TRANSFORMERS MAGAZINE'S
INDUSTRY NAVIGATOR

INVESTMENTS, ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY

CONFERENCE 2024

Eco-Innovation in Power: Enhancing Transformer Longevity with MICAFLUID's Sustainable Oil Treatment Technologies

Presented by Marius Grisaru

MICAFLUID

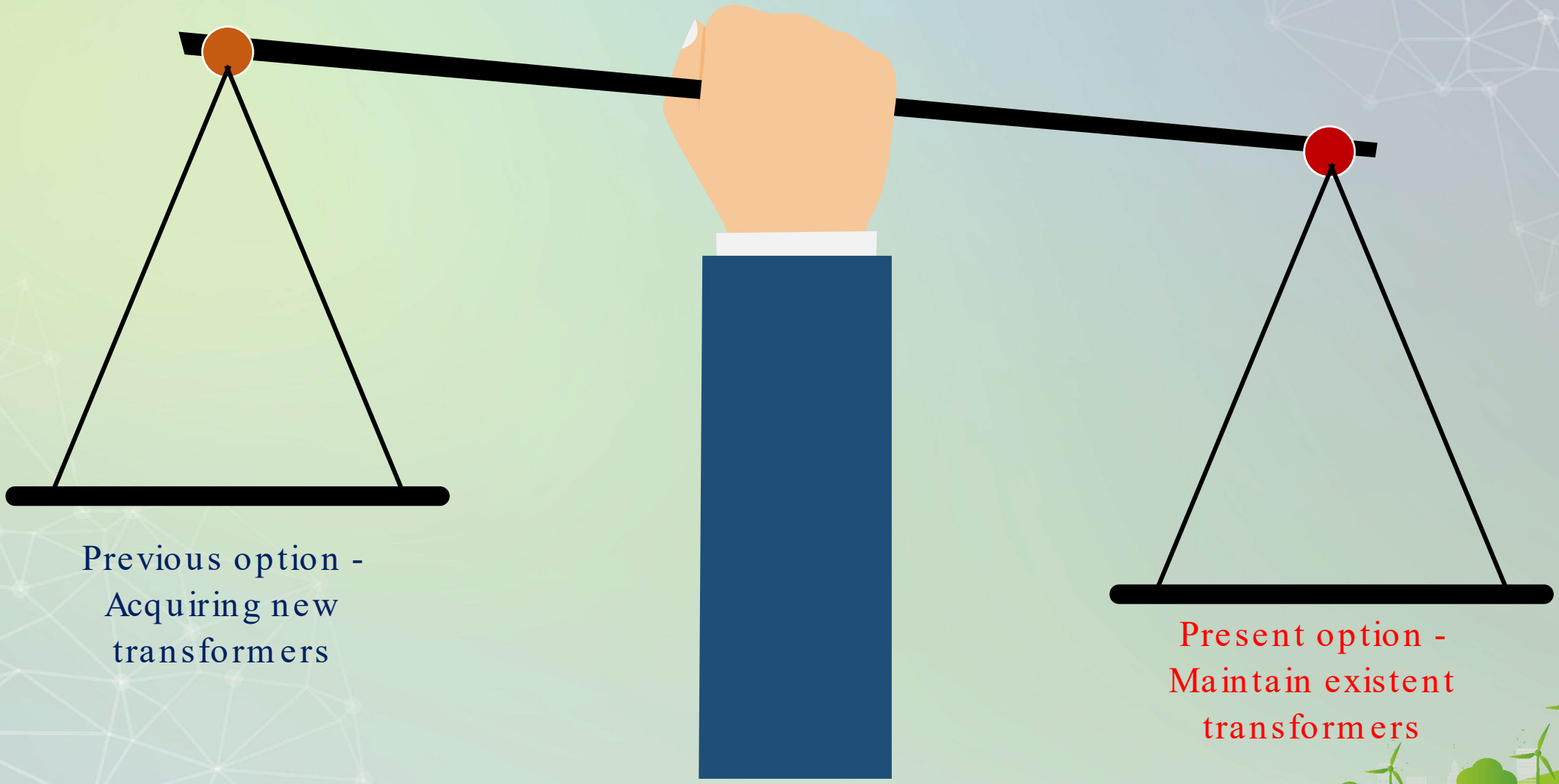
MICAFLUID

Content:

- Comparing maintenance and life extension of active transformers versus buying new ones.
- The growing importance of expertise in maintaining modern power transformers' insulating materials.
- Identifying optimal times for cost-effective oil treatment.
- Employing durable oil technology for treatment and monitoring oil treatment parameters.
- Necessities like degassing, reclaiming, and dehydration for power transformers.
- MICAFLUID's Best Available Technology (BAT) benefits both environmental and transformer health.
- Preventing premature transformer aging to significantly exceed manufacturers’ expected lifespans.
- Conserving the precious resource of insulating oil

MICAFLUID

The balance of acquisition versus preservation



Previous option - Acquiring new transformers

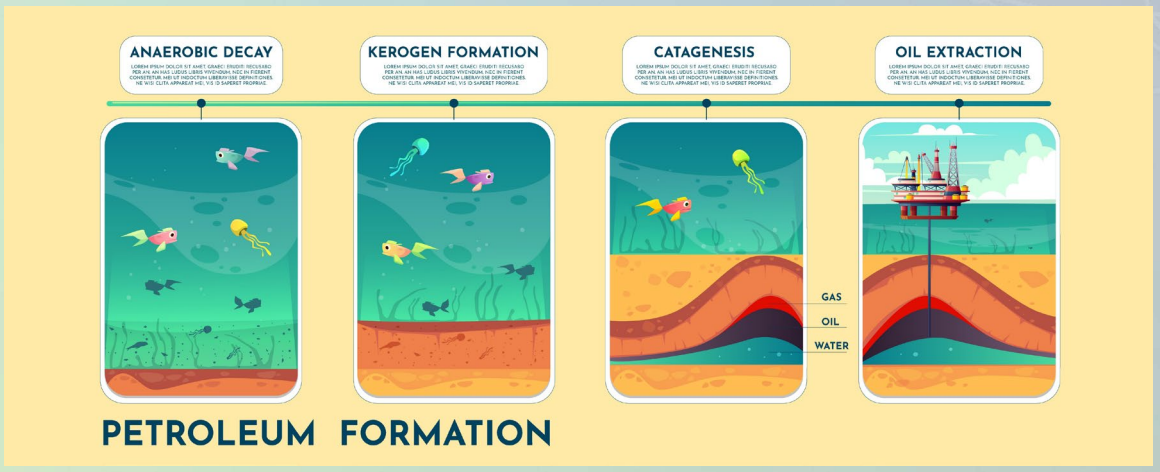
Present option - Maintain existent transformers

