



Oilregeneration - positive Aspects on Transformer oils

Naal Nayef & Marcel Rybensky Filtervac

Mr. Na`al Nayef is a professional mechanical engineer working as the Engineering and Sales manager for Filtervac International Inc.; Mr. Nayef has been involved in the green energy products development in terms of design, manufacturing and testing. With over 19 years' experience in high level engineering and several patents awarded in the green energy sector; Mr. Nayef has gained reputable role in improving performance and economics for oil treatment systems sector.





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Oilregeneration - positive Aspects on Transformer oils



Oil Regeneration - Positive Aspects on Transformer Oils

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Transformer Oil Regeneration



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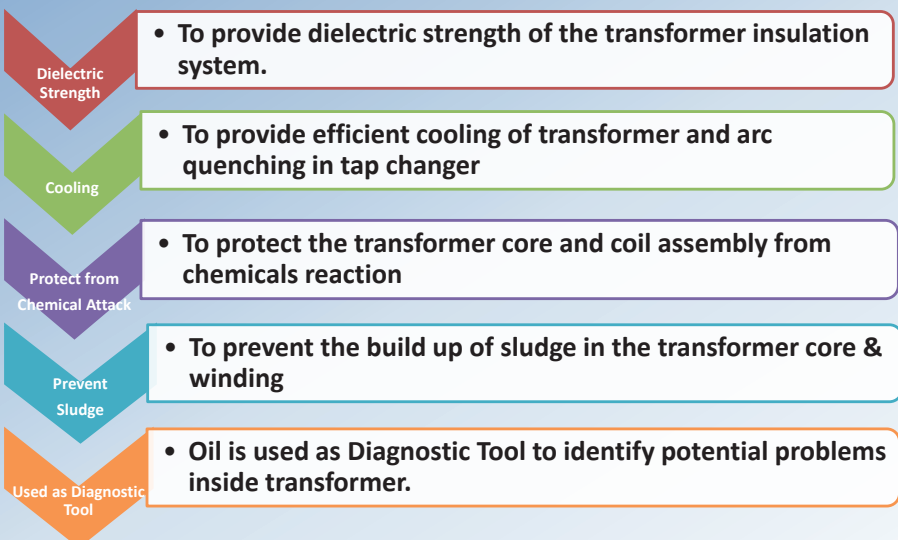
Oilregeneration - positive Aspects on Transformer oils

 **PRESENTATION OVERVIEW**

- TRANSFORMER OIL FUNCTIONS
- OIL & PAPER INSULATION DEGRADATION FACTORS
- EFFECTS OF OIL RE-GENERATION AND OIL CHANGING
- CHANGING THE TRANSFORMER OIL WILL NOT SOLVE THE PROBLEM
- THE SOLUTION - OIL REGENERATION
 - ❖ OIL REGENERATION KEY PROPERTIES IMPROVEMENT
 - ❖ WHEN SHOULD REGENERATION TAKE PLACE?
 - ❖ OIL COLOUR
 - ✓ OIL COLOUR RESTORATION
 - ✓ PRACTICAL EXAMPLE IMPROVING OIL PROPERTIES (OIL COLOUR)
- OIL SLUDGE
 - ❖ SLUDGE FORMATION IN OIL AND TREATMENT BY REGENERATION
- CORROSIVE SULPHUR
 - ❖ SULPHUR COMPOUNDS
 - ❖ PRACTICAL EXAMPLES TREATMENT OF CORROSIVE SULPHUR
- FILTERVAC'S OIL REGENERATION TEST RESULTS
- TYPICAL FILTERVAC ECOIL OIL REGENERATION RESULTS
- ADVANTAGES OF OIL REGENERATION

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 **TRANSFORMER OIL FUNCTIONS**




- To provide dielectric strength of the transformer insulation system.
- To provide efficient cooling of transformer and arc quenching in tap changer
- To protect the transformer core and coil assembly from chemicals reaction
- To prevent the build up of sludge in the transformer core & winding
- Oil is used as Diagnostic Tool to identify potential problems inside transformer.

