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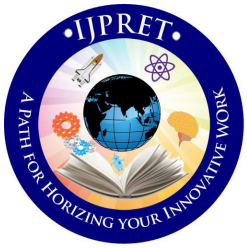

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THE FILTRATION PROCESS OF POWER TRANSFORMER

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Abstract

In this work are addressed characteristics of transformer oil, types of transformer oil, transformer oil parameters, physical properties, chemical and electrical oil and examination, cleaning, filtering and drying transformer oil.

INTRODUCTION

In the power transformer insulating oil is known as oil transformer. Transformer oil, it is mainly used for transformer insulation and cooling purposes.

In addition, this oil also serves two other purposes: helps to maintain the transformer core and coils which are fully immersed within the oil and prevents direct contact with atmospheric oxygen cellulose (paper insulation for winding insulation) which is sensitive to oxidation.

When using oil as insulating material, quickly breaks down insulation features, especially the presence of water in its composition it weakens apparent dielectric specifics.

Other integral quantities and the release of gases significantly affect dielectric characteristics decay.

For this reason, the oil should be cleaned or replaced, if it does not comply with insulating material.

Types of transformer oil

In general there are two types of transformer oil:

1. Paraffin based transformer oil
2. Naphtha based transformer oil

Parameters of transformer oil

Transformer oil parameters are categorized in several categories and they are:

1. Electrical parameters - Dielectric Strength, Specific Resistance, Dielectric Disspation Factor.
2. Chemical Parameters - water content, Acidity, and Sludge Content.
3. Physical Parameters – Inter Facial Tension, Viscosity, Flash Point, Pour Point.

In the table below, are given electrical characteristics, thermal and physical properties of the oil.

Basic features of Mineral Oil	Numerical values
Density[kg/m3]	880-920
Chinetic Viscosiy [m2*s-1]	
temperature 30°C	3.8*10-3
temperature 20°C	4.5*10-3
Burning temperature of the vapors [°C]	350
Dielectric Strength 20°C [kV/cm]	320
Specific Electrical Resistance [Ωcm]	

20°C	1013
100°C	1010
Dielectric losses tgδ	
temperature 20°C	1-5*10-3
temperature 100°C	3-15*10-3
Relative Permitivity Ɛr	2.1-2.3

Mineral oil is distinguished with great value specific electric resistance (about 10^{13} Ωm), but with increasing temperature, the resistance value drops very quickly. Relative permittivity oil is to be used even more; oil dielectric loss should be much smaller.

The weakening of oil features is due to the development of many processes in the oil exploitation. The most important processes that affect the decay characteristics of mineral oil are:

• The influence of temperature in which the oil

• Contact with metals, which are its aging catalyst,

• The influence of light on the oil,

• Impact of oil subject field intensity.

To eliminate the above causes that affect the aging of the oil, measures are taken to prevent or slow the aging process oil. Elements that slow down the aging of materials are called inhibitors. Used oil in transformer is recovered by removing add-ons and the amount of moisture.

THE REVIEW OF TRANSFORMER OIL

Recipient oil Reviews

Receiving reviews of new transformer oil , ordered in tanks or steel strength, is made after reviewing the oil sample in the laboratory to determine its quality, the values which must be met according to the table given below (see Table 1 and Table 2).

Figure 1 Device to examine the oil transformer

In the event that the oil is used to lubrfication the transformer in place, in which case the processing of the oil is controlled by determining the dielectric strength values.

Lubrification or over lubrificate is allowed when dielectric strength reaches the value given in tab. 1.nr.8.2.2

Accepting reviews of new transformer oil

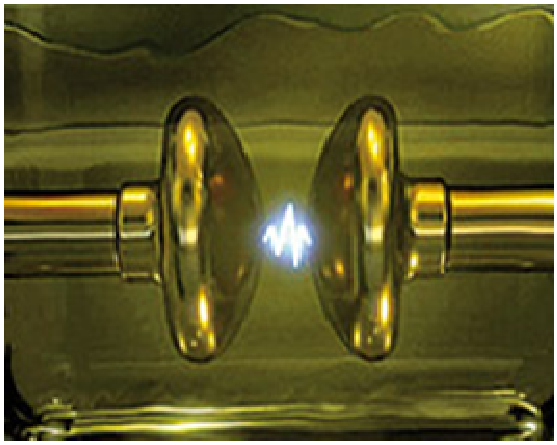

Figure 2 Measurement of Dielectric strength

The quality of new ordered oil for the new transformer is determent based on the characteristics values obtained from the examination of the sample analyzed by oil tab. 1 No. 1. up No. 11.

