Testing And Chemical Analysis of Transformer Oil

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ABSTRACT

The article is devoted to the maximum permissible indicators of physical chemical and dielectric properties of both newly filled and used transformer oil. Fresh oil poured into all types of oil-filled bushings, as well as operating oil for leaking bushings. Define the nominal voltage for the tap changer contactor.

Keywords: Transformer oil, dielectric, moisture, pollution, oil aging, on-load tap-changers, oil breakdown strength.

Introduction

Transformer oil is a refined oil fraction used to fill power units, transformers, reactors and oil circuit breakers. This mineral substance is an electrical insulator, protecting components from overheating and exposure to water. The service life of the equipment, wear resistance and resource of equipment directly depend on its quality.

However, oil products in the process of use lose their original physical and chemical properties, cease to comply with ISO.

A change in its characteristics also occurs with moisture, pollution, ingress of air or other gas, and, finally, as a result of natural aging of both the oil itself and solid insulation. Testing and chemical analysis of transformer oil is the oldest and most common way to check the condition of transformers.

Transformer oil acts as a dielectric and as a cooling medium, and for tap-changers also as an arc quenching medium. Fresh transformer oil is light yellow in color and has high physical, chemical and dielectric properties. Oil aging in operation is associated with its oxidation. Subject to all the rules of transformer installation and oil filling [5], at the first stage, the oxidation process is slow.

Changes in the oil are hardly detectable by conventional methods, but the stability of the oil gradually decreases. At the second stage, the oil turns brown, becomes cloudy, the acid number and ash content increase, low molecular weight acids appear, which have a harmful effect on both paper insulation and metals. Precipitation appears, which can worsen the cooling conditions of the windings.

In addition to internal, so to speak, "natural" causes of oil aging (high temperature, insulating varnish, residual moisture in oil and paper insulation, copper and other materials that oil comes into contact with), external causes also affect - insufficient cleaning of the transformer when changing oil, water ingress,

contact failure, short-circuited circuits and other causes of local overheating, etc. Thus, when water enters, the penetration strength of the oil decreases. In general, the viscosity and flash point of an oil increase in service due to the evaporation of light oil fractions. But in the presence of local overheating due to the decomposition of the oil at a high temperature without access to air, the flash point may decrease.

The maximum allowable indicators of the physicochemical and dielectric properties of both newly poured and operated transformer oil are limited by the standards [2] and are given in Table. 1. Naturally, the requirements for the oil in operation are lower than for the newly filled one. For some types of oil, as well as for oil in some types of transformers, the requirements may differ from those indicated in Table. 1, which should be specified in the relevant technical specifications or manufacturer's instructions.

The rated voltages Unom indicated in the second column of Table 1 refer to the higher voltage winding of the transformer, if the oil sample is taken from the transformer tank or the oil is intended for filling into the tank. For the oil of high-voltage bushings, the rated bushing voltage is taken. For an on-load tap-changer contactor, the rated voltage is determined by its installation location. If the device is installed "in line" (in autotransformers on the medium voltage side), then the rated voltage of this winding is assumed, if in the neutral - 35 kW (for transformers of 110 kW and more) or 10 kW.

According to [2], in transformers with voltage up to 35 kW, in all cases, the oil is tested according to p.p. 1-5 tab. 1 (the so-called reduced analysis). This also applies to samples taken during operation, and to the oil being poured, and to the oil of transported transformers. In transformers with a voltage of 110 kW and more, the check is carried out according to paragraphs. 1-6 tab. 1, and equipped with nitrogen or film protection - according to paragraphs 1-7.9.

Fresh oil poured into all types of oil-filled bushings, as well as operating oil of leaky bushings, is tested according to paragraphs. 1-5 tab. 1. The test according to clause 6 is carried out only for bushings with a voltage of 220 kW or more, as well as for bushings of lower voltage, if tg 5 of the main insulation or its last layers is increased. The oil of sealed bushings is tested in operation (according to items 1-6) only in case of an increase in tg of the main insulation or its last layers and when the oil pressure in the bushing rises above the norm.

