operation “closing without current/breaking of rated short-circuit current” was explained by increasing generation of micro particles for the interrupter with axial magnetic field. This is the consequence of the fact that for interrupters with transverse magnetic field micro particles were created also bridge explosion during contact parting.

It should be pointed out that the considered switching operations did not degrade dielectric strength of vacuum interrupters below the rated values. It was found that in interrupters with poor contact materials, the dielectric strength can deteriorate below the limits required by standards.