Quality of new ordered oil for the new transformer will be verified by analyzing the electrical characteristics of the sample of crude oil under the tab. 1. No. 8 and No. 9.
New ordered oil, for the used transformer, is verified in the same way as the new ordered oil, for new transformer under the tab. 1 from No. 1 to No. 11, as used oil under the tab. 1 from No. 1 to No. 10.

Oil should satisfy the limit values at least in the second group, Table 3, as well as values in tab. 1 from No. 1 to No. 5.

Accepting reviews of used oil

Used oil in the transformer is usable if the examination of the sample analyzed by tab. 2 from No. 1 to No. 10, it is determined that the oil belongs to the first group or the second group according to tab. 3.

Before lubricate oil needs to be processed, wherein oil processing is controlled by determining the value of dielectric strength.

Lubrifiction is allowed when dielectric strength reaches the value given in Table 1 No. 8.

For Oils without inhibitors, the obtained values are compared for additional neutral number with the same values before artificial aging.

The oil Review before the transformers is set to work

Before the release of the first new transformer, oil is checked by tab. 2.Shortly

before the transformer connection that has been out of work for more than two months, needs to be verified the further use of oil, by testing the dielectric strength of oil sample according to the tab. 2 No. 1.

Periodic Reviews

Periodic reviews of oil for power transformers from 1 MVA and above and starting voltage 35kV A or higher under tab. 2 from No. 1 to No. 10. In the case of power transformers with smaller power and lower tensions, these reviews are examined by the dielectric strength of the oil under the tab. 2 No. 1.

Based on the results of the research of oil, prior to release of the transformer, oils (ie transformers) are divided into 4 groups:

1. The first group: Oils in good condition,

2. The second group: Oils in satisfactory condition,

3. The third group: suspicious Oils

4. Fourth Group: Oils in usable condition

Group I: In the case of the first group oils normally in two to three years before significant changes are not expected during normal operation characteristics, taking into account that they are in good oils. Therefore, working with these types of oils, is based on other periodical reviews every 2 - 3 years.

Group II: In the case of the second oil group, that are in satisfactory condition, in the next 2 years, no significant changes are expected, therefore the work with these oils is based on periodic reviews for every 2 years.

Group III: In this case, considering the characteristics in doubtful condition, it can be expected that the characteristics of transformer insulation, have received closed values, so that future behavior of transformers can be incredible. Such state requires tougher control, and need to be reviewed more often, depending on the results of all analyzes details of the isolation transformer. If the results of the verification of isolation transformers are not satisfactory, the transformer along with the oil is classified in the fourth group.

Group IV: The fourth group oils are practically useless and therefore, transformers are not reliable group for further use in the state in which they are.

With Oils (transformers) of group IV, should be acting in the following way:

- If the case the oil is classified in Group IV due to moisture, while it belongs to aging characteristics is classified in group I or II, the oil should be processed and strong isolation transformer should be dried.

- If the case the oil is classified in group IV because of age, regardless of the features that contain moisture, the oil must be replaced with new or used oil, that could be classified in the first or second.

Verification of transformer oils during failure state

After Transformer failure, the oil sample needs to be verified the possibility of using it further. This verification is done in the case of oils according to the results of previous verifications that belong to group I or II, and also in the case of oils that belong to group III and IV, but only in terms of moisture.

Review is done on a processed sample of oil according to Tab. 2 from No.1 to No.10. The oil is usable if it belongs to the group II according to Tab. 3.