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 **OIL & PAPER
INSULATION DEGRADATION FACTORS**
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Heat	<ul style="list-style-type: none">• Chemical reactions occur faster at higher temperatures• Each 8 °C rise above design will cut the life of the paper in half
Oxygen	<ul style="list-style-type: none">• The higher the oxygen content, the faster the reaction.• 10 times transformer life at the same temperature if oxygen is < 300 ppm
Water	<ul style="list-style-type: none">• Doubling moisture content will cut transformer life by half• Moisture content in insulation paper is hundreds of times greater than in the oil
Oil Oxidation	<ul style="list-style-type: none">• Insulation paper has an affinity for acids, peroxides and other oxidation reactants• Acid concentration of 0.1 mg KOH/gm will result in 35% reduction in tensile strength of insulation paper

 **EFFECTS OF OIL
RE-GENERATION AND OIL CHANGING**
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BOTH OIL CHANGE AND RE-GENERATION HAS BEEN PERFORMED ON TWO IDENTICAL TRANSFORMER.

<p>The acidity increases rapidly after an oil change. As early as a few months the acidity level can reach the same levels as before the oil change. This increase is caused by cross contamination from residual oil and sludge left in the tank core and in the winding insulation. This will contaminate the new oil. Almost all embedded and deposited ageing residue products remain in the transformer. This will cause the rapid ageing of the new oil.</p>	<p>Once the transformer oil has been regenerated, the acidity levels are approximately the same after six years of operation as when first regenerated. According to our world wide experience the acidity and other aging parameters, have acceptable values many years after oil re-generation process.</p>
Oil Change 	Oil Re-Generation 



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FILTERVAC INTERNATIONAL INC. **CHANGING THE TRANSFORMER OIL WILL NOT SOLVE THE ROUTE PROBLEM**

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Oil Changing	Oil Regeneration
Price to buy new oil is higher than price to regenerate old oil + high production loss due to shutdown.	More economical than oil changing; system is paid back within one to two years
Additional costs associated with disposing of used oil and the associated handling risks and potential environmental contamination	Small amount of new oil is required for make-up. About 2 to 5% of the transformer volume is required for transformer top up.
20% of old oil will remain in the transformer with no removal of sludge	Regeneration removes sludge and cleans transformer internal components
New oil requires vacuum drying and filling system with additive injection.	One system provides oil regeneration, vacuum filling and additive injection
Does not remove existing corrosive sulfur and DBDS in the oil	Removal/Reduction of corrosive sulfur & DBDS by selecting CST Option in existing oil
Interruption to transformer operation. Vacuum filling is not safe for aged transformer winding.	No interruption to transformer operation utilizing Filtervac's On-line treatment option

FILTERVAC INTERNATIONAL INC. **THE SOLUTION**

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Oil Regeneration

Initial color	After 1 pass	After 2 pass	After 3 pass	After 4 pass	After 5 pass	After 6 pass	Final Color
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THE NUMBER OF PASSES IS DEPENDENT ON

- INITIAL OIL QUALITY BEING REGENERATED
- SIZE OF ELECTRICAL TRANSFORMER (QUANTITY OF OIL)
- CLAY AND FLOW RATE CAPACITY OF SYSTEM BEING USED TO REGENERATE
- TYPE OF TECHNOLOGY AND MANUFACTURER OF EQUIPMENT USED TO REGENERATE

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OIL REGENERATION

Mobile Onsite Transformer Oil Regeneration System www.filtervac.com

Regeneration of oil is a process which eliminates acidic and colloidal contaminants and products of oil deterioration from the oil. This is achieved by chemical and adsorbent means to obtain an oil with many characteristics similar to those of a new product. Regeneration is highly effective in absorbing the polar impurities and degradation products from aged transformer oil. The purified oil flows back into the transformer. Depending on the size of the transformer and the condition of the old insulating oil complete purification can take several days or weeks.

