Cradle to Grave Oil Management

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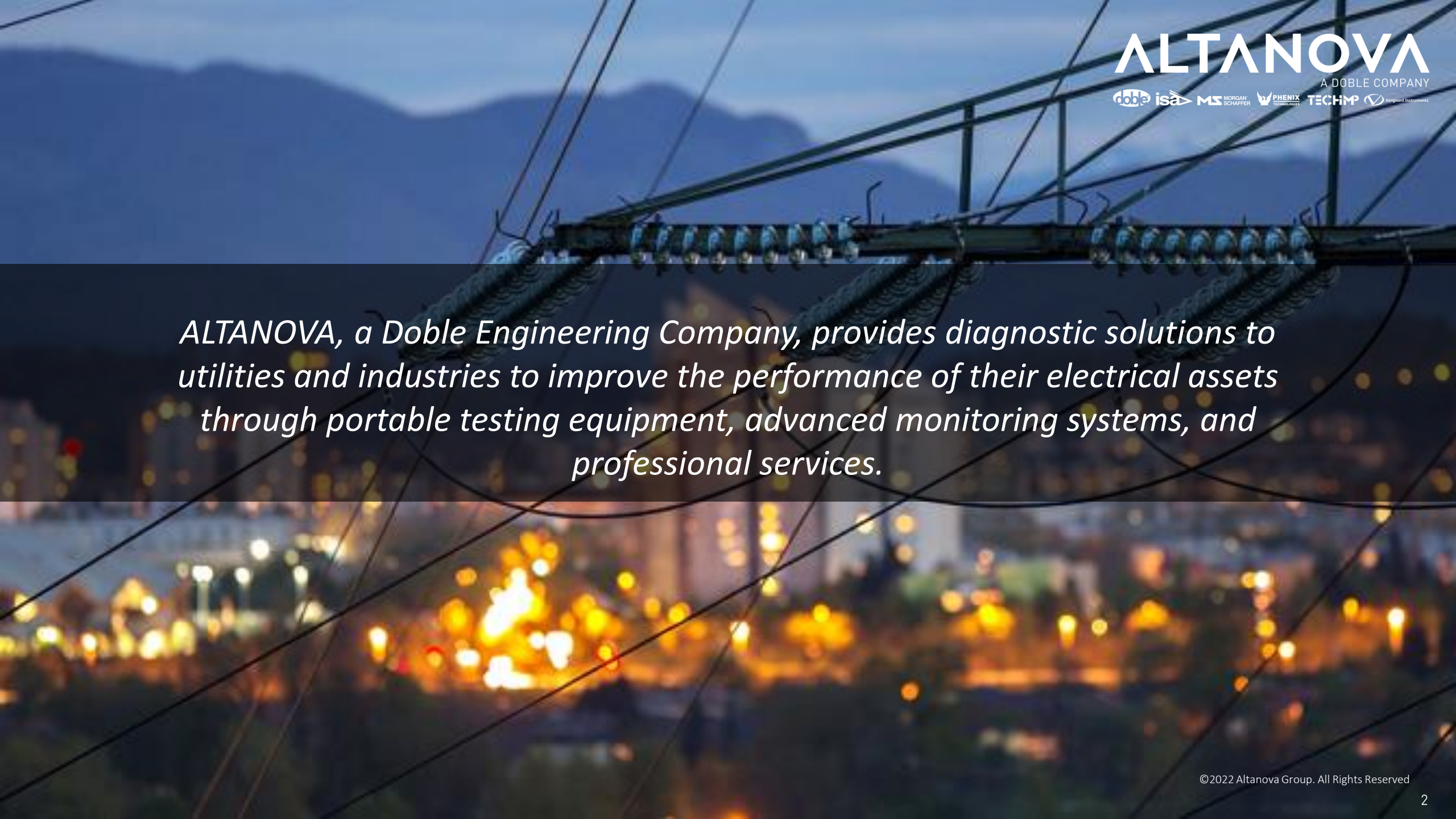


ALTANOVA
A DOBLE COMPANY

ALTANOVA, a Doble Engineering Company, provides diagnostic solutions to utilities and industries to improve the performance of their electrical assets through portable testing equipment, advanced monitoring systems, and professional services.