If the controlled transformer in failure condition requires oil spill, the work performer is obligated to do in clean power casting or steel tank before discharge (load) oil mixing should be done in laboratory and based on the verification of mixing results should be established for its use.

Verification during annual checks and revisions

During annual checks or revisions of transformers, before and after completion of the work, it must be verified further use of oil, by checking oil dielectric strength according to Tab. 2.

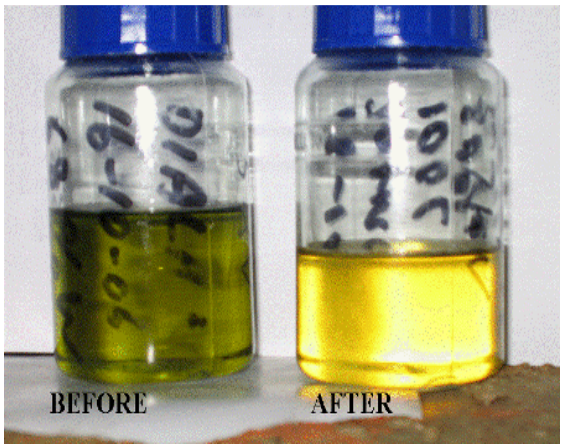

Figure 3 shows the appearance of the oil before and after the filtration process.

Mixing oils

In the Transformer can stream up to 5% of the oil total quantity without prior verification of the characteristics of the mixture.

Mixing oils, Regardless of whether they are inhibiting or not inhibiting, reports greater than 5% - 9% allowed only after verification of mixing characteristics in laboratory.

Mixing oils are permitted if the verification results of mixing are the same or better than the results of the verification of the worst oil mixture.

Cleaning, filtering, drying transformer oil when transformer is without voltage and below voltage

Machine for oil filtering "mobile"

This machine is important because it does filter the oil transformer under voltage, which means no electrical cuts during the time of filtration. Transformer oil filtration lasts for days and this is a significant advantage.

Figure 4 shows the appearance of a mobile machine which makes filtering, the elimination of water from transformer oil and its core working without interruption.

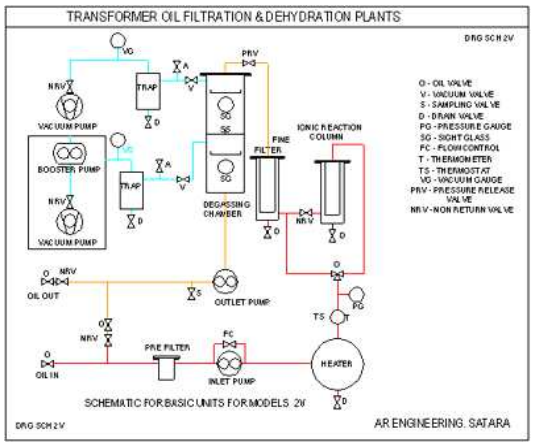

Figure 5 shows the technological scheme of oil filtration process.

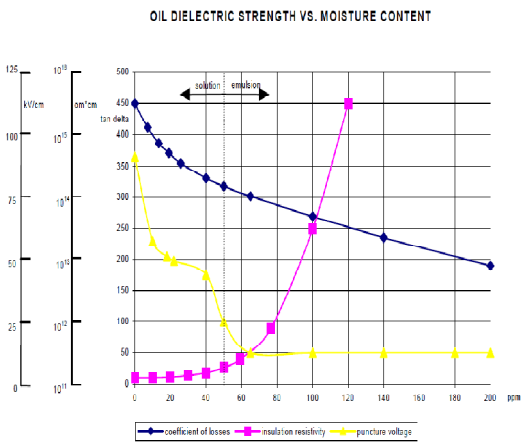

Figure 6 shows the dependence of dielectric strength, moisture content.

Through this machine "MOBILE" for filtering oil there are being achieved satisfactory results.

The machine is designed for the following tasks:

Online degassing, dehydration and filtration of transformer with all oils.

Filling the first electrical insulating oil.

Regeneration, distillation, isolation,

Expected results by filtering insulating oil are:

• Low moisture content in the exit of the machine.