Marius Grisaru, Senior Consultant, grisaru@gmail.com

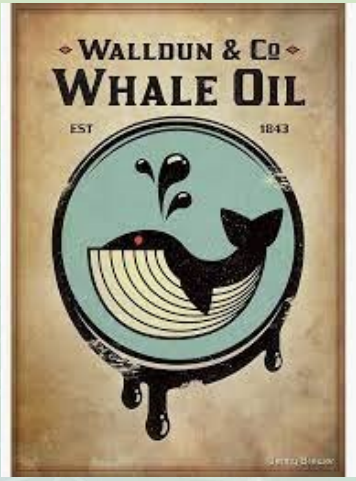
MICAFLUID

Oil industry origins and its consequences

Samuel Kier converted petroleum to lamp oil by distillation. Early 1800s



World's first industrial oil well in Baku, 1846

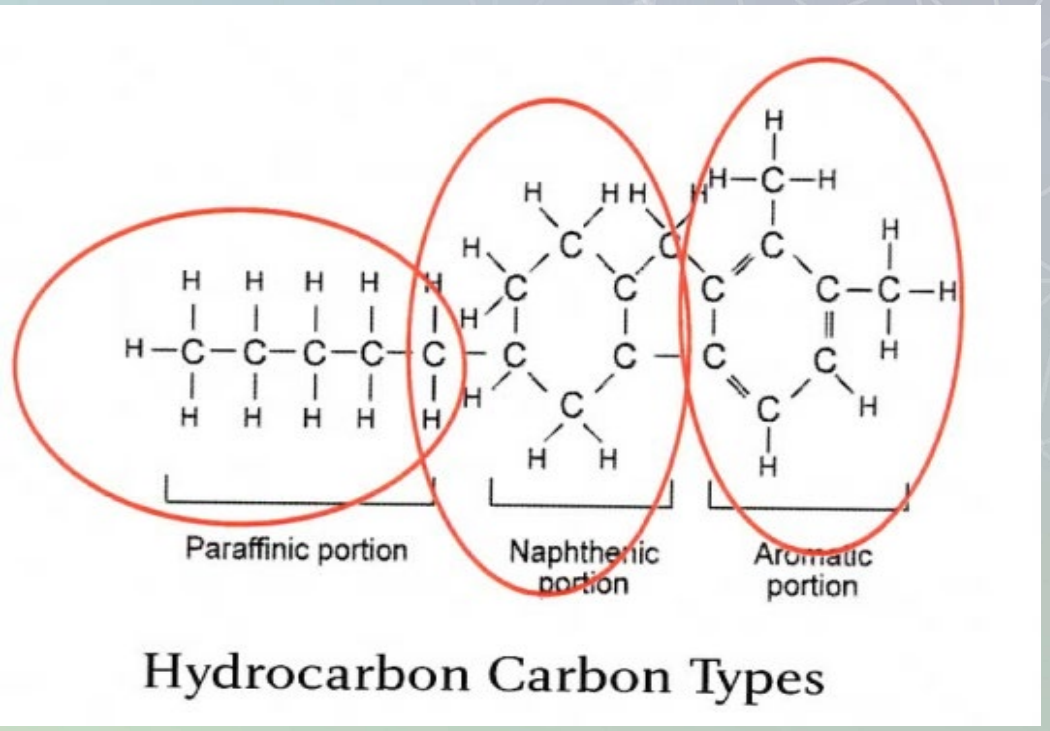


Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Crude oil composition:

- 84% - Carbon
- 14% - Hydrogen attached to carbons
- 1-2 - Sulfur compounds
- Some Nitrogen present as organic amine
- Some Oxygen attached to carbons, forming organic molecules such as alcohol
- Some Metals such as Vanadium, Arsenic, Nickel, Iron, Copper.
- Some Chloride Salts



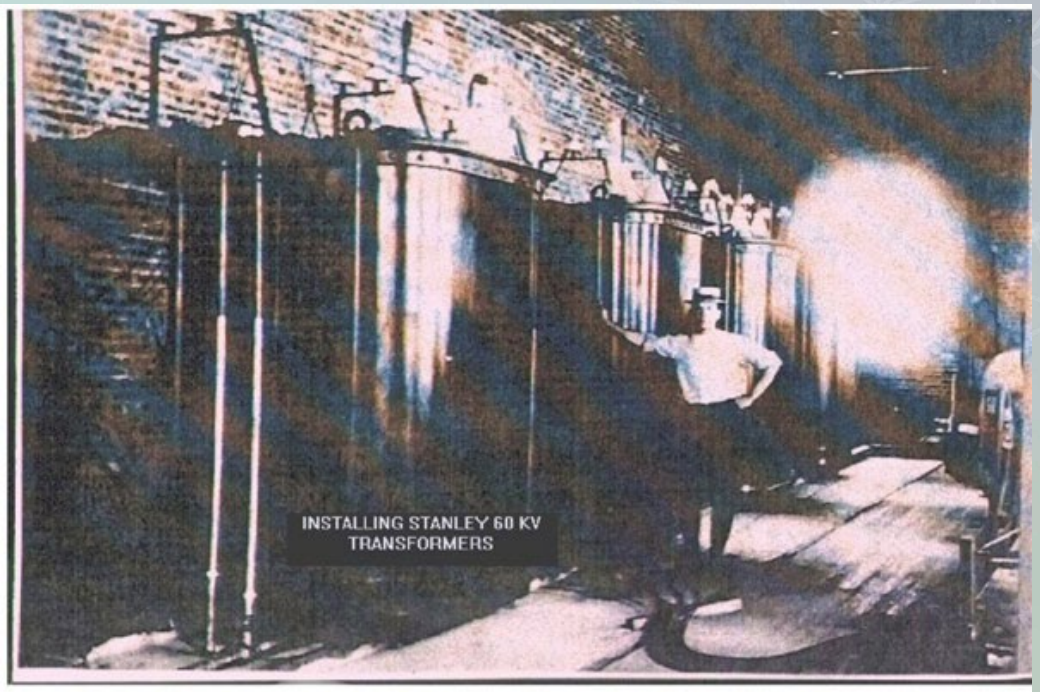
Hydrocarbon Carbon Types

MICAFLUID

Large transformers for low voltage and power

1891

- Transformer used on the Lauffen to Frankfurt demonstration line.

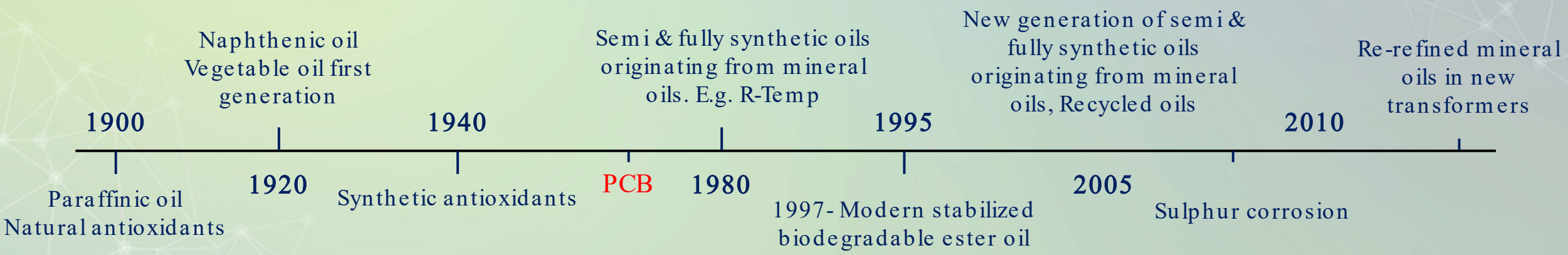


SECOND GENERATION TRANSFORMERS
Stanley oil filled transformers rated at 800V to11kv and 60kv. Replaced air cooled transformers in 1904.