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OIL REGENERATION KEY PROPERTIES IMPROVEMENT

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Interfacial Tension	• Removing Oxidation Products & polar degradation contaminants.	
Sludge Removal	• Removal of Sludge by processing through the Filtervac's Durasorb Process	
Neutralization Number	• Removal of acids Alcohols, Aldehydes, Epoxides, Keytones, Peroxides and Soaps	
Particulate Matter	• Filtration will result in removal of particulate matter	
Dielectric Strength	• Water Removal by Dehydration Through High Vacuum Process	
Depolarization	• Removing Corrosive Sulfur and DBDS Products	
Oil Passivation	• Prevent Copper Sulfide Formation in Transformer Winding	

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WHEN SHOULD REGENERATION TAKE PLACE?

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When the oil shows unacceptable results for neutralization number "Acidity", interfacial tension, color, corrosive sulphur content 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 far

• <0.1 mg KOH/g Oil

Neutralization Number

• Acidity > 0.06 mg KOH/g oil
• and IFT < 30 mN/m

Combination of acidity and IFT

• Color 3 to 4 as per ASTM D1500

Color

• 3a to 3b as per ASTM D130

Corrosive Sulphur

• Where perceptible sludge is detected reclaim oil

Sludge

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OIL COLOUR VS ACIDITY VS IFT

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GOOD	PROP A	MARGINAL	BAD	VERY BAD	EXTREMELY BAD	CLASS 7 OILS
Effect on transformer						
Providing these functions 1. Efficient Cooling 2. Preserving insulation.	Polar compounds (sludges) in solution (products of oil oxidation) causes the drop in IFT.	Fatty Acids coat the windings. Sludges in solution (products of oil oxidation) causes the drop in IFT. Sludges in insulation voids highly probable.	In almost 100% of the transformers in this range sludges are deposited on core and coils. Sludges are first deposited in fin areas.	Deposited sludges continue to oxidize and harden. Sludges insulate cooling fins, block vents causing higher operating temperatures. Premature failure a good possibility.	Sludges insulate cooling fins, block vents causing higher operating temperatures.	
Acid (Neut) No. mg KOH/g						
0.03 to 0.10	0.05 to 0.10	0.11 to 0.15	0.16 to 0.40	0.41 to 0.65	0.66 to 1.50	1.50 and higher
Interfacial Tension Dynes/CM						
30-45	27-29	24-27	18-24	14-18	10-14	6-9

Transformer oil colour and classification chart

- New Oil is Visually Clear in colour**
- Turbidity, sludge, carbon and free water have an effect on oil colour**
- Acceptable oil will be clear and bright, free from and visible contamination**

TRANSFORMER OIL CLASSIFICATIONS	
1. Good Oils	NN 0.00 - 0.10 IFT 30.0 - 45.0 (Pale Yellow) M.I.N. 300 - 1500
2. Proposition A Oils	NN 0.05 - 0.10 IFT 27.1 - 29.9 (Yellow) M.I.N. 271 - 600
3. Marginal Oils	NN 0.11 - 0.15 IFT 24.0 - 27.0 (Bright Yellow) M.I.N. 160 - 318
4. Bad Oils	NN 0.16 - 0.40 IFT 18.0 - 23.9 (Amber) M.I.N. 45 - 159
5. Very Bad Oils	NN 0.41 - 0.65 IFT 14.0 - 17.9 (Brown) M.I.N. 22 - 44
6. Extremely Bad Oils	NN 0.66 - 1.50 IFT 9.0 - 13.9 (Dark Brown) M.I.N. 6 - 21
7. Oils in Disastrous Condition	NN 1.51 or more (Black)

Ref: Oil condition based on ASTM D 1500 colour testing

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OIL COLOUR RESTORATION

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0.5

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**End of Oil
Regeneration
Process**

2

3

4

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↑

**Start of Oil
Regeneration
Process**

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PRACTICAL EXAMPLE IMPROVING OIL PROPERTIES

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Report # 97553 Sample # 3

Serial Number: 406199 Equipment Number: FSL-AL-01

Substation Name: SEC-W HVP Jeddah Preservation System: Free Breather

Design Type: Core Transformer Name: FSL-AL-01Shunt

Manufacturer: TRAFU UNION Transformer Type: Reactor

MFR. Year: 1981 Maximum kV: 380

Cooling System: ONAF Maximum MVAR: 250

Fluid Type: Mineral XFMR Oil Capacity: 69000 Lts

COLOR & NEUT.

Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	Interfacial Tension dynes/cm	Neut. No. mgKOH/g	PF 100C %	Inhibitor Content %
			D 1533 IEC 60814		D 1500	D 877A	D 971 ISO 6295	D 974	D 924	D 2668
97553	06/10/2010	78	5	1	L 1.0	59	47	< 0.01	0.952	ND
92413	08/18/2009	86	62	12	L 7.5	16	18	0.13	22.300	ND

FROM

7. Oils in Disastrous Condition
NN 1.51 or more (Black)

➔

TO

1. Good Oils
NN 0.00 - 0.10
IFT 30.0 - 45.0 (Pale Yellow)
M.I.N. 300 - 1500

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IMPROVING OIL PROPERTIES**

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<p>Report # 97553 Sample # 2</p> <p>Serial Number: 407049 Equipment Number: TR-1</p> <p>Substation Name: SASS - Makkah Preservation System: Sealed Conservator</p> <p>Design Type: Core Type Transformer Name: SASS-TR # 01</p> <p>Manufacturer: TrU Transformer Type: Transformer</p> <p>MFR. Year: 1986 Maximum kV: 420</p> <p>Cooling System: OFAF Maximum MVA: 500</p> <p>Fluid Type: Mineral XFMR Oil Capacity: 87000 Kilograms</p>	<p>COLOR & NEUT. #</p>
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Oil Quality Tests

Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	Interfacial Tension dynes/cm	Neut. No. mgKOH/g	PF 100C %	Inhibitor Content %
97553	06/10/2010	60	18	7	L 1.0	54	43	< 0.01	1.278	ND
95450	12/28/2009	68	33	11	L 7.0	50	9	0.17		ND

FROM

7. Oils in Disastrous Condition
NN 1.51 or more
(Black)

➔

TO

1. Good Oils
NN 0.00 - 0.10
IFT 30.0 - 45.0
(Pale Yellow)
M.I.N. 300 - 1500

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FILTERVAC INTERNATIONAL INC. **PRACTICAL EXAMPLE
IMPROVING OIL PROPERTIES**

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<p>Report # 97553 Sample # 1</p> <p>Serial Number: 407047 Equipment Number: TR-2</p> <p>Substation Name: SASS - West Makkah Preservation System: Sealed Conservator</p> <p>Design Type: Core Type Transformer Name: SASS-TR # 02</p> <p>Manufacturer: TrU Transformer Type: Transformer</p> <p>MFR. Year: 1986 Maximum kV: 420</p> <p>Cooling System: OFAF Maximum MVA: 500</p> <p>Fluid Type: Mineral XFMR Oil Capacity: 87000 Kilograms</p>	<p>COLOR & NEUT. #</p>
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Oil Quality Tests

Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	Interfacial Tension dynes/cm	Neut. No. mgKOH/g	PF 100C %	Inhibitor Content %
97553	05/08/2010	52	16	5	L 1.0	60	47	< 0.01	0.159	ND
96068	02/24/2010	80	21	5	L 1.0	65	43	< 0.01	1.290	ND
95450	12/28/2009	66	30	10	L 7.0	60	19	0.12		ND

FROM

7. Oils in Disastrous Condition
NN 1.51 or more
(Black)

➔

TO

1. Good Oils
NN 0.00 - 0.10
IFT 30.0 - 45.0
(Pale Yellow)
M.I.N. 300 - 1500

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OIL SLUDGE

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Sludge Formation Factors

- Electrical Stresses
- Missed Preventive Maintenance
- hydroc arbons
- Oxygen
- Moisture
- Heat
- Vibration

