Transformer Life Extension - Part 2
Regeneration of Transformeroil

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University of Hannover

Prof. Dr. Hossein Borsie since 1986 academic director of the University of Hannover, Institute of Hochspannungstchnik. He is a member of VDE, DKE and various Cigré Task Forces and national and international working groups for standards.

Prof. Dr. Hossein Borsie studied and received his PhD in electrical engineering at the Technical University of Hanover. He habilitated with the Venia Legendi „High Voltage Measurement". In 1979 he was appointed to the University of Ferdowsi Mashhad in Iran for the field Enegietechnik. He was from 1980 to 1982 and dean per dean of engineering. In the period 1981 to 1985, he was also Scientific Advisor to the Minister of Energy Inranischen.

The transformer factory „Reza Trans factory" was founded in 1982. Prof. Borsi took over from 1982 to 1985 the technical directorate. He is the author of more than 350 national and international publications. He has 25 national and international patents and is the author and co-author of several books. The focus of his previous research activities are high-voltage measurement technique, solid and liquid insulation, monitoring and diagnosis of vari-

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Life Extension of TRANSFORMERS by Oil-regeneration

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Requirements of insulating oils

1. To meet the **Insulation function**, the oil must have high dielectric strength and low dielectric dissipation factor to withstand the electric stresses imposed in service.

2. To meet the **Heat transfer and Cooling functions**, the oil must have viscosity and pour point that are sufficiently low to ensure that oil circulation is not impaired at the most extreme low temperature conditions for the equipment.

3. To meet the **Arc quenching function**, the oil requires a combination of high dielectric strength, low viscosity and high flash point to provide sufficient insulation and cooling to ensure the arching is extinguished.

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Requirements of insulating oils

4. To have low viscosity to enable **Optimum impregnation** of the solid insulation in transformer

5. Measuring different parameters of the oil such as Gas in Oil analysis allows a **Diagnostic of the condition** of transformer

Functions of an insulating liquid

- Insulation
- Impregnation
- Heat transfer (cooling)
- Fire Extinguishing
- Dielectric
- Diagnostic

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Sludge Formation in Oil

Oxidation begins as soon as the oil is placed in the transformer. Deterioration results from the effects of oxidation. Contamination results from moisture or other foreign substances and starts after the transformer is energized.

Unstable hydrocarbons plus oxygen, moisture, heat, vibration, and electrical stresses result finally in the terminal stage of oil degradation as an insulating medium, that is the formation of sludge. Sludge is the first visible sign that oil needs to be regenerated.

Sludge precipitates out of the oil where it attacks solid insulation and can reduce effective cooling. The sludge builds up in layers whose hardness depends on how the unit has been operated and how long maintenance has been ignored.

Sludge formation depends on the presence of oxygen in an energized transformer. This oxygen may come from outside air, but also comes from the breakdown of the Kraft paper insulation.

The probability of sludge accumulation increases if the oil shows an increase in neutralization (acid) number, a drop in interfacial tension, and a deepening of color.

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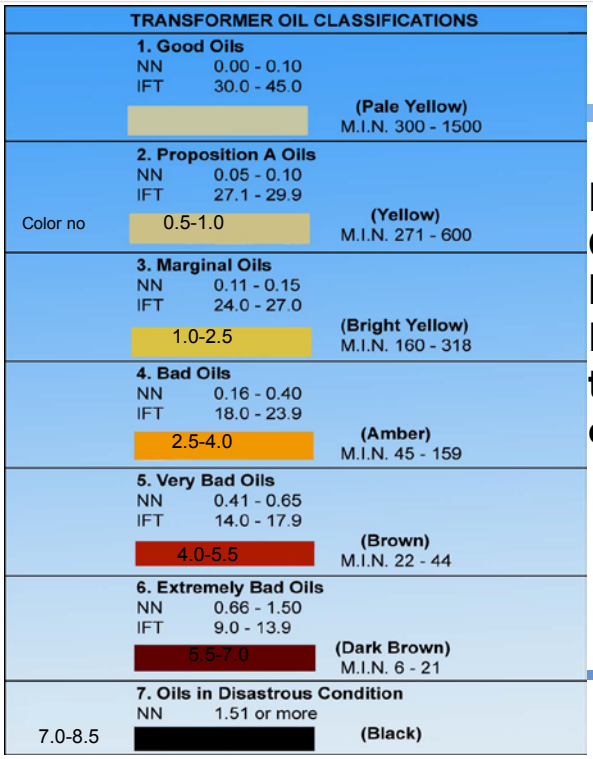