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

A timeline of insulating liquids for power transformers

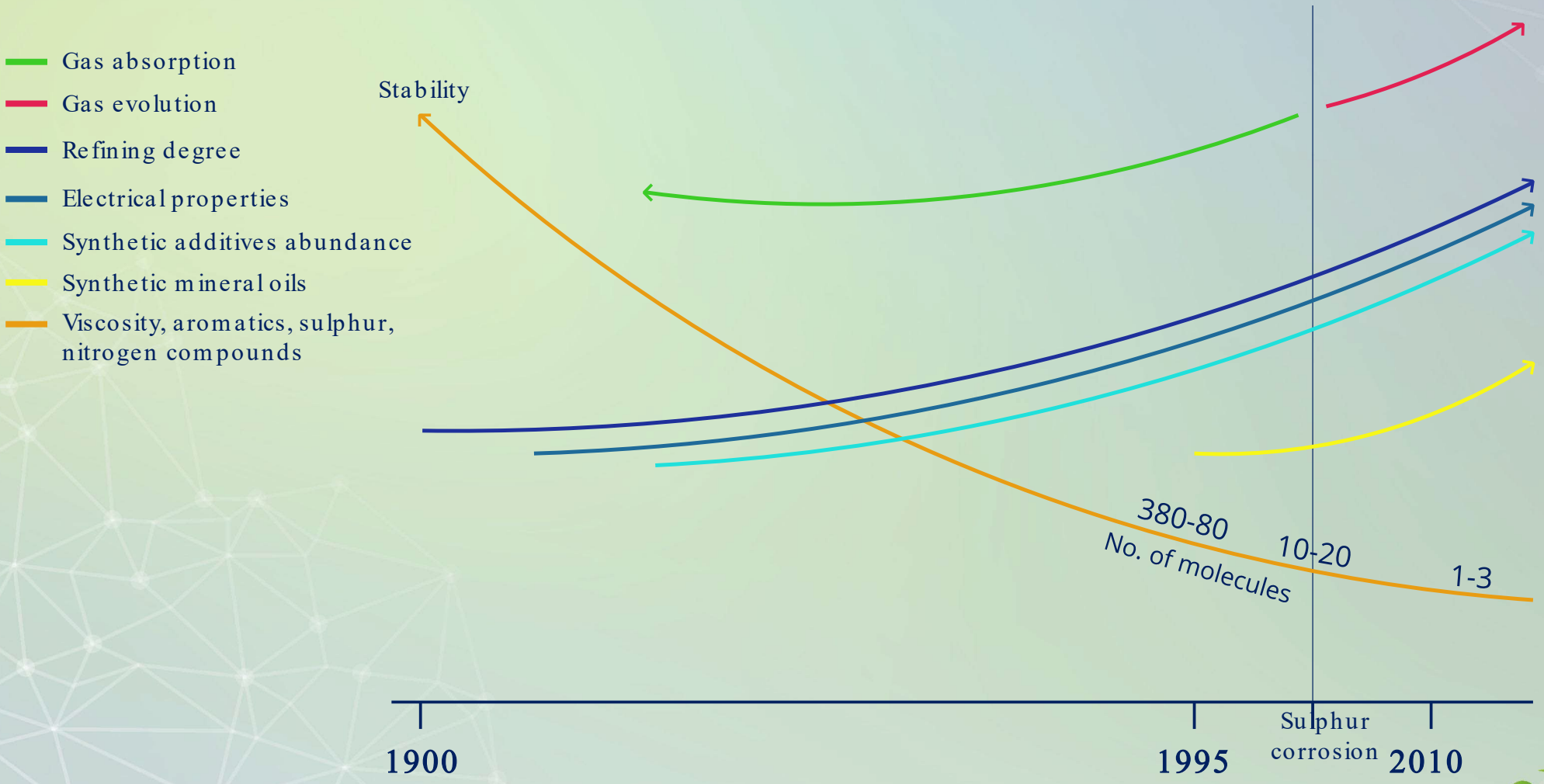


Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

A timeline of insulating mineral oil properties

Transformer oil quality is a compromise between the opposite properties.



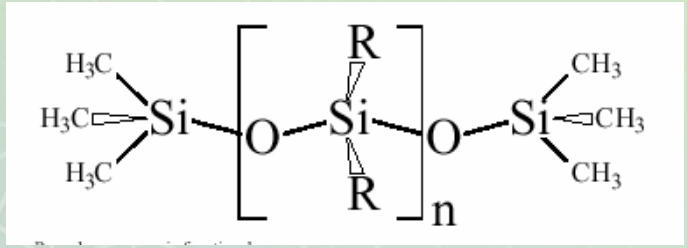
Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

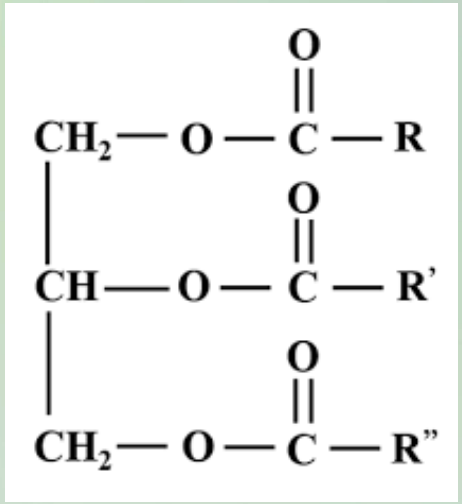
Different Types of dielectric fluid –

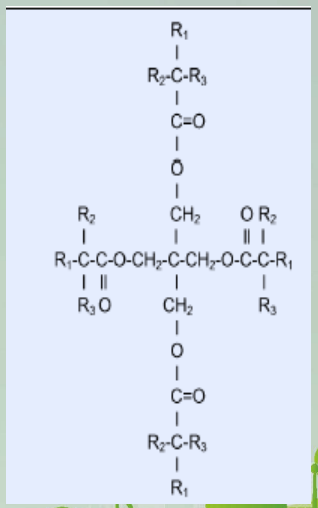
Different liquid treatment approaches

- Mineral Oils
  - Naphthenic
  - Paraffinic
- Silicone Fluid



- Synthetic transformer oils
  - Organic (vegetable oils) Natural Esters
  - Petroleum Synthetic Esters PAOs

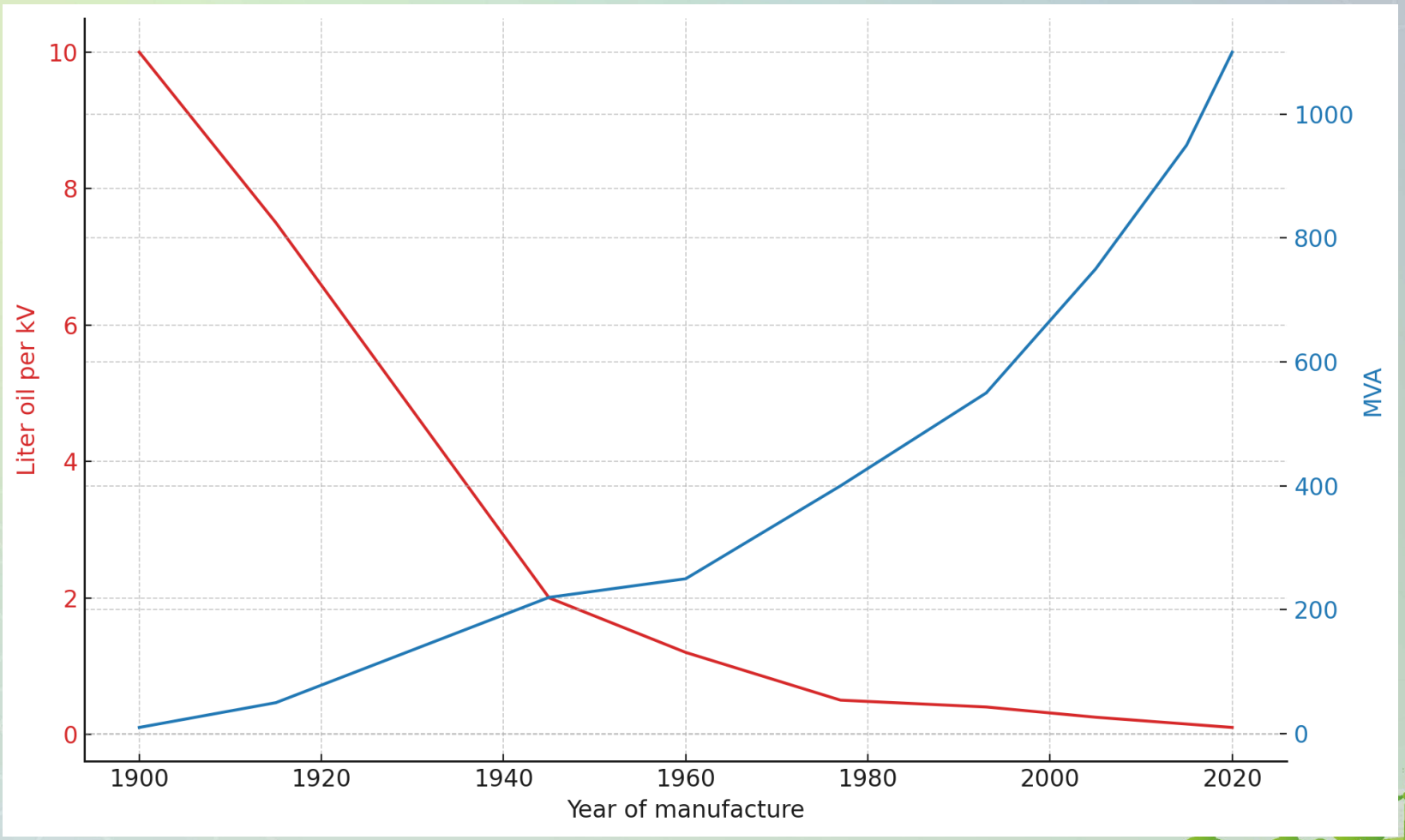




MICAFLUID

Transformers power and liter per voltage through the years

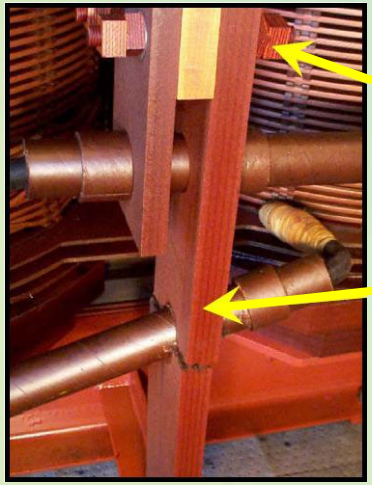
Trends for transformer power in MVA and liter per vs year of manufacture



Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Cellulose – The Achiles' heel

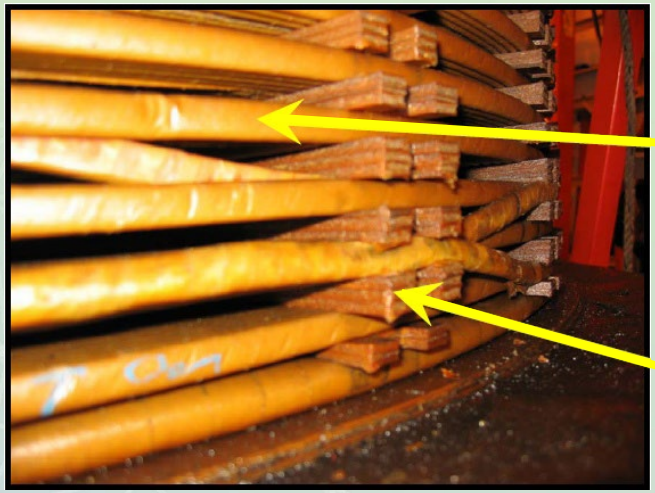


Laminate Bolts

Supports

Paper wrapping

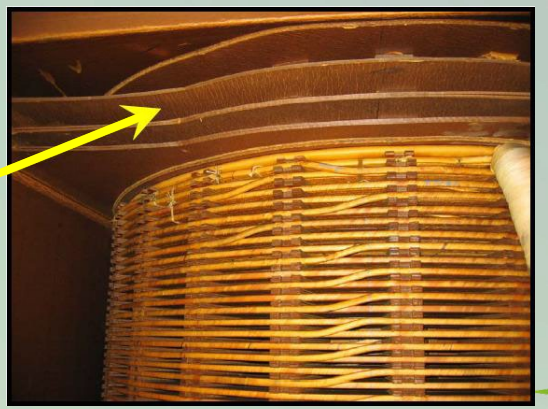
IEEE defines the end of transformer life after loss of strength in the cellulose structure.



Paper wrapping

Press board spacers

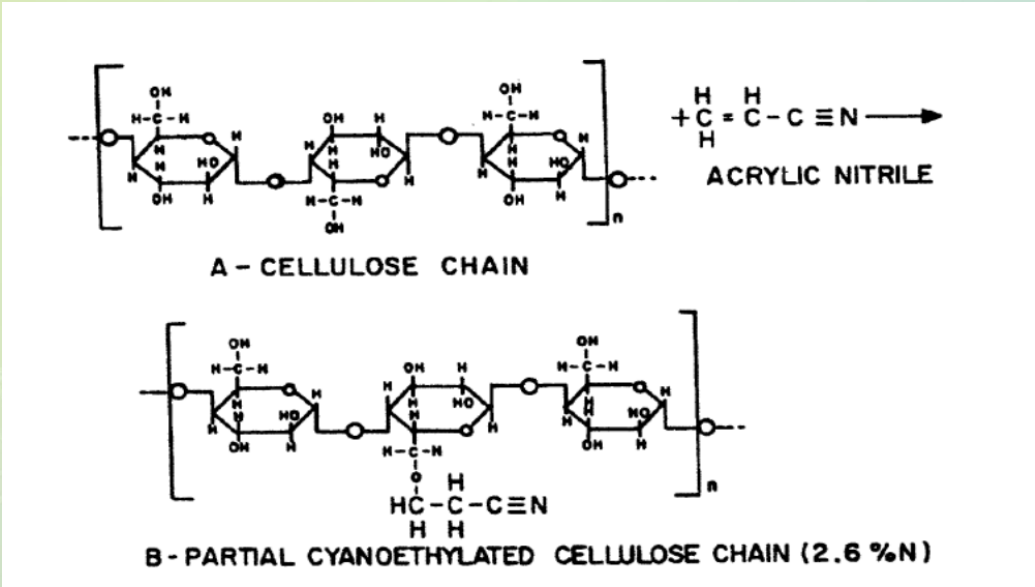
Laminate
Oil flow guides



Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Insulating cellulose timeline



1900 — Insulation paper

1920 — Kraft cellulose

1960 — Thermally upgraded paper

1980 — Nomex

2000 — Improved thermally upgraded paper

2010 — Semi-synthetic thermally upgraded with a higher stability

Built-in sensors?

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Water and air are controllable and reducible factors for preventing failures in transformers

Diverse types of energies translated to elevated temperatures.