Altanova History

1938 I.S.A. Istrumentazioni Sistemi Automatici S.r.l. is established in Taino ITALY

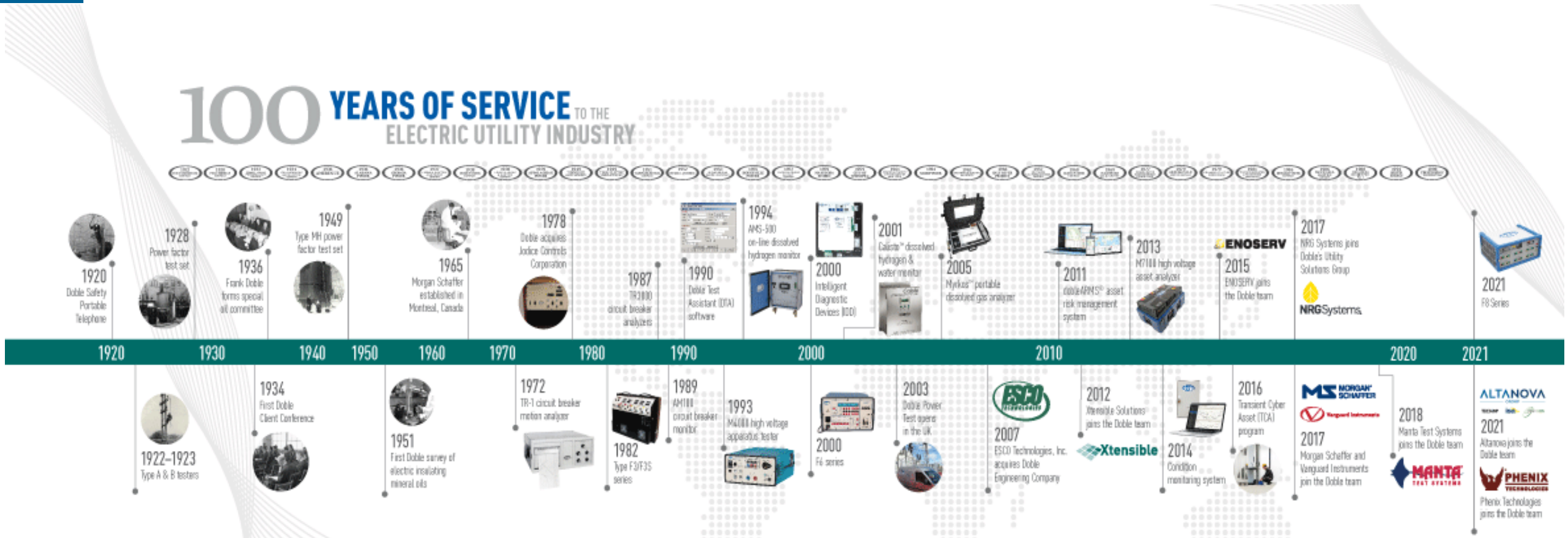
1999 TECHIMP was born as a spin-off from the University of Bologna ITALY.

2017 I.S.A. and TECHIMP merge giving birth to the ALTANOVA GROUP

2019 INTELLISAW joins ALTANOVA GROUP

2021 ALTANOVA GROUP becomes part of ESCO Technology Group and joins the Doble Engineering Company, as part of the USG division.

Doble History



Altanova Today

ALTANOVA
A DOBLE COMPANY

100
COUNTRIES

12
GLOBAL FACILITY LOCATIONS

150+
EMPLOYEES

150+
SALES PARTNERS

5550+
CUSTOMERS GLOBALLY

Part of ESCO Technologies' Utility Solutions Group

PRODUCT BRANDS

doble® isa MORGAN SCHAFFER® PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

Our Solutions

Electrical Test Equipment

Essential for day-to-day maintenance tests of electrical assets. Useful in specific phases of the asset lifecycle:

- Procure
- Operate
- Maintain
- Decommission.

Professional Services

Diversified offer according to the electrical asset lifecycle:

- Installation and commissioning
- Diagnostic test
- Data analysis
- Consultancy
- Training.

Monitoring Systems

Shift from a time-based maintenance to a condition-based maintenance.

Focus on predictive maintenance and shift in focus from electric asset value cost to network outage costs.

Strong evolution of digitalization trend in the power industry.