Sludge

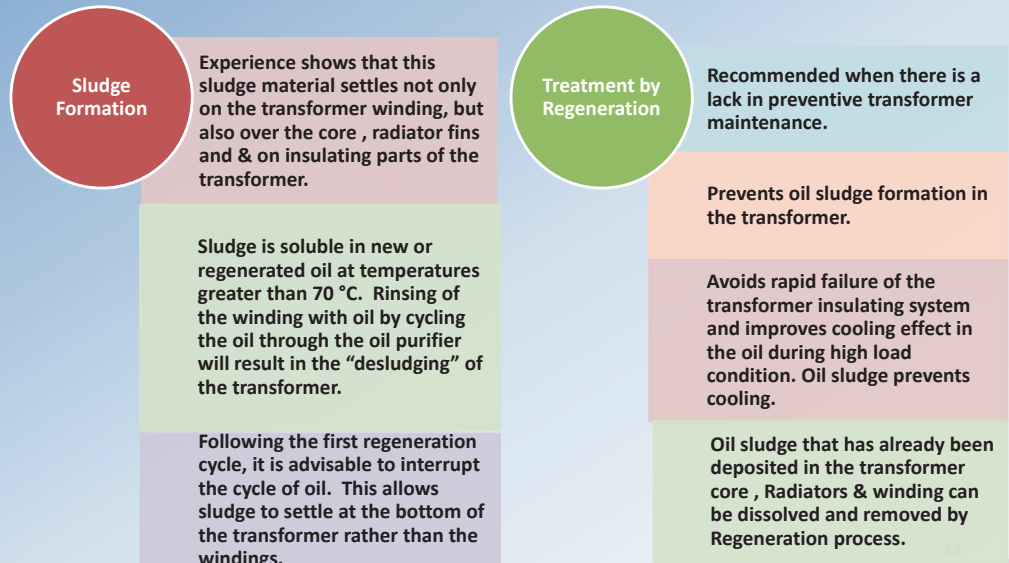
SLUDGE FORMATION DEPENDS ON THE PRESENCE OF OXYGEN IN AN ENERGIZED TRANSFORMER. THIS OXYGEN MAY COME FROM OUTSIDE AIR, BUT ALSO COMES FROM THE BREAKDOWN OF THE KRAFT PAPER INSULATION.

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SLUDGE FORMATION IN OIL AND TREATMENT BY REGENERATION

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Sludge Formation

Experience shows that this sludge material settles not only on the transformer winding, but also over the core , radiator fins and & on insulating parts of the transformer.

Sludge is soluble in new or regenerated oil at temperatures greater than 70 °C. Rinsing of the winding with oil by cycling the oil through the oil purifier will result in the “desludging” of the transformer.

Following the first regeneration cycle, it is advisable to interrupt the cycle of oil. This allows sludge to settle at the bottom of the transformer rather than the windings.

Treatment by Regeneration

Recommended when there is a lack in preventive transformer maintenance.

Prevents oil sludge formation in the transformer.


Avoids rapid failure of the transformer insulating system and improves cooling effect in the oil during high load condition. Oil sludge prevents cooling.

Oil sludge that has already been deposited in the transformer core , Radiators & winding can be dissolved and removed by Regeneration process.



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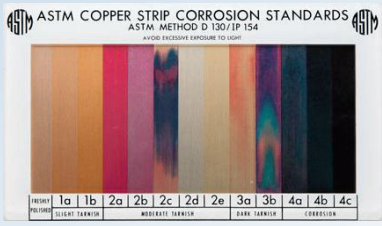
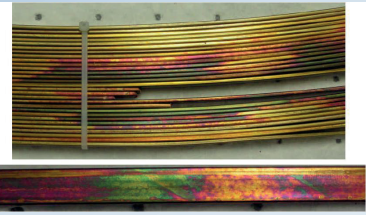
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CORROSIVE SULPHUR

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- Elemental sulphur and thermally unstable sulphur compounds in insulating oil cause corrosion of internal transformer components. In particular, metals such as copper and silver.
- Not formed in transformer's normal operational conditions
 - ❖ Known sources of contamination: poorly refined crude oil, addition of chemical compounds
 - ❖ Other Suspected sources: gaskets, water-based glues, copper and kraft paper



ASTM COPPER STRIP CORROSION STANDARDS
ASTM METHOD D 130/IP 154
AVOID EXCESSIVE EXPOSURE TO LIGHT

1a	1b	2a	2b	2c	2d	2e	3a	3b	4a	4b	4c
SLIGHT TANNING		MODERATE TANNING				DARK TANNING		CORROSION			