Oxygen

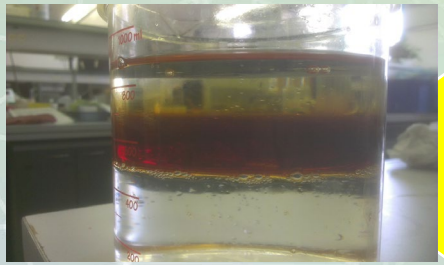
Moisture

Degassing

Dehydration

Antioxidant depleting

Electrical, mechanical, magnetic stresses



Oil degradation: polar compounds, acids and sludge

Oil reclaiming

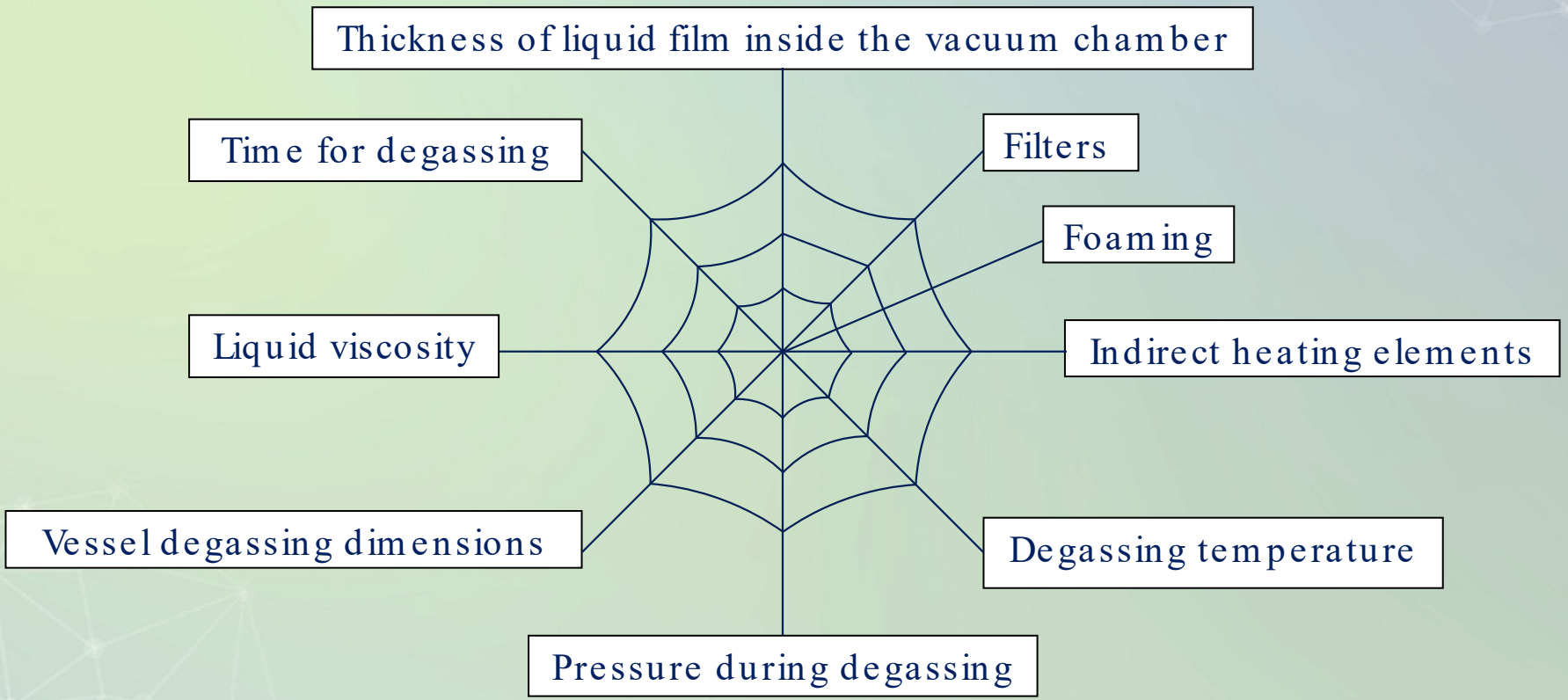
Cellulose degradation

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Degassing and Dehydrating Web:

Managing Contradictory Tensions



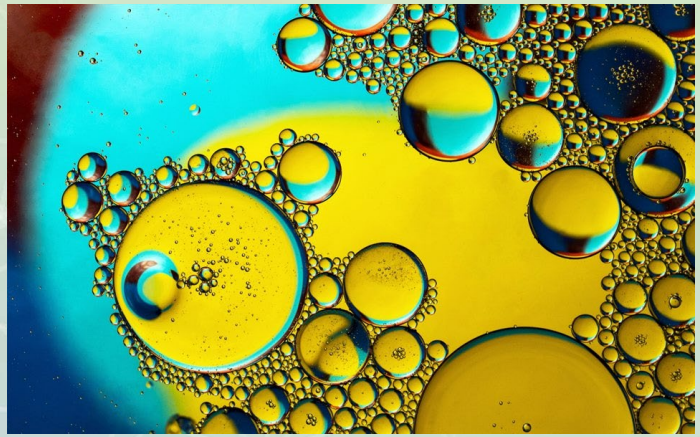
Marius Grisaru, Senior Consultant, grisaru@gmail.com

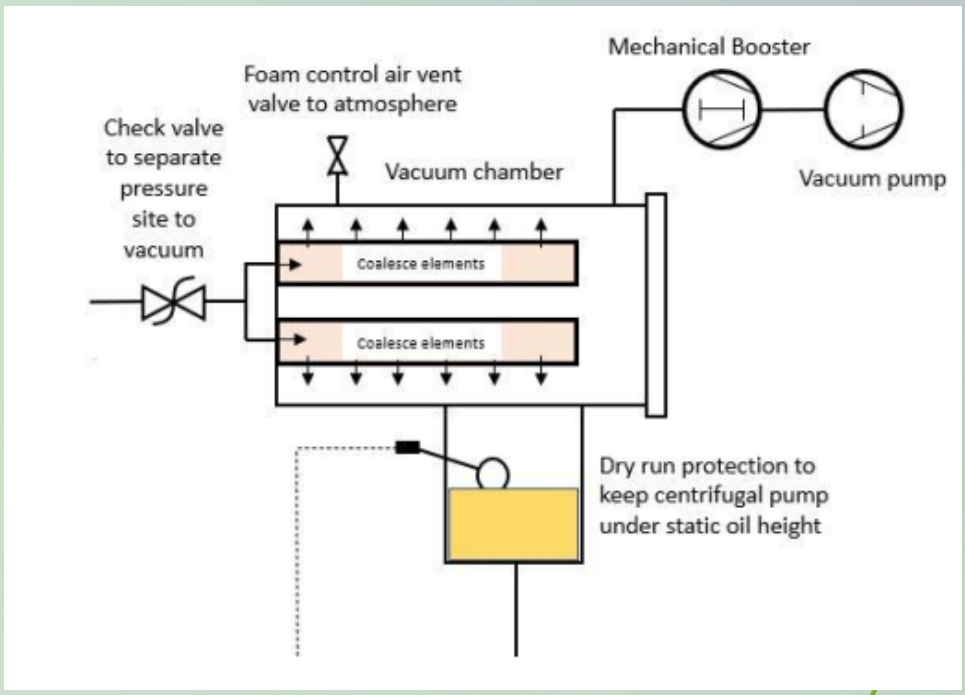
MICAFLUID

Coalescence method for degassing

Coalescing system

- Operating pressure less 0.1mbar exceeds vapor pressure limits of oil
- High pressure drop requires inlet pump
- Small surface reduced efficiency
- Excessive foaming requires breaking vacuum
- Micro bubble coalescence inside transformer tank
- High-cost maintenance





Marius Grisaru, Senior Consultant, grisaru@gmail.com

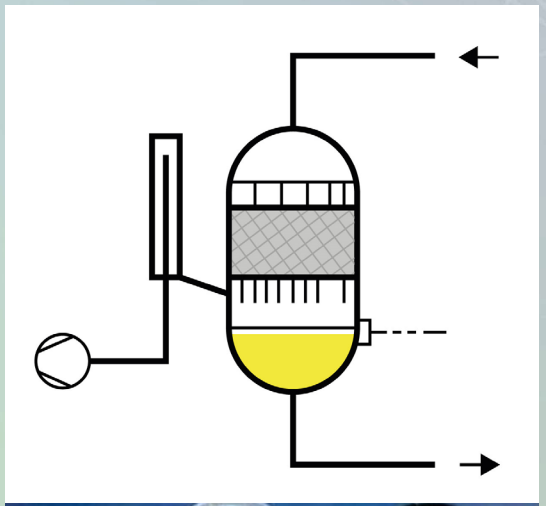
MICAFLUID

Thin film degasser by Raschig ring –

The most adequate method for power transformers

Thin film degassing

- Operating vacuum within vapor pressure limit of dielectric fluid
- No inlet pump required even for high viscosity oils
- 60% larger surface area compared to other technologies on the market
- Foam reduction without breaking vacuum, no micro bubbles
- Maintenance-free degasser