Ref:
Oil condition based on ASTM D 1500 color testing comparisons

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	Symptoms	Diagnosis	Treatment
1.	Breakdown voltage low	Moisture or solids in oil	Oil purification
2.	Oil colour orange/brown	Oil deterioration	Oil regeneration
3.	Visible sludge in oil/transformer	Insulation deterioration	Transformer desludging
4.	Free water in oil or oil cloudy	Insulation Saturated	Transformer dry-out

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Effects of Oil Re-generation and Oil Changing

Both **oil change** and **Re-generation** has been performed on two identical transformer.

Oil change:- The acidity increases rapidly after oil change. After few years the acidity level is nearly same as before the oil change. This increase is caused by contamination from the residual oil left in the tank, core and in the winding insulation, which contaminates the new oil faster.

Oil Re-generation:- Considering the transformer from which the oil was re-generated, six years later the acidity level is approximately at the same low level. According to our world wide experience the acidity and other aging parameters, have acceptable values many years after oil re-generation process.

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Oil regeneration or Oil reclaiming

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- When should reclaiming take place?
- When the oil shows unacceptable values for neutralization, interfacial tension and dissipation factor, then reclaiming should be considered. Since the ageing of cellulose insulation is an irreversible process, it is important to reclaim oil before the degradation has gone too far.
- The state of a transformer's oil-cellulose insulation system is one of the key parameters influencing the transformer's life expectancy and reliability
- The aging rate of insulating materials depends on parameters such as:
- - Original insulation material quality
- - Oil temperature
- - Moisture content
- - Acid content
- - Particle content
- - Sludge content
- Oxidation is the main reason for oil aging. The aging rate of oil is influenced by temperature, as well as metals like copper and iron.
- Moisture, acids, particles and sludge are the oxidation products that cause the most concern.
- Reclaiming of transformer oil is a measure to restore the oil's properties to very near those of new oil.

But it is important to point out that reclaiming is not a drying process. If the transformer insulation is very wet, drying of the transformer should be considered in combination with reclaiming.

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Transformer life expectancy by Oil Re-Gen & Oil change

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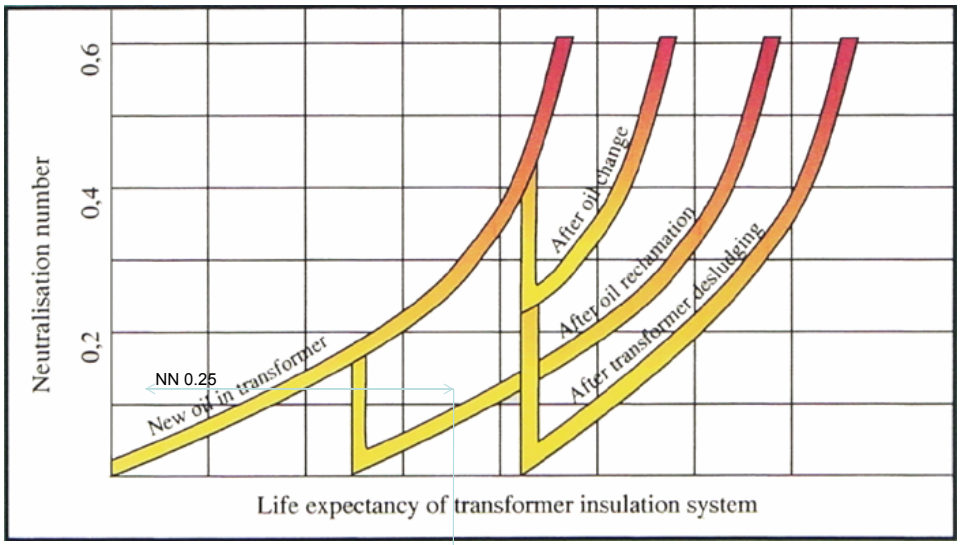