Testing And Monitoring Solutions For:

ALTANOVA
A DOBLE COMPANY
doble isa MS MORGAN SCHAFFER PHENIX TECHNOLOGIES TECHIMP Vanguard Instruments

- Power transformers
- Circuit breakers
- HV gas insulated switchgears
- MV/HV/EHV cables
- MV/LV switchgears
- Batteries
- Current & voltage transformers
- Protective relays
- Meters and transducers
- Rotating machines
- Variable speed drives
- Overhead lines






Overview

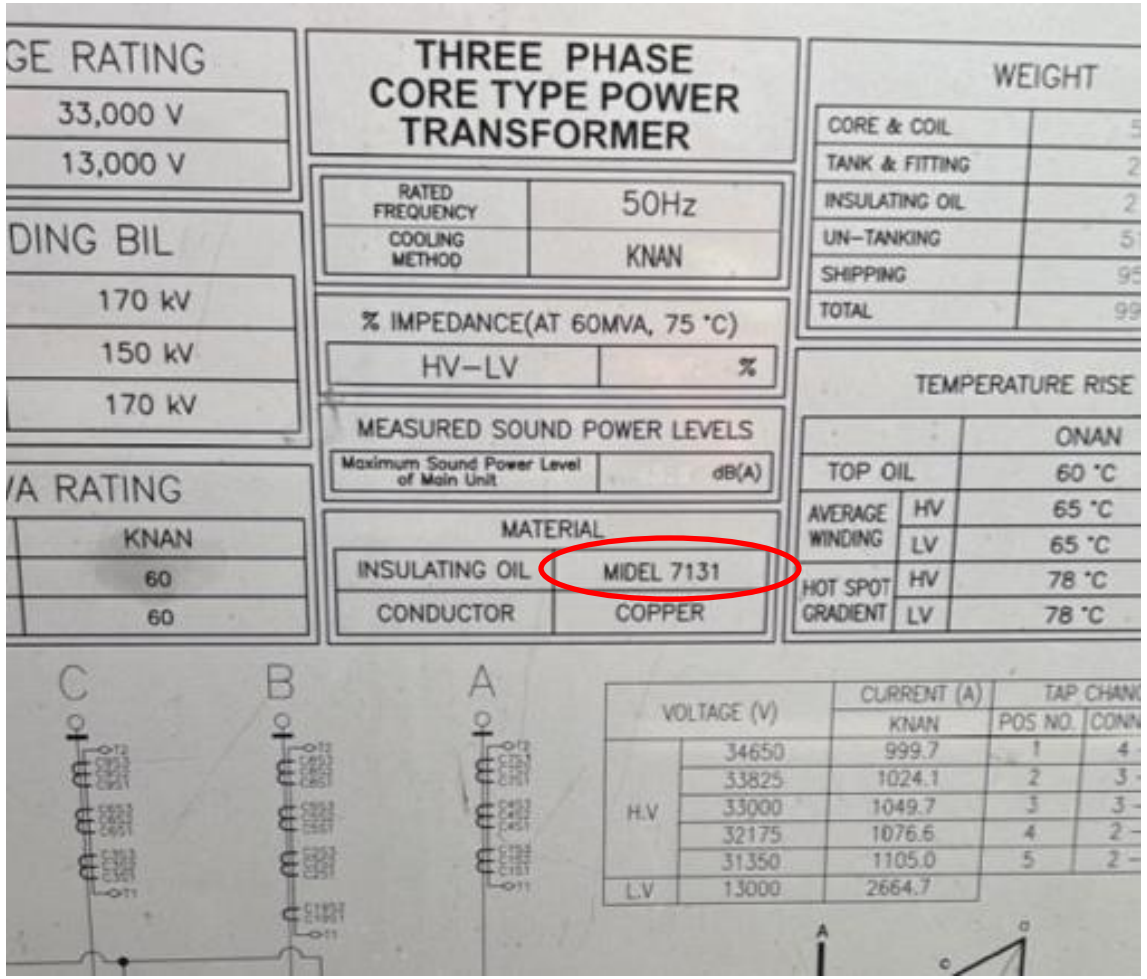
- Mineral Oil Overview
- Managing your oil supply
- Drum / Bulk Delivery, Storage and Temporary Oil Storage
- Good Sampling Technique, Visual Inspections and Data Recording
- Lab Selection and Management
- Oil degradation
- Maintaining Oil
- Oil additives
- Oil changes
- Disposal of Oil