Chemical Industry Examples

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

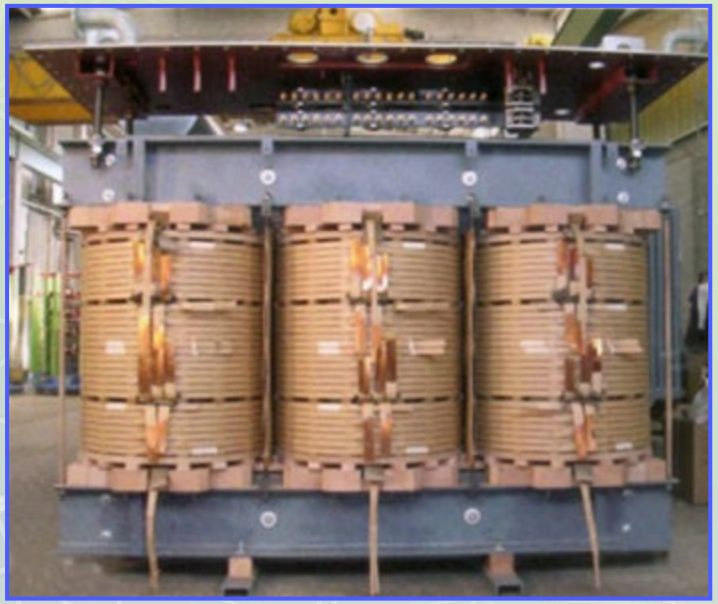
Transformer Insulation System

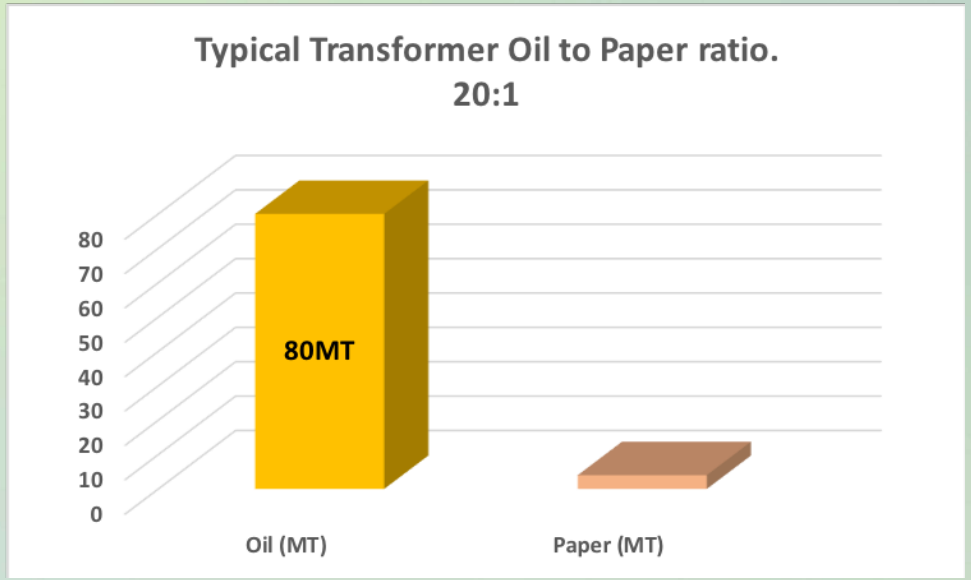
Cellulose impregnated by insulating oil and contain water in different forms

Typical transformer has an oil to paper ratio of 20:1

For every Kilogram of paper insulation (cellulose) in a transformer there are 20kg of oil.

So if you have 80MT of oil in the transformer you will have approximately 4 MT of paper.
This is the Dry Weight of the paper insulation.





Marius Grisaru, Senior Consultant, grisaru@gmail.com

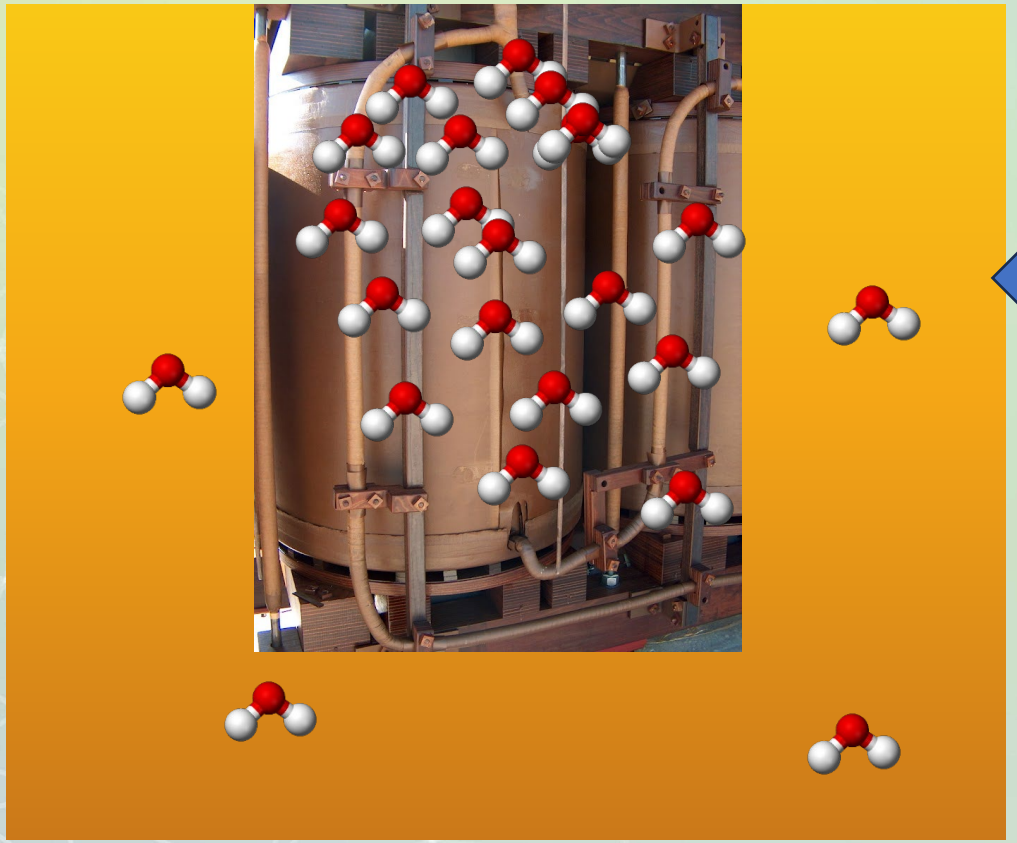
MICAFLUID

Water distribution in power transformer at two temperatures

25°C

H_20

70°C



Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

The consequence of undehydrated cellulose

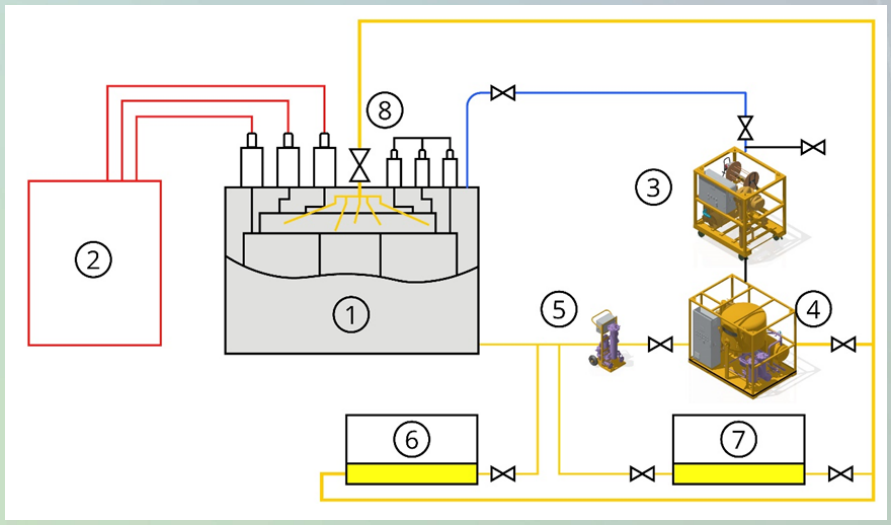
Failed transformer due excessive moisture in cellulose insulation at 4.30 am

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Efficiency reduction of water quantity inside transformers

Parameter	Measure	Initiate oil treatment	Target values
Water content	ppm	20< or 30<	<10
Breakdown voltage	kV	<40 or <50	60<



In case water in oil and water in cellulose exceeds acceptable limits, dehydration is required.

By IEC60422

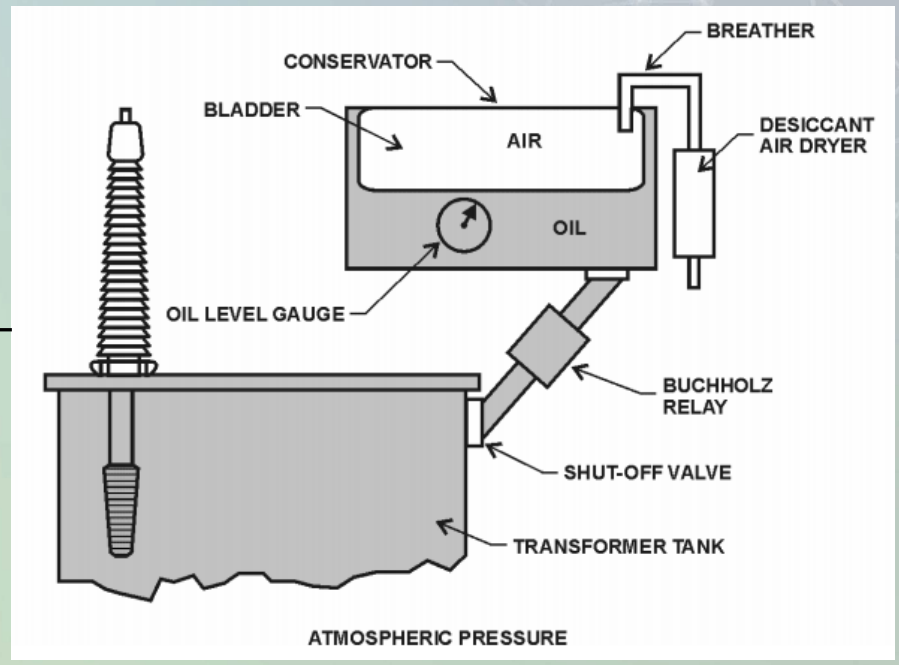
1. Transformer
2. LFH unit
3. Vacuum unit
4. Oil treatment plant
5. Feeding pump
6. Used oil tank
7. Waste oil tank
8. Hot oil spray