The oil from the tap changer contactors is tested according to p.p. 1, 2, 5 tab. 1. If the on-load tap-changer is located in a separate tank, its oil is also subject to testing. In this case, if the selector tank is connected by a tube to the transformer tank, the oil is subjected to the same tests as from the main transformer tank. With a completely insulated selector tank, the tests according to p.p. 1,2,5.

Table 1. Limit values of transformer oil quality indicators according to standards [2]

No. Indicator name	Oil index value						
	fresh			after pouring			
	TKp	GOST 10121-76	T-750	TKp	ISO 10121-76	T-750	operational all brands
1. Breakdown voltage, kW, at:							
Unom<15 kW	thirty	thirty	-	25	25	-	20
Unom = 15-35 kW	35	35	-	thirty	thirty	-	25
Unom= 60-220 kW	45	45	-	40	40	-	35
Unom= 330-500 kW	55(60)	55(60)	55(60)	50(55)	50(55)	50(55)	45
Unom=750 kW	-	-	65(70)	-	-	60(65)	55(60)
The same for tap							

changers:							
Unom=10 kW	thirty	thirty	-	25	25	-	25
Unom=35 kW	35	35	-	thirty	thirty	-	thirty
Unom=110 kW	45	45	-	40	40	-	35
Unom=220 kW	45	45	-	40	40	-	40
2. Mechanical impurities	Absence (visual)						
3. Acid number, mg KOH/g	0.02	0.02	0.01	0.02	0.02	0.01	0.25
4. Water-soluble acids and alkalis, mg KOH/g.							
for transformers over 630 MW-A and sealed bushings up to 500 kW	Absence						0.014
for leaky bushings	Absence						0.03
5. Flash point, °C	135	150	135	135	150	135	Decrease no more than 5°C compared to the previous analysis
6.tgδ, %, at 20°C for:							
Unom < 220 kW	0.2	0.2	-	0.3	0.3	-	0.7
Unom= 330-500 kW	0.2	0.2	-	0.3	0.3	-	0.5
at 70 °C for:							
Unom < 220 kW	1.5	2.0	0.3	2.0	2.5	0.5	7.0
Unom= 330-500 kW	1.5	2.0	0.3	2.0	2.5	0.5	5.0
Unom=750 kW	1;5	2.0	0.3	2.0	2.5	0.5	5.0
at 90 °C	2.6	2.6	0.5	-	-	0.7	-
7. Moisture content, % by weight, for:							
Unom<220 kW	0.001	0.001	0.001	0.001	0.001	0.001	according to factory standards
Unom=330-550 kW	0.001	0.001	0.001	0.001	0.001	0.001	(0.0025)
Unom=500 kW	0.001	0.001	0.001	0.001	0.001	0.001	(0.002)
8. Pour point, °C	-45	-45	-55	-	-	-	-
9. Gas content	0.1	0.1	0.1	0.1	0.1	0.1	-

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Conclusion

Purification of transformer oil involves the use of a whole range of devices, and in some cases installations. One of the most popular lines used for this procedure consists of adsorber blocks, oil heating, centrifugal cleaning and a breakdown voltage control device. Such a system will help clean up previously used substances in the transformer. Upon completion of cleaning, the oil can be refilled into the equipment.

To determine the quality of the materials used, it is enough to study their characteristics. Mineral oil must have a minimum viscosity so as not to freeze at sub-zero temperatures. It is possible to prevent the consequences of the appearance of electric arcs thanks to the function of the arc quenching medium. Oil can play the role of an electrical insulator. To do this, it must be purified from impurities of any kind. High-quality fuel and lubricant is able to withstand temperatures up to + 3000C. This is his boiling point. Therefore, it is often used as an additional cooler in transformers. Antioxidant additives can prevent the early onset of symptoms

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