Mineral Oil Overview

- Mineral oil has been used as a dielectric insulant since the late 1800's
- Its chemistry is well understood
- Extinguishes arcs
- Transfers heat from the core
- It's cheap, but it is not perfect
- Given the right conditions it oxidises
- it's flammable with a relatively low flash point
- It is not biodegradable
- It retains gassing information that can be analysed for diagnostics
- It is supplied very dry and free from physical contamination
- Has a low affinity for moisture
- But looked after can last for decades
- It needs storing properly and using in good time

Managing Your Oil Supply

- Identify the type of Oil you require e.g. Inhibited Uninhibited, Passivated, Silicone, Ester
- Use a reputable supplier and manufacturer, have them periodically audited for quality control by your company e.g. once a year
- Vet the container supplier, e.g. drums etc.
- Keep records of all visits so a pattern of diminishing standards can be identified and addressed before the need to change suppliers
- Don’t be afraid to change suppliers if they fail to live up to expectations



Taking Delivery of Oil

- Oil supplied in Bulk or drums regardless of New or Reclaimed status, should be supplied with a quality certificate stating the oil properties at filling.
- Oil suppliers should be vetted for their quality procedures regarding the supply and handling of insulating oil.

CERTIFICATE OF ANALYSIS
LIGHT MINERAL OIL

Batch No:	4393804
Best Before :	April 2022

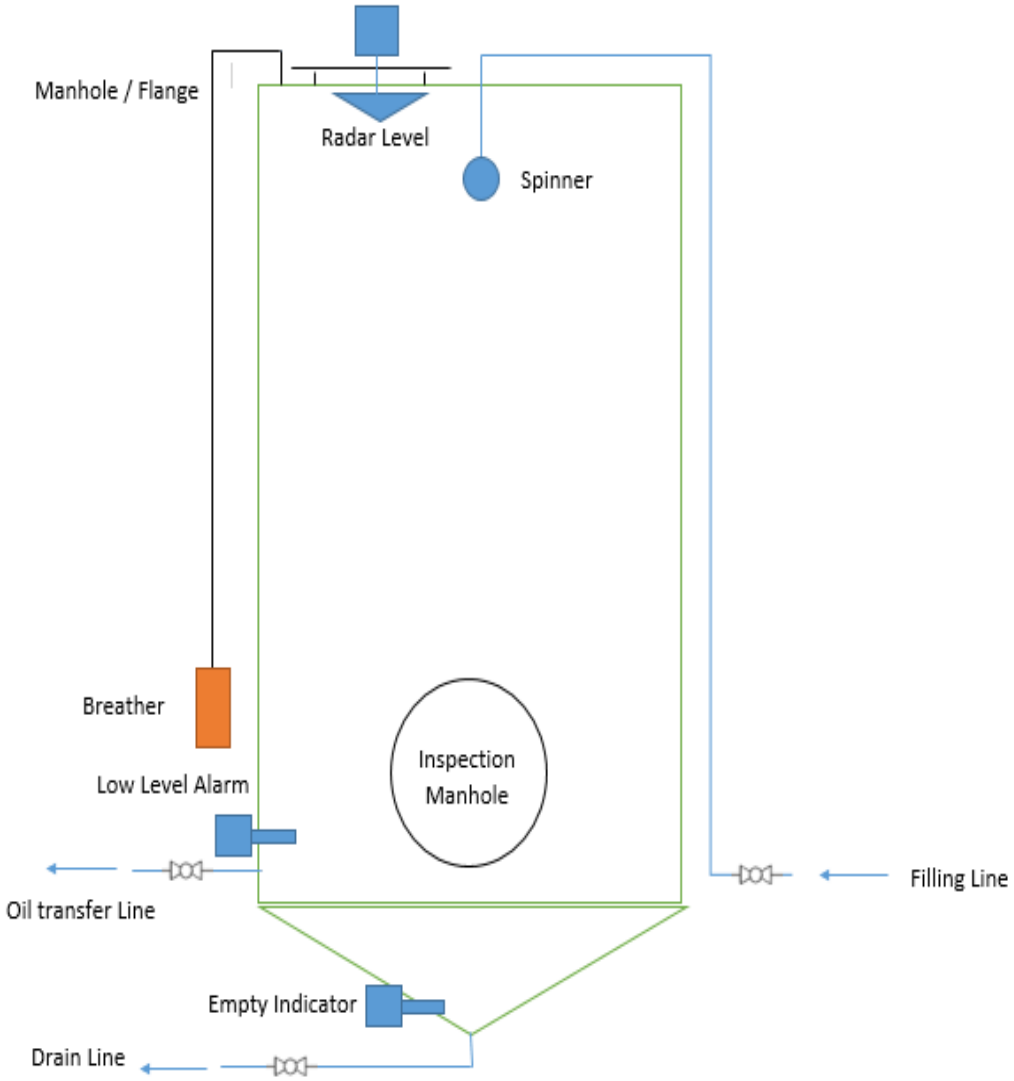
TEST	METHOD	SPECIFICATION	ANALYSIS
Viscosity @ 40°C	ASTM D445	14.0 – 17.0	15.67 cSt
Colour Saybolt	ASTM D156	25.0 minimum	30
Relative Density @ 15°C	ASTM D4052	0.830 – 0.860	0.837 g/ml
Relative Density @ 20°C	ASTM D4052	0.810 – 0.875	0.834 g/ml
Flash Point	ASTM D92	150°C minimum	180°C
Pour Point	ASTM D5950	-6°C maximum	-21°C
Acidity/Alkalinity	EP	Complies	Complies
Readily Carbonisable Substances	EP	Complies	Complies
Solid Paraffins	EP	Complies	Complies
Polycyclic Aromatics	EP	Complies	Complies
Odour	In house	Odourless	Odourless