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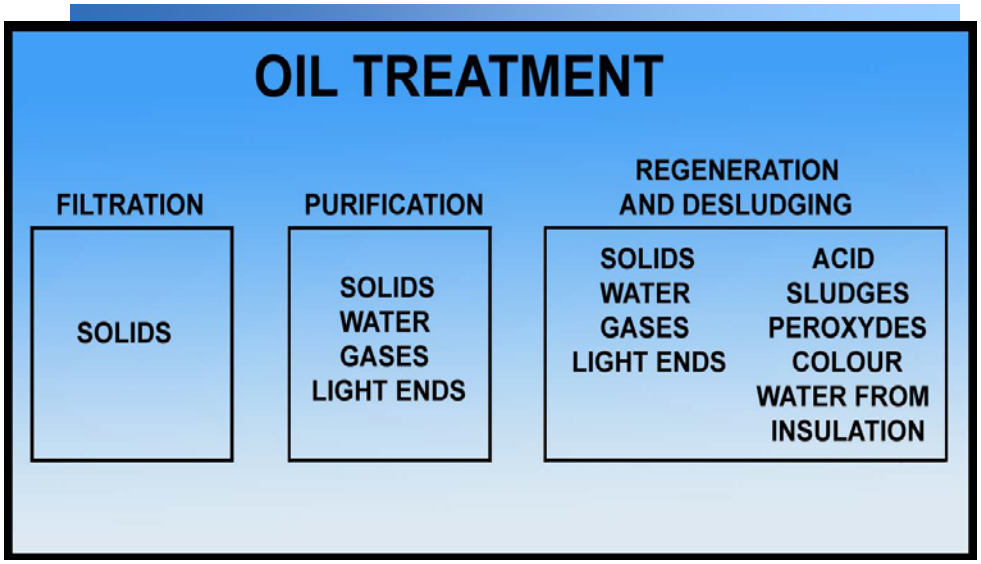

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Re-generated Oil

Whenever possible, re-Generate used transformer oil since it will be a better transformer fluid than new transformer oil.

At least 80 percent of the hydrocarbons of even heavily used oil can be reused after oxidation products are eliminated.

It will be necessary to add the oxygen inhibitor BHT (2,6-Ditertiary-Butyl-Para-Cresol (DBPC)) to re-generated oil.

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What is Oil Re-generation ?

According to IEC, **"it is a process which eliminates, by chemical and adsorbent means, the acidic and colloidal contaminants and products of oil deterioration from the oil, to obtain an oil with many characteristics similar to those of a new product".**

Degassing and filtering is not a re-generation Process.

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WHY OIL REGENERATION FOR TRANSFORMER?

For removing acids, sludge and other degrading products from the oil.

"aging rate of the oil is lowered. This will also have a beneficial effect on the aging of the paper".

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When should Re-generation take place?

When the oil shows unacceptable results for neutralization number, interfacial tension and dissipation factor then the regeneration should be considered.

