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Spectral measurement of the precipitations composition in OIP insulation of the high-voltage bushings

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Currently, there is a tendency to replace oil-filled high-voltage equipment with transformers, current transformers, voltage transformers, high-voltage bushings without mineral (transformer) oil in internal insulation in order to protect environment, as well as to reduce the financial and physical costs of electrical equipment maintenance. Despite of this, a large amount of the oil-filled equipment operate in the Russian power grid complexes. Therefore, diagnostic methods of the equipment condition with liquid dielectrics are still relevant, especially in terms of high sensitivity to certain characteristics, obtaining sufficient information to understand the processes occurring with insulation inside the equipment.

Physicochemical control methods can be distinguished among the other diagnostic methods of the oil-filled equipment, which help to understand the processes inside the insulation system. During equipment diagnostics using physico-chemical methods there are some important points: compliance with the technology to determine one indicator or another, correct assessment of equipment insulation condition according to certain criteria, correct interpretation of the data obtained, in relation to prediction and residual insulation life of uninterrupted operation of high-voltage equipment.

In laboratory practice, most often the following three main groups of indicators characterizing the oil properties in operation can be established by the methods of physico-chemical control:

- Electrophysical - (dielectric conductivity, dielectric loss and dielectric strength);
- Physical (color, transparency, viscosity, mechanical - impurities, flash point in a closed cup, freezing point, density);
-Chemical - (acid value, water-soluble acids and alkalis, sludge, antioxidant additive).

Each of these indicators, most of all, a totality of characteristics indicates the degree of thermal and electrochemical aging of the oil, the formation of ionic impurities in it, which reduce the electrophysical parameters of the insulation. Among the indicators that directly or indirectly indicate the potential formation of precipitation in the operated insulation system, it is necessary to indicate the following: acid value, the content of water-soluble acids, soluble sludge, optical

opacity, loss tangent of a dielectric. However, traditional methods are not always able to fix the formation starting of the colloid-dispersed inclusions preceding the formation of sediment on solid internal insulation of electrical equipment.

Compounds that are capable of initiating the formation of heavy components, are primarily such compounds include molecules of organic compounds, including ions of various metals. The danger of ionic metal-containing impurities is that by accumulating in liquid and solid cellulose dielectrics, under the influence of an electric field, charged particles increase the conduction current, and as a result leads to electrical strength dropping. In addition, metal ions initiate the formation of colloidal and fine compounds. Through prolonged exposure of high intensity of the electric field, elevated temperature the colloidal systems undergo a redistribution of the relative concentration of dispersed phases in different layers of the liquid. Firstly, it leads to current-carrying bridges in the thickness of the liquid dielectric. Secondly, it leads to sedimentation and accumulation of waxy precipitates on structural elements, as a rule, in the area of high intensity of the electric field. The formed solid particles cause blockage of cooling channels, reduction of electrical insulating gaps, increasing of heterogeneity and electric field strength, partial breakdown of insulation, the formation of gas microbubbles, which ultimately can lead to the destruction of the “oil-cellulose dielectric” system.

In practice, it is very important to recognize the beginning of the development of colloid-dispersed processes leading to the formation of products of deep “aging” of oil and cellulose insulation in order to effective diagnostic of the internal insulation system conditions and maintain the electrical properties of dielectrics at the proper level. With the development of spectral methods, it becomes quite possible to introduce a purposeful control of the impurities concentration, namely metal ions into the diagnostic system.

This study shows the relevance of the introduction of the spectral method in practical diagnostics of high-voltage equipment with liquid dielectrics on the example of studying the precipitations elemental composition and paper insulation from high-voltage bushings. Individual cases from the practice of hermetic bushings operating, rejected according to the results of chromatographic analysis of dissolved gases in oil are also explained. Physicochemical parameters of the oil from the bushings did not cause any concern. However, during the detailed examination of the internal insulation of the bushings wax-like precipitates were revealed, their composition was established using atomic absorption spectrometry [AAS]. In addition, the composition of the paper insulation layers of high-voltage bushings was analyzed for the content of organometallic impurities.