Taking Delivery of Oil

- Record all deliveries and collections of oil on a dedicated ledger showing date, tank results prior to delivery, assessment of sump run off (bulk storage), tank volume prior to delivery, delivery/collection vehicle registration number, tank number, test results, delivered/collected oil volume, tank volume / oil volume after delivery and the operator's name.
- Oil should be sampled and tested for a minimum of Moisture and Dielectric strength and other oil quality tests when available, on receipt of the oil. This is to confirm the validity of the certificate of conformity it was supplied with. Oil failing to meet the required properties should be rejected and not transferred to storage vessels, where it would contaminate pre-existing feedstock and the vessel itself.

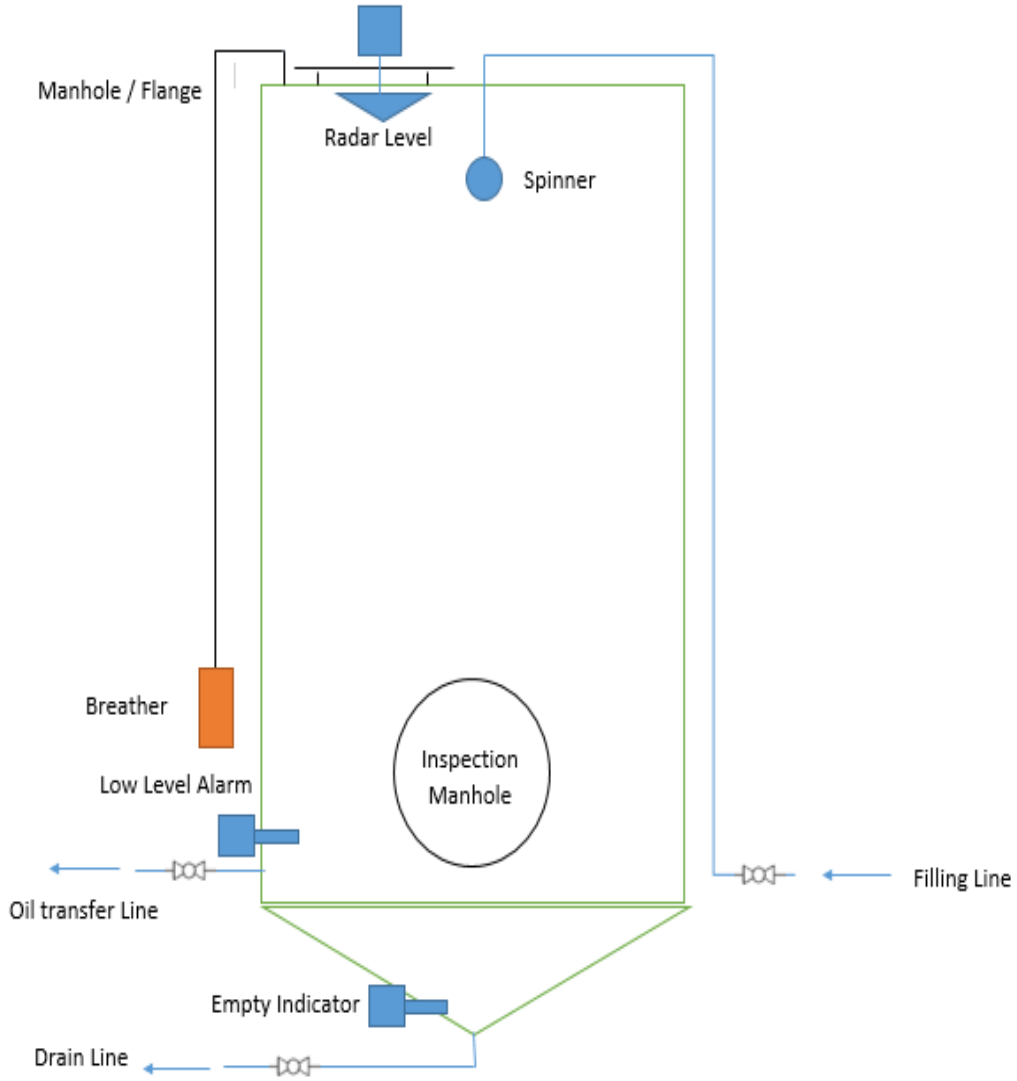
Oil Storage

- Bulk oil should be stored in a vertically mounted bunded tank with inspection covers at ground level, bottom drain valve at the bottom of a conical base, oil should be withdrawn higher than this area. Tank inspections should be undertaken at 3 yearly intervals.
- Mobile processing units can be used to recondition the oil in the tank
- The use of detergents during cleaning or people entering the tank to clean it should be avoided, unless the tank is heavily soiled. Oil should be used to flush the tank and disposed before a mobile processing unit is used to ensure any moisture and fibres introduced during the process have been removed



Bulk Oil Storage

- Breathers and level gauges should be inspected and maintained regularly just as you would for transformers.
- Breathers should be removed or bypassed during filling just as you would for transformers
- Gaskets and valves should be periodically examined for leaks



Drummed Oil Storage

- Drummed storage areas should be indoors and out of direct sunlight
- Drums should be stored in a temperature controlled building to minimise drum breathing
- Drums should be located in a bunded area so that any spillages are contained
- Where the use of bunds is not possible, sleeping policemen can be used at access egress points providing the floor is made of sound concrete
- Any water or dust that collects on the top of the drums should be removed and not be allowed to settle, use 100% polypropylene lint free wipes

Drummed Oil Storage

- Floors should be cleaned regularly to minimise the risk of slipping due to oil residue
- Ideally drums should be stored on their sides on a specially designed rack with the bungs at 9 and 3 o'clock
- Stock rotation is important and drummed oil should ideally be used within a few months of delivery – remember first in, first out
- Oil in metal drums is usually only guaranteed for 2 weeks, oil in 25L plastic drums comes without any guarantee
- Oil oil can still be used, provided it is tested before use, it will be better if the oil is dosed via a processing unit
- Segregate different oil types on different bunds