Since the aging of insulation is an irreversible process, it is important to reclaim at the right time before the degradation has gone too much

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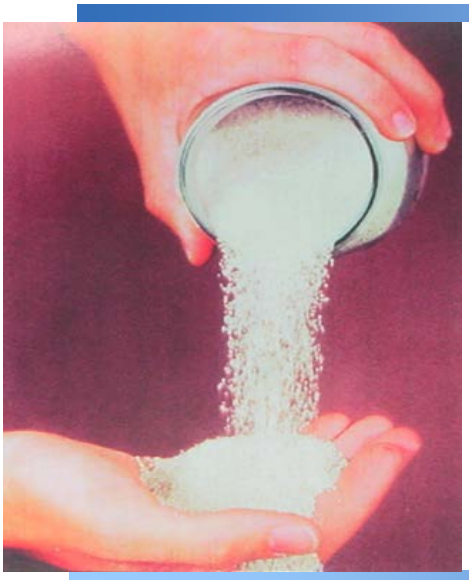

Fuller's Earth

- mineral substance, generally classified as a sedimentary clay, characterized by the property of absorbing basic colors and removing them from oils.
- used chiefly in bleaching and clarifying petroleum and secondarily in refining oils.

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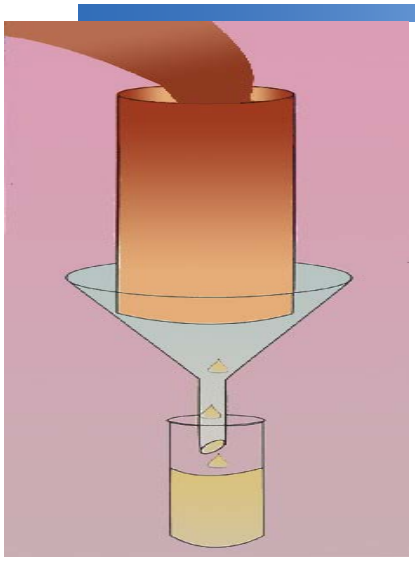

Fuller's Earth

- dirty oil being cleaned by fuller's earth

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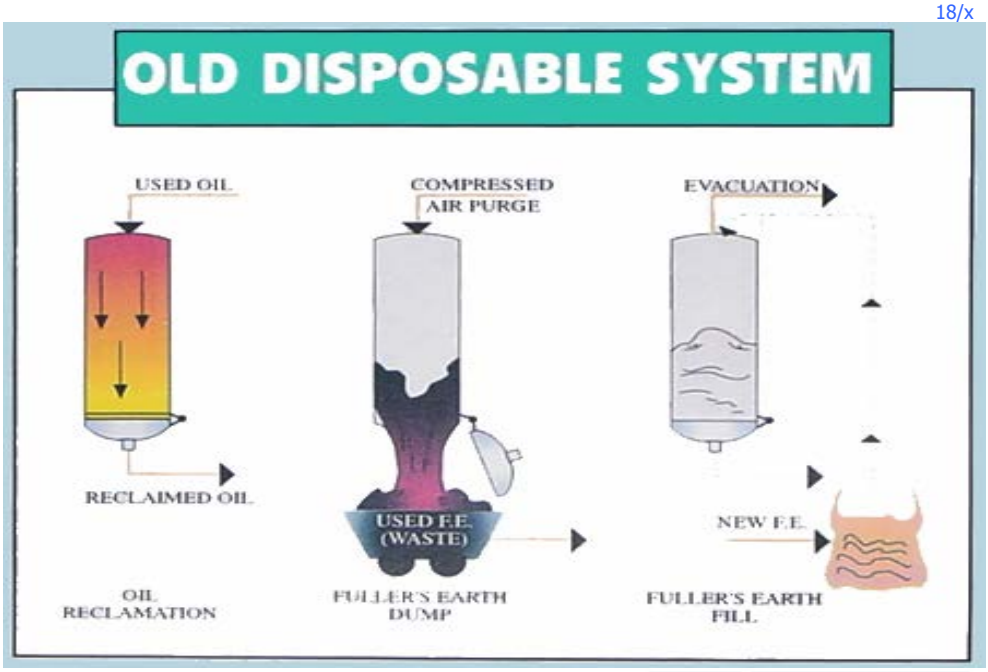