• Low gas / content at the exit of the machine,

• Eliminate of extra gas in isolation,

• Dry isolation transformer,

• Easy and Safe operation,

• Measurement and online registration work process,

• Flexibility to work (a variety of oils and different amounts).

CONCLUSIONS

In this paper are given metalized oil ingredients, chemical features and other technical aspects of insulating oil, based on IEC standards. Insulating oil has bigger use in SEE (Power System) Power Transformers, whether is isolation material or is use for its winding cooling

Given that mineral oil finds a great use in practice as in: power cables, power switches, cable heads, In this paper are shown the modern methods and equipment for filtering the oil, and for the elimination of moisture and other waste, which represents a major contribution to the

Professionals in the field, and a high safety environment. Also in this paper are offered concrete examples of equipment for oil review, its standard filtering tables IEC, and process review of oil along with the results.

Table 1

Appropriate characteristics of insulating unused oils

No.	Characteristics of Oil test methods Boundary value	Testing Methods	Boundary value
1	Sludge Content	IEC	Clean, transparent, blur-free, without solid ingredients
2	Density 20°C	IEC	≤ 0.895 g/m^3
3	Viscosity at 20°C 15°C	IEC	≤ 30cSt ≤ 800cSt
4	Flash Point	IEC	≥ 140°C
5	Pour Point	IEC	≤ 30°C
6	Neutralizing number	IEC	≤ 0.30 mgKOH/g
7	Corrosive Sulphur	IEC	≤ 2
8	Dielectric strength	IEC	≥ 200kV/cm
9	Ingredient of dielectric loss at 90 ° C IEC ≤ 5 * 10-3	IEC	≤ $5*10^{-3}$
10	The presence of inhibitors	IEC	assigned qualitatively

Table 2

Appropriate characteristics of insulating used oils

No.	Characteristics of Oil	Testing Methods	Boundary value
1	Dielectric strength [kV/cm]		
	• untill 110kV		≥ 120kV/cm
	• 110kV	IEC	≥ 160kV/cm
	• more than 220kV		≥ 180kV/cm
2	Dielectric Disspation Factor tgδ	IEC	≥ $1000*10^{-3}$
3	Specific Electrical Resistance 90°C	IEC	≥ $0.1*10^{12}$ Ωcm
4	Flash Point	IEC	The maximum reduction allowed in 10°C in relation to the new oil.
5	Neutralizing number	IEC	≤ 0.5 mgKOH/g oil
6	Layer of insoluble or soluble in the oil *	IEC-422	No or only trace
7	Inter Facial Tension	IEC	≥ 15dyn/cm
8	Presence of Inhibitor **	IEC	Can verify
9	Water Content	IEC	≤ 30ppm
	• untill 110kV		
	• 110kV		
	• more than 220kV		
10	Chimic Stability ***	IEC 10A	Verified us required
	• Non-inhibitor Oil	(C.O)23	
	• Inhibitor Oil		

Note:

*** Qualitatively determined**

****Verified only if verified presence of inhibitor**

*****Verified us required.**

No.	Characteristics of Oil	Group I	Group II	Group III	Group IV
1	Dielectric strength [kV/cm]				
	• until 110kV	≥ 140	≥ 140	≥ 120	< 120
	• 110kV	≥ 180	≥ 180	≥ 160	< 160
	• more than 220kV	≥ 200	≥ 200	≥ 180	< 180
2	Specific Electrical Resistance in [Ωcm] at 90°C	≥ 10^{12}	≥ $0.2*10^{12}$	≥ $0.1*10^{12}$	< $0.1*10^{12}$
3	Dielectric Disspation Factor tgδ 90°C	≤ $50*10^{-3}$	≤ $200*10^{-3}$	≤ $1000*10^{-3}$	> $1000*10^{-3}$
4	Neutralizing number in mg KOH/g oil	≤ 0.05	≤ 0.20	≤ 0.50	> 0.50
5	Dried or non dried oil layer	No	No	Only trace	Yes
6	Inter Facial Tension in dyn/cm	≥ 25	≥ 20	≥ 15	< 15

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