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Modern transformers with a bladder in the conservator are more prone to sludge

Transformer Type	Approximate Time Period Before Sludging Begins
Transformers with free air access	10 years
Transformers with conservators	15 years
Transformers bolted tight (sealed) with no nitrogen	50 years
Transformers with nitrogen over oil	67 years

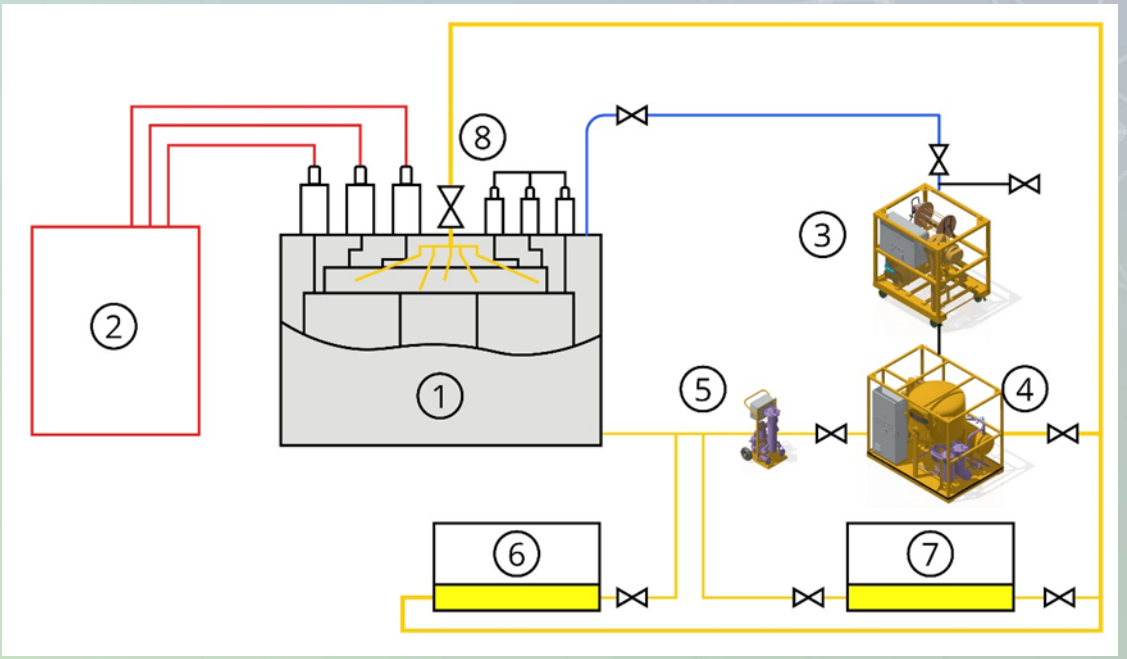


Maintenance of liquid insulation, 1990, Western Area Power Administration, Power System Maintenance Manual, chapter 10

MICAFLUID

Efficient reduction of total gas quantity inside transformers

MVA	Transformer type (kV)	Target value	Action level 1	Action level 2	Action level 3
		Immediate after degassing	Normal operation	Degas in 3 year	Degas in 2 year
>100MVA	>400 kV	0.5	<1.5	1.5-3	>3
	<400 kV	1.5	<3	3-6	>6
<100MVA	All voltages	2	<4	4-6	>6



1. Transformer
2. LFH unit
3. Vacuum unit
4. Oil treatment plant
5. Feeding pump
6. Used oil tank
7. Waste oil tank
8. Hot oil spray

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Corrosive sulfur oil may cause critical failure

Oil treatment dedicated to removing this dangerous property

Unprofessional oil treatment may induce serious damages
through transformer oil corrosiveness

Dahlund, M., P. Lorin, and P. Werle. "Effects of on-line reclaiming on the corrosive sulphur content of transformer oil." *Presentation at the CIGRE SC A2, A3 & B3 Joint Colloquium, Cape Town*. 2009.

Marius Grisaru, Senior Consultant, grisaru@gmail.com

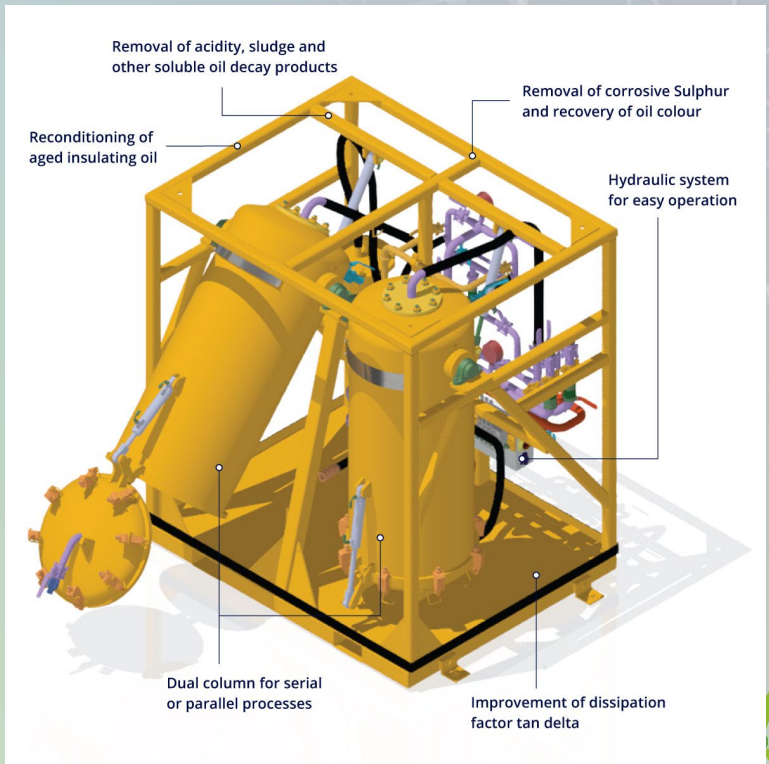
MICAFLUID

The only effective treatment for improving the dielectric properties of aged oils is regeneration with Fuller's earth

Oil regeneration unit type Regeneration CRP

Parameter	Measure	Initiate oil treatment if:	Target values
Interfacial tension (IFT)	mN/m	< 32 (TB413)	35<
Acidity	mgKOH/gm	0.1<	<0.03
Oxidation index	IFT/acidity	<600 (TB413)	
Dissipation factor	@90°C	0.05< (TB413)	<0.015 or <0.01