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SULPHUR COMPOUNDS

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- Multiple Sources = Multiple Compounds
- Thiophens, Disulphides, Thio-ethers, Mercaptans, Sulphur
- Dibenzyl-Disulphide (DBDS) was identified experimentally to be a primary compound in corrosive sulphur related faults

Increasing order of corrosion →



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PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 102165 Sample # 1													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	D1816-1mm kV	Interfacial Tension dynes/cm	Neut. No. mgKOH/g	PF25C %	PF 100C %	Specific Gravity 60/60	Inhibitor Content %	Visual
			D1533 IEC 60814		D1500	D1816	ISO 6295	D974	D924	D924	D1298	D2688	D1524
102165	01/22/2011	44	3	2	L 0.5	38	49	< 0.01	< 0.001	0.054	0.888	0.146	Clear & Bright-Few Particles
100864	11/07/2010	50	3	2	L 0.5	34	45	< 0.01	0.007	0.107	0.883	0.285	Clear & Bright-Fine Particles

Additional Oil Quality Tests				
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive Level (D 1275B)	Sulfur, Corrosive Tarnish Level (D 1275B)
102165	01/22/2011	44	Non-corrosive	1b
100864	11/07/2010	50	Non-corrosive	3b

Sulfur by D1275B is acceptable.

XFMR Oil Capacity: 75000 Kilograms

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PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 102744 Sample # 3													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	D1816-1mm kV	Interfacial Tension dynes/cm	Neut. No. mgKOH/g	PF25C %	PF 100C %	Specific Gravity 60/60	Inhibitor Content %	Visual
			D1533 IEC 60814		D1500	D1816	ISO 6295	D974	D924	D924	D1298	D2688	D1524
102744	02/23/2011	19	2	4	L 0.5	34	49	< 0.01	0.002		0.888	ND	Clear & Bright-Few Particles
100864	11/07/2010	52	6	3	L 1.0	17	36	0.03	0.012	0.259	0.888	ND	Clear & Bright-Fine Particles

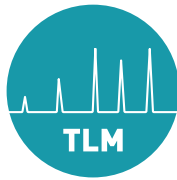
Additional Oil Quality Tests				
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive Level (D 1275B)	Sulfur, Corrosive Tarnish Level (D 1275B)
102744	02/23/2011	19	Non-corrosive	1b
100864	11/07/2010	52	Corrosive	4a

Sulfur by D1275B is acceptable.

XFMR Oil Capacity: 78460 Liters

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PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 135696 Sample # 5													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	D1816-1mm kV	Interfacial Tension mN/m	Neut. No. mgKOH/g	PF 100C %	Specific Gravity (Rel. Density) 60/60	Inhibitor Content: D 2668 %	Visual
			D1533 IEC 60814		D1500	D877	D1816	D971 ISO 6295	D974	D924	D1298	D2668	D1524
135696	01/08/2014		16		L 1.0		36	43	< 0.01		0.878		Clear & Bright-Many Particles
131446	09/11/2013		38		L 1.5	29	14	37	0.02	1.052	0.889	0.243	Clear & Bright
Additional Oil Quality Tests													
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive Level (D 1275B)	Sulfur, Corrosive Tarnish Level (D 1275B)	Visual								
135696	01/08/2014		D1275B	D130	2c								
131446	09/11/2013		D1275B	Non-corrosive	4a								
Sulfur by D1275B is acceptable.													

ASTM COPPER STRIP CORROSION STANDARDS
ASTM METHOD D 130 / IP 154
AVOID EXCESSIVE EXPOSURE TO LIGHT

XFMR Oil Capacity: 1450 Kilograms

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FILTERVAC INTERNATIONAL INC.

PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 135696 Sample # 9													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	D1816-1mm kV	Interfacial Tension mN/m	Neut. No. mgKOH/g	PF 100C %	Specific Gravity (Rel. Density) 60/60	Inhibitor Content: D 2668 %	Visual
			D1533 IEC 60814		D1500	D877	D1816	D971 ISO 6295	D974	D924	D1298	D2668	D1524
135696	01/08/2014		31		L 0.5		37	38	< 0.01		0.876		Clear & Bright-Many Particles
131446	09/11/2013		46		L 0.5	36	14	38	0.01	0.426	0.866	0.104	Clear & Bright-Few Particles
Additional Oil Quality Tests													
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive Level (D 1275B)	Sulfur, Corrosive Tarnish Level (D 1275B)	Visual								
135696	01/08/2014		D1275B	D130	1b								
131446	09/11/2013		D1275B	Non-corrosive	4a								
Sulfur by D1275B is acceptable.													

