

## **Transformer oil, the main characteristics.**

### **The equipment used and methods of cleaning oil**

Transformer oil - fraction of purified crude oil, obtained by the distillation, boiling at from 300 ° C to 400 ° C. Depending on the origin of crude oil, oil has different properties and these distinctive properties of the feedstock affect the properties of the oil. Oil has a complex structure of hydrocarbon molecules with an average weight of 220-340 AU, and contains the following main components .



1. Paraffins  
10-15 %
- 2 . Naphthyl or cycloparaffins  
60-70 %
- 3 . Aromatics  
15-20%
- 4 . Asphalt resinous substance  
2.1 %
- 5 . Sulphur compounds  
< 1%
6. Nitrogen Compounds  
< 0.8 %
7. Naphthenic acid  
< 0.02 %
8. Antioxidant additives ( ionol )  
0.2-0.5 %

### **General requirements and properties**

Dielectric properties of oils are determined mainly by the dielectric loss tangent. Dielectric strength of transformer oil is mainly determined by the presence of fiber and water, so the mechanical impurities and water in oils must be completely absent . Low pour point (-45 ° C and below) is necessary to preserve their mobility at low temperatures . To ensure effective heat dissipation transformer oil should have a viscosity at least point not less than 95 , 125, 135 and 150 ° C for various brands.

The most important property of transformer oils - stability against oxidation , i.e, the ability of oil to save settings after prolonged use.

A lot of sorts of used transformer oils is inhibited with antioxidant additives - 2,6- Diteritary butilparakrezolom (also known under the names ionol , Agidol -1 , etc.). Additive effectiveness is based on its ability to interact with the active peroxy radicals , which are formed by a chain of hydrocarbons and the oxidation reaction are the main carriers of it . Transformer oil , inhibited ionol is oxidized , usually with a pronounced induction period . In the first period the oil susceptible to additives are oxidized very slowly, as all originating in the volume of oil oxidation chains are broken oxidation inhibitor . After depletion of the additive, oil oxidizes at a rate close to the rate of oxidation of the base oil. Effect of the additive , the more effective the longer the induction period of oxidation of the oil , and this depends on the efficiency of the hydrocarbon composition of the oil and the presence of impurities of non-hydrocarbon compounds , oil oxidation promoter ( nitrogenous bases , naphthenic acids , oxygen-containing products of oil oxidation). Happening in cleaning oil distillates reduction of aromatic hydrocarbons, and non-hydrocarbon impurities removal enhances the stability of the inhibited ionol transformer oil .

### **Basic physical and chemical properties of the oil.**

The main characteristics of the oil are the following: it is fuel, biodegradable , practically non-toxic , does not violate the ozone layer. The density of the oil is usually in the range of  $(0.84-0.89) \times 10^3 \text{ kg/m}^3$ . Viscosity is one of the most important properties of the oil. From the standpoint of high dielectric strength is desirable to have a higher viscosity oil . In order to perform additional features in transformers well (such as the cooling medium ) and switches (like environment where moving drive components ), the oil must have a low viscosity, otherwise the transformers are not properly cooled, and switches can break arc at their appointed time. Therefore, one may choose a compromise value for the viscosity of different oils . Kinematic viscosity for most oils at  $20^\circ \text{C}$  is  $28-30 \times 10^{-6} \text{ m}^2 / \text{s}$  .

### **Using of oil**

Before filling of electro apparatuses oil shall have thermal vacuum processing. In power transformers and protection film without leaking glands to pour transformer oil with a water content of 0.0025% (wt. fraction) is allowed. Solids content, defined as the cleanliness class, should be no worse than 11th for equipment with voltage up to 220 kV and no worse 9th equipment for voltages above 220 kV. Rates of breakdown voltage depending on the operating voltage of the equipment must be equal (kV). Immediately after pouring the oil in the transformer, allowable values for breakdown voltage is on 5kV lower than that before oil filling. The cleanliness class degrade of transformer oil by one is allowed and increase the air content of 0.5% .

Pour point is the temperature at which the oil is thickened so that the inclination of the tube with the cooled oil at  $45^\circ$  its level remains constant for 1 minute . In oil circuit breakers pour point is crucial. Fresh oil should solidify at a temperature of  $-45^\circ \text{C}$ ; in the southern parts of the country are allowed to use oil with a pour point of  $-35^\circ \text{C}$ . For operating oil it is allowed number of deviations from the curing temperature normalized depending on whether the oil in the transformer or switch , operates in the same indoors or outdoors. For special arctic grades oil pour point is reduced to  $-(60-65)^\circ \text{C}$  , but the temperature is reduced and the flash-to  $90-100^\circ \text{C}$ .

Flashpoint is the temperature of the heated oil in a crucible in which its vapors form a mixture with air, flammable for presentation to her flame. Flash is so fast that the oil does not have time to warm up and catches fire. Flash point of insulating oil must not be less than 135 ° C. If you heat the oil above the flash point, there is a moment when the oil flames with the presence to the flame.

The temperature at which the oil flames and burns at least 5 seconds is called oil ignition.

The temperature at which ignition occurs in a closed crucible, in the presence of air without the presentation to the flame is called the auto-ignition temperature. For transformer oil it is 350-400 ° C. Permittivity of oil is low and varies between 2.1-2.4. Dissipation factor is determined by the presence of impurities in the oil. In pure oil it should not exceed  $2 \times 10^{-2}$  at 90 ° C and an operating frequency of 50 Hz. In the oxidized oil polluted and humid tgδ increases and can reach more than 0.2.

Dielectric strength of oil is determined in a standard arrester with hemispherical electrodes with a diameter of 25.4 mm and an inter electrode distance of 2.5 mm. Breakdown voltage must be at least 70 kV, with a dielectric strength of oil discharger is not less than 280 kV / cm.

Oil is able to dissolve and absorb quite considerable amounts of air and other gases. According to reports in 1 cm<sup>3</sup> of oil is dissolved at room temperature: nitrogen 0.086 cm<sup>3</sup>; 0.16 cm<sup>3</sup> of oxygen; 1.2 cm<sup>3</sup> of carbon dioxide. Wherein the oxygen is not only dissolved but also chemically combined with the oil to form oxidation products. Gassing of oil is very often a sign of an incipient defect in the transformer's winding.

### **The equipment used and methods of cleaning oil**

There is a large gap between the life of transformer and the life of the transformer oil. The transformer can be operated without repair 10-15 years, oil requires cleaning, and within 4-5 years - regeneration. Cleaning, drying and oil recovery. Cleaning of oil is called such an operation through which contaminated or oxidized oil is purified to suitable condition for further use. After a good cleaning, oil should fully recovers their initial properties, i.e must be completely transparent, must not contain acids, precipitation, water, coal, and other contaminants. Reasons for withdrawal of oil exploitation can be of two kinds. If the oil during operation were only contaminated with substances and various uniform and has not undergone profound changes, then to restore enough one should use one of the techniques described below mechanical cleaning. For regeneration (cleaning) of waste transformer oil there are used a variety of equipment and systems, whose operation is based, as a rule, use a combination of methods (physical, physico-chemical and chemical), which makes it possible to regenerate (clean) waste oils of different brands with varying degrees reduction of quality indicators. It should be noted that during regeneration (purified) oils may receive base oil quality identical "fresh", the output of the oil depending on the quality of raw materials is 80-90%, thus, the base oil can be recovered (cleaned) by another at least twice, but it is possible to realize with the application of modern technological processes.