TB413 - Insulating Oil Reclamation and Dechlorination, CIGRE2010

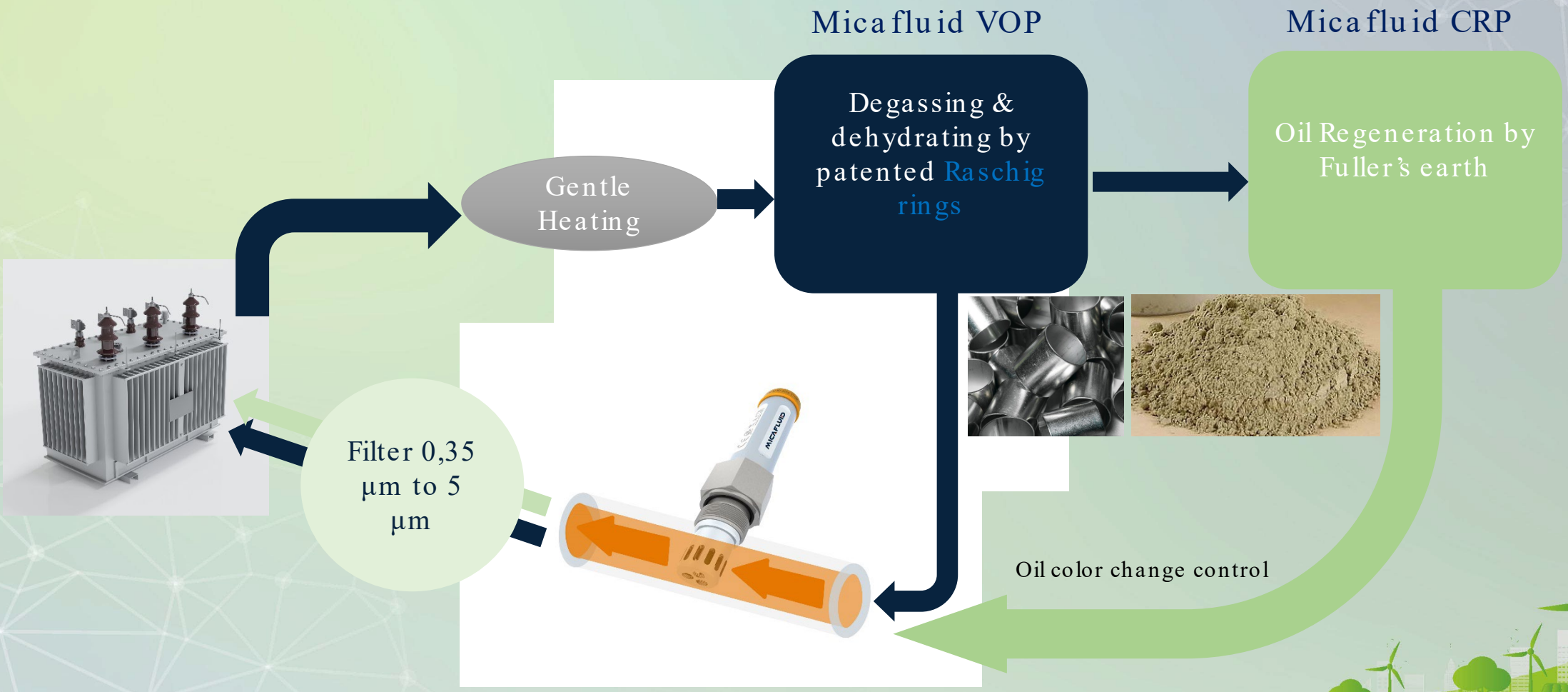


Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

MICAFLUID Technology Advantages:

Transformer-Adapted Monitored Process



Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

MICAFLUID full Inline Monitoring

In-line gas and water content Measurement

VZ212A applied on a VOP plant to measure water and total gas content

In-line Tan Delta measurement

VZ220A applied on a VOP plant to measure Tan Delta

In-line breakdown voltage measurement with MicaSonic™

MicaSonic™ applied on a VOP plant to measure:
-Breakdown voltage [kV]
-Moisture content [ppm]
(at 20 °C and actual temp. as per IEC)

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

MICAFLUID advantages for the environment and transformer owner

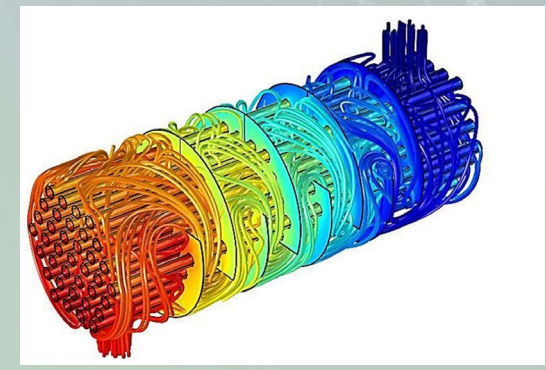
No foam

Allow treatment of high viscosity oils as esters and silicone.

Automatic froth control

Oil is not thermically stressed – molecular chemical stability. Unable to become sulfur corrosive.

$$C_{10}H_{22} + C_{10}H_{22} \rightarrow C_5H_{12}\ C_5H_{12} + C_5H_{12}\ C_5H_{12}$$

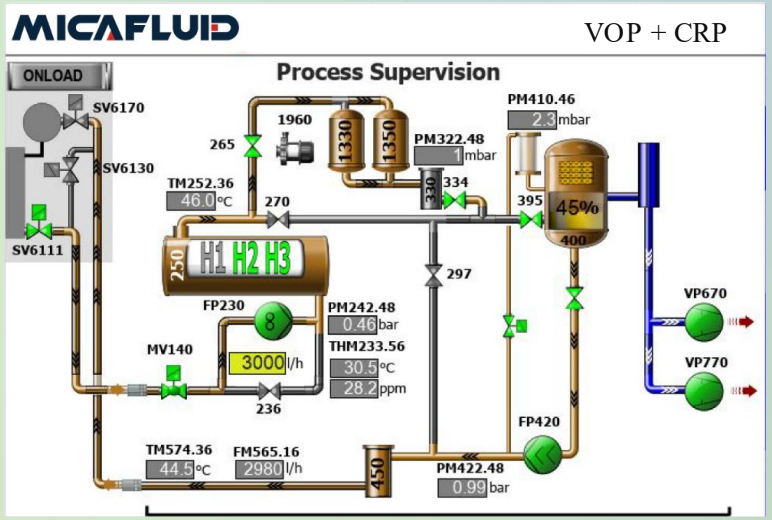


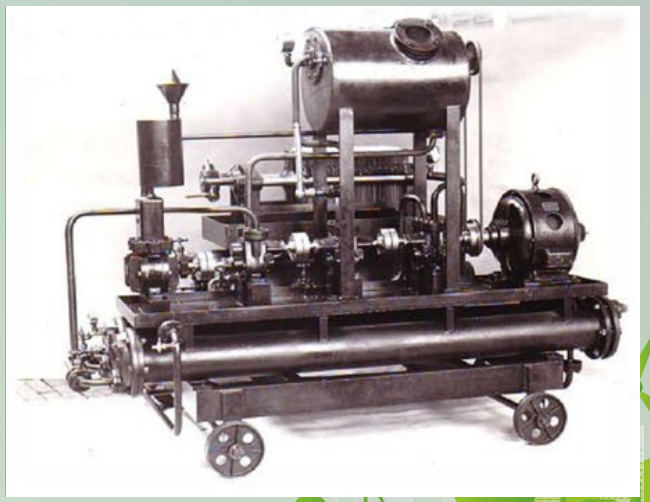
Streamlines temperature distribution and prevent hot spot cracking using a baffle configuration whereby oil is indirectly heated and automatically regulated to the setpoint, ensuring a thermal flux of < 1 W/cm2.

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

MICAFLUID: the past, present and future





Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

MICAFLUID advantages for sustainable IoT

Cost and travel reduction through IoT, where something like the MVA support platform opens new possibilities to remotely diagnose, supervise or support oil treatment or monitoring of a transformer.

mva
machine virtual assistance

Decrease the Carbon footprint with the Internet of Things!

Support.
Connect.
Supervise.

Marius Grisaru, Senior Consultant, grisaru@gmail.com

MICAFLUID

Conclusions and recommendations

- Oil-filled Power Transformer maintenance demands focused expertise & experience of this particular and narrow domain.
- Transformer oil treatment should be performed judiciously, by adequate methods and by the best available technology.
- Driven by Swiss technology since 1913, MICAFLUID is on a mission to give a longer and better life to transformers.
- MICAFLUID oil treatment plants are economic and safer for the environment, the electric industry and the community. It also provides manufacturers with solutions to achieve their ESG milestones and certifications.
- By implementing practical power transformer circular economy, MICAFLUID technology reduces the amount of precious material disposal.

Together with the right **technology partner**, a **significant contribution** can be made to the **environment** while **saving money** when adequate and **timely oil treatment** is done within the **transformer's life-cycle**.

Marius Grisaru, Senior Consultant, grisaru@gmail.com