Using Drums for Temporary Storage

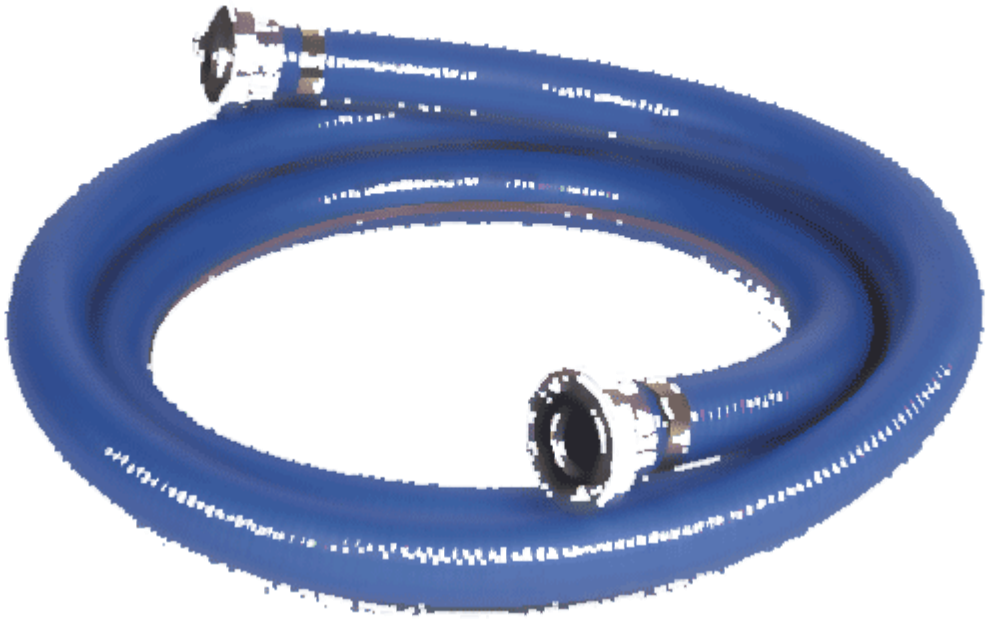
- Allocate each drum a serial number and label accordingly
- Record each occasion used in a ledger
- Limit reuses to 5
- Store empty ‘clean’ drums under cover and sheltered from dust, wind and rain
- Use a drum inspection lamp and mirror to inspect inside the drum before use, looking for signs of moisture, rust, dirt or damage
- Do not reuse for clean oil storage any drum showing signs of the above
- Inspect the bung gasket and change if distorted, worn or damaged
- Inspect the bung and drum threads and clean if necessary
- Examine drum exterior for signs of damage e.g. welds, seams, chime and dents
- Downgrade any damaged but intact drum for use with dirty oil
- Keep drum filling equipment scrupulously clean and flush before use

Using Drums for Temporary Storage

- Drum filling should be carried out in a dry, dust free environment with drafts excluded. Tents can be used on site to assist with achieving this
- Bungs should only be removed for inspection and filling and should be replaced finger tight where more than one operation is required
- Bung gaskets and threads can become damaged on overtightening. A torque wrench (set to approximately 27Nm) or drum key should be used to minimise this wear and tear
- Drums filled with clean oil should be stored under cover, preferably indoors, in a dry dust free enclosure, out of direct sunlight and at a stable temperature
- Oil stored over 200 Litres may come under the control of pollution regulations which varies from country to country, oil stored over 3000L will likely need a specific site licence.

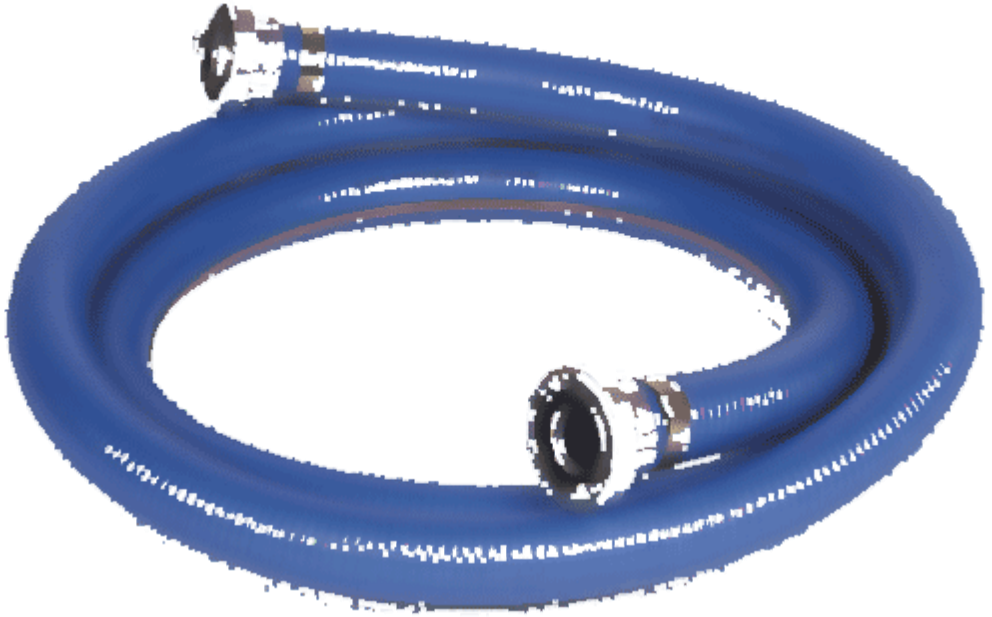
Filling HV Equipment

- Oil filling equipment should be regularly serviced, flushed with clean oil prior to each use and contaminated hoses discarded and replaced.
- The oil to be used for flushing/filling/topping up should be sampled and tested prior to use
- The electrical equipment should have two sets of samples taken before and after maintenance to ensure oil quality remains the same or improves as the result of maintenance activities.