ASTM COPPER STRIP CORROSION STANDARDS
ASTM METHOD D 130 / IP 154
AVOID EXCESSIVE EXPOSURE TO LIGHT

XFMR Oil Capacity: 300 Kilograms

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PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 135696 Sample # 16													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	D1816-1mm kV	Interfacial Tension mN/m	Neut. No. mgKOH/g	PF 100C %	Specific Gravity (Rel. Density) 60/60	Inhibitor Content-D 2668 %	Visual
			D1533 IEC 60814		D1500	D877	D1816	D971 ISO 6295	D974	D924	D1298	D2668	D1524
135696	01/08/2014		28		L 0.5		36	42	< 0.01		0.875		Clear & Bright-Many Particles
131446	09/11/2013		22		L 1.5	23	17	38	0.02	1.324	0.889	0.256	Clear & Bright-Few Particles
Additional Oil Quality Tests													
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive D 1275B	Sulfur, Corrosive Tarnish Level (D 1275B)									
135696	01/08/2014		Non-corrosive	1b									
131446	09/11/2013		Corrosive	4a									

ASTM COPPER STRIP CORROSION STANDARDS
ASTM METHOD D 130/JP 154
ALWAYS INCLUDE CAPSULE TO SCALE

1a | 1b | 2a | 2b | 2c | 2d | 2e | 3a | 3b | 4a | 4b | 4c

XFMR Oil Capacity: 200 Kilograms

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PRACTICAL EXAMPLE TREATMENT OF CORROSIVE SULPHUR

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Oil Quality Tests													
Report # 135696 Sample # 18													
Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	Diel D877 kV	D1816-1mm kV	Interfacial Tension mN/m	Neut. No. mgKOH/g	PF 100C %	Specific Gravity (Rel. Density) 60/60	Inhibitor Content-D 2668 %	Visual
			D1533 IEC 60814		D1500	D877	D1816	D971 ISO 6295	D974	D924	D1298	D2668	D1524
135696	01/08/2014		12		L 0.5		37	42	< 0.01		0.884		Clear & Bright-Many Particles
131446	09/11/2013		22		L 1.5	23	17	38	0.02	1.324	0.889	0.256	Clear & Bright
Additional Oil Quality Tests													
Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive D 1275B	Sulfur, Corrosive Tarnish Level (D 1275B)									
135696	01/08/2014		Non-corrosive	1b									
131446	09/11/2013		Corrosive	4a									

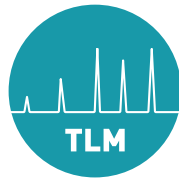
ASTM COPPER STRIP CORROSION STANDARDS
ASTM METHOD D 130/JP 154
ALWAYS INCLUDE CAPSULE TO SCALE

1a | 1b | 2a | 2b | 2c | 2d | 2e | 3a | 3b | 4a | 4b | 4c

XFMR Oil Capacity: 1450 Kilograms

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Doble Engineering Company 85 Walnut Street Watertown, MA 02472 USA Tel. 617-926-4900 Fax. 617-926-0528 http://www.doble.com



**TRANSFORMER-LIFE-MANAGEMENT
CONFERENCE**

Oilregeneration - positive Aspects on Transformer oils

FILTERVAC INTERNATIONAL INC.