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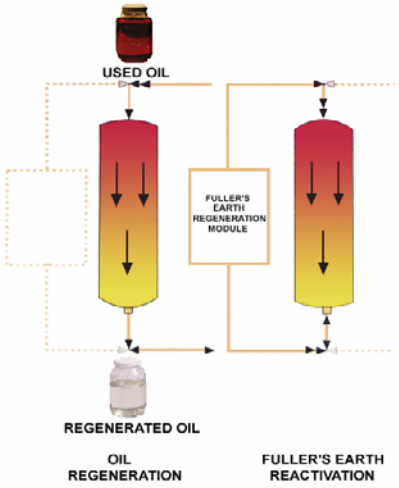

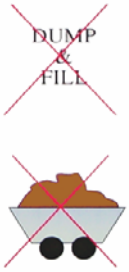

- Fuller's Earth is permanently installed in regeneration plant
- Fuller's Earth is reactivated without its removal from the plant.
- Waste disposal problems are eliminated.
- Loss of product is minimized

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EXISTING CONVENTIONAL (DISPOSABLE FULLER'S EARTH) TECHNOLOGY

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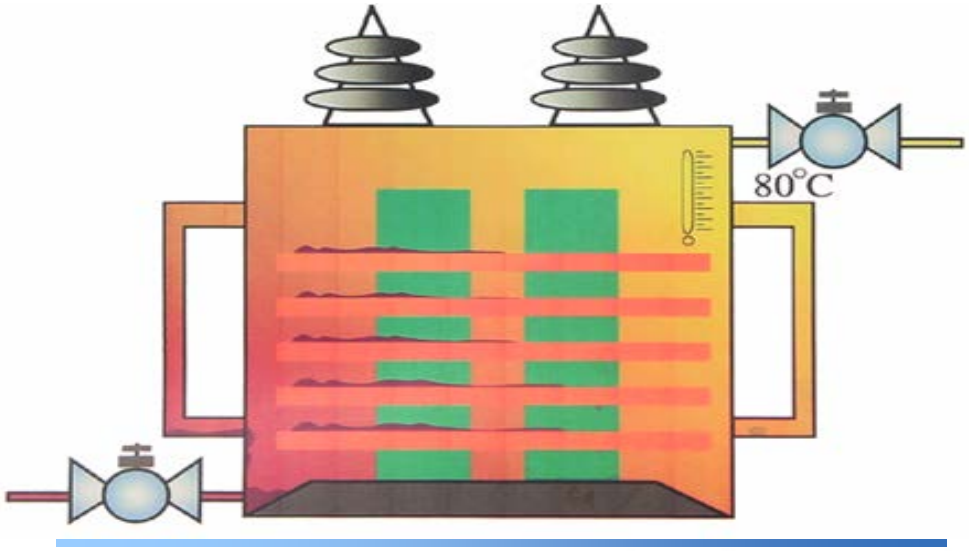
Transformer De-sludging



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COMPARISON OF CONVENTIONAL FULLER'S EARTH FILTRATION SYSTEM (DISPOSABLE) AND NEW ECOIL FILTRATION SYSTEM

DESCRIPTION	CONVENTIONAL	ECOIL
Amount of Waste as a % of Treated Oil	10	0.05
Amount of Oil Loss During Reclamation as a % of Treated Oil	6	0.05
How Many Times Same Fuller's Earth Utilized	1	400
Number of Man Hours Required Per 24 Hours	48	1
Degree of Automation	LIMITED	FULL
Estimated Amount of New Fuller's Earth Required for 2 Years Operation KG/Pounds	576 000 / 1 250 000	1500 / 3300
Amount of Oil Processed With One Charge of Clay. L/Gallons	3000 / 800	4 000 000 / 1 060 000
Running Cost Per 1L/1 Gallon of Oil Treated (Excl. Labour)	34 US cents	0.8 US cents
Field Self Sufficiency W/O Logistic Support	ONE WEEK	6 MONTHS