Filling HV Equipment

- The second set of samples can be used to confirm as found and as left results, should the lab find the sample quality poor, breakage occurs in transit or lab error occurs.
- This practice will not only highlight the quality of the oil but will highlight any deficiency in oil handling or flushing.
- Results of all testing and maintenance activities should be recorded in the substation maintenance log, a copy of which can remain onsite for reference and auditing



Sampling Technique, Visual Inspections, and Data Logging

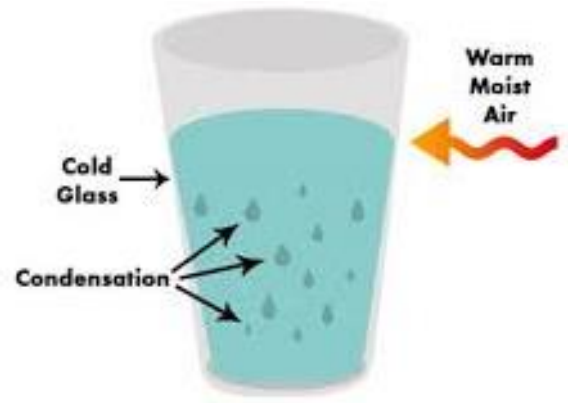
- Predicative maintenance rather than reactive
- Identify Incipient faults early and before they become an issue
- Minimize outages in particular unplanned ones
- Assist with maintenance planning and scheduling
- Improve reliability of equipment
- Reduce risk of failures
- Reduce risk collateral damage
- Safety of Staff, Contractors and Public
- Keep insurers happy and reduces premiums

Knowing what tests to perform and why?

- DGA most important in all in service assets, frequency will change depending on criticality, incipient issues, voltage class etc.
- Oil quality annually for most circumstances, BDV, IFT, acidity etc.
- Less frequent in new Tx – furans, annually above 1ppm total furans
- Special tests – Additive testing like Inhibitor, Passivator, DBDS
- Unused Oil Tests – Viscosity, flash point
- Delivery tests – minimum moisture and BDV
- Before using oil tests – minimum moisture and BDV
- Stray gassing testing – problems with oil or contamination
- Investigative testing – when there's an unusual problem or you want to test if a procedure will work
- Doble can support you with test allocation and what to do about the results

Sampling Considerations

- Ambient conditions
- Sample point and sampling equipment cleanliness
- Correct and clean sampling equipment and bottles
- Get a representative sample from the bulk of the liquid without contamination from the valve, sample container, atmosphere or previous apparatus tested.
- Fully acclimatised sampling equipment



Sampling Considerations

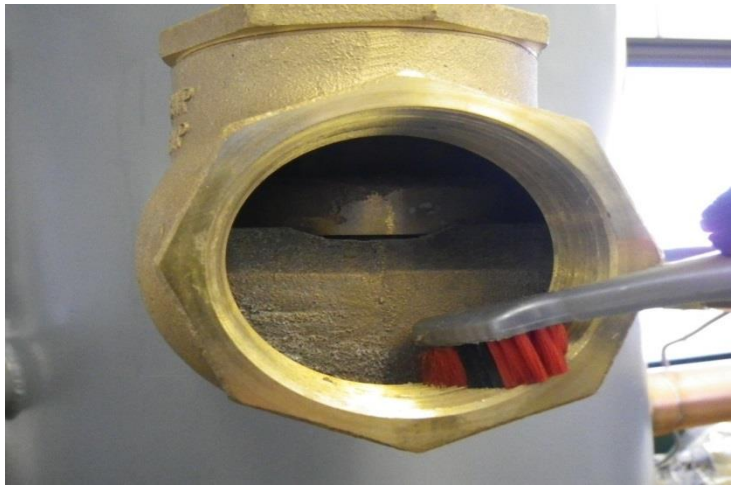
Paper Towels

Chamois Leather

Cotton Rags

All produce fibres which absorb moisture; they can catastrophically reduce breakdown voltage under test and increase moisture. This will result in data uncertainty, resample requests, lost management time, lost engineer time, possible outages and if poorly managed, expenditure on unnecessary maintenance.