FILTERVAC'S OIL REGENERATION TEST RESULTS

www.filtervac.com

Oil Analysis of Regeneration by Fullers Earth treatment process 400kV Transformer, National Grid Company, UK

Test	Before Process	After Regeneration	After 1 Year Operation	After 2 Years Operation
Moisture ppm	23	8	10	11
Acidity mg KOH/gm	0.20	<0.01	0.01	0.02
Dielectric kV	35	76	71	69
Sludge content %	0.02	<0.01	<0.01	<0.01
Resistivity at 90°C	2.5	226	184	160
Dielectric Dissipation Factor (DDF) at 90°C	0.095	0.005	0.006	0.009
Oxidation Stability Total Acid mg KOH/g sludge% by mass	0.48 2.29	0.16 1.23	0.18 1.30	0.19 1.32
Viscosity at 40°C	11.9	11.8	11.8	11.6
Interfacial Tension	25	40	38	36
Corrosive Sulphur	Positive	negative	negative	negative
Phosphorus ppm	11	ND	ND	ND

FILTERVAC INTERNATIONAL INC.

TYPICAL FILTERVAC ECOIL OIL REGENERATION RESULTS

www.filtervac.com

No	TBest Parameter	ASTM Test	Unit	Before Regeneration (Dirty Oil)	After Regeneration (Cleaned Oil)	IEEE limits
1	Colour	D-1500	L	>7.0	0.5	Max. 2.0
2	Corrosive Sulphur	D-1275		Corrosive	Non-Corrosive	
3	Breakdown Voltage (2mm Gap)	D-877 Part B	KV	15	> 40	Min. 30
4	Gas content	D-3612	%	15	0.1	
5	Interfacial Tension	D-971	Dynes/cm	10	40 -50	Min. 30
6	Neutralization Number	D-974e	mgKOH/g	0.8	0.01	Max. 0.05
7	Water Content	D-1533	ppm	100	> 10	Max. 20

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FILTERVAC INTERNATIONAL INC. **PRACTICAL EXAMPLE
IMPROVING ALL OIL PROPERTIES** www.filtervac.com

Additional Oil Quality Tests **Report # 110641 Sample # 4**

Report #	Sample Date	Top Oil Temp °C	Sulfur, Corrosive D 1275B	Sulfur, Corrosive Tamish Level (D 1275B)	Serial Number:	Equipment Number:
110641	01/29/2012	40	D1275B Corrosive	D130 3b	5251121	GT-8
108937	12/12/2011	32	Non-corrosive	4b	PP3 JEDDAH, KSA	Open Conservator
					Design Type: Core Type	Transformer Name: GEN XFMR
					Manufacturer: TrU	Transformer Type: Transformer
					MFR. Year: 1978	Maximum KV: 138
					Cooling System: ONAN/ONAF	Maximum MVA: 73
					Fluid Type: Mineral	XFMR Oil Capacity: 21900 Kilograms

Report #	Sample Date	Top Oil Temp °C	Water Content ppm	Relative Saturation %	Color	D1816-1mm kV	Interfacial Tension mN/m	Neut. No. mgKOH/g	PF25C %	PF 100C %	Specific Gravity 60/60	Inhibitor Content %	Visual
110641	01/29/2012	40	6	5	L 1.0	32	43	0.01	0.006	0.977	0.875	ND	Clear & Bright-Fine Particles
108937	12/12/2011	32	26	7	L 5.0	21	10	0.11	0.454	14.700	0.849	ND	Clear & Bright

5. Very Bad Oils
 NN 0.41 - 0.65
 IFT 14.0 - 17.9
 (Brown)
 M.I.N. 22 - 44

1. Good Oils
 NN 0.00 - 0.10
 IFT 30.0 - 45.0
 (Pale Yellow)
 M.I.N. 300 - 1500

ASTM CORROSION STANDARDS

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FILTERVAC INTERNATIONAL INC. **SUITABLE FOR ALL POWER TRANSFORMERS** **ADVANTAGES OF OIL REGENERATION** www.filtervac.com

- Extension of the transformer service life and increase reliability of transformers operation
- Significant financial savings compared to oil replacement, including handling and disposal costs. Economically independent of the current price of new oil
- No problems with transport and disposal of the used transformer oil. No operational loss caused by transformer shutdown (Online process)
- In contrast to an oil replacement the transformer internal components and insulation are also cleaned.
- Improves the quality of insulating oil to that of new oil.
- Sustainable improvement in the condition of the insulation.

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TRANSFORMER-LIFE-MANAGEMENT
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Oilregeneration - positive Aspects on Transformer oils

Thank you

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