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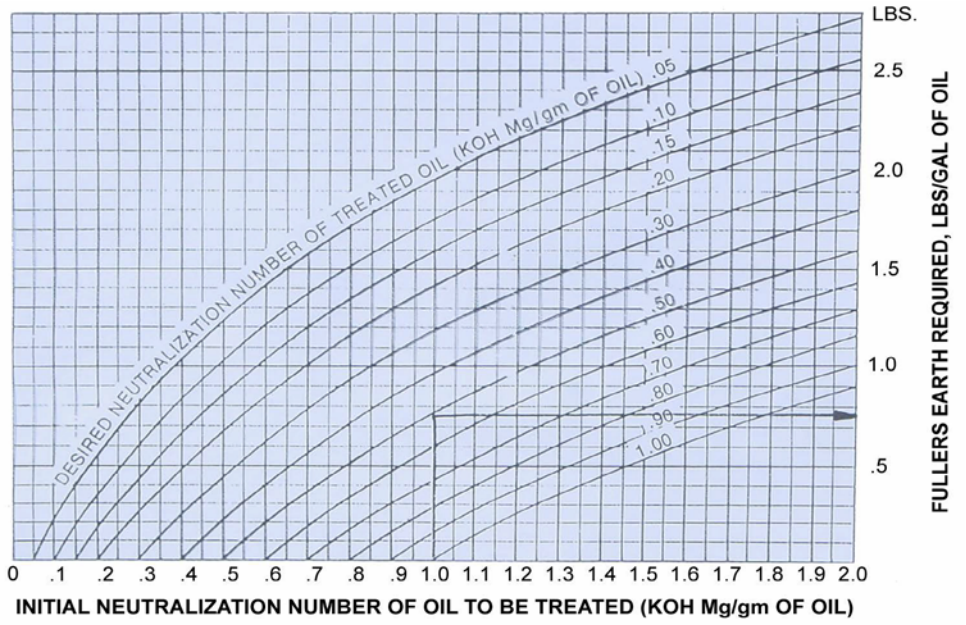

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PERFORMANCE OF FILTERVAC'S OIL REGENERATION PLANT AFTER SINGLE PASS TREATMENT

Test	ASTM Method	IEEE Recommend-ation	After Reclamation
Electric Strength (kv)	D877	30	40
Water Content (mg/kg)	D1533	35	5
Neutralization Value (mg KOH/g)	D974	0.05	0.03
Power (Dissipation) Factor @ 100°C %	D924	1	0.5
Interfacial Tension	D971	35	40
Oxidation stability 164h neutralisation value (mg KOH/g) sludge (% by mass)	D2440	 0.5 0.25	 0.4 0.10

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Oil-regeneration System

Regeneration Part

Drying and degassing Part

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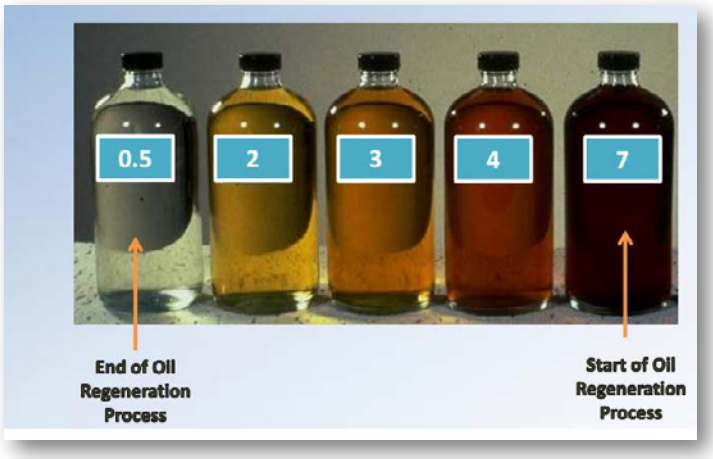
Colour of regenerated oil after different passes



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Example of re-generated oil in Golshahr plant

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Oil data after re-generation

Oil data before regeneration

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Online re-generation of a 132 kV, 30MVA Transformer

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Oil after one pass

Oil bevor re-generation

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Onste re-generation of a transformer in a Steel company

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Oil of the transformer in the steel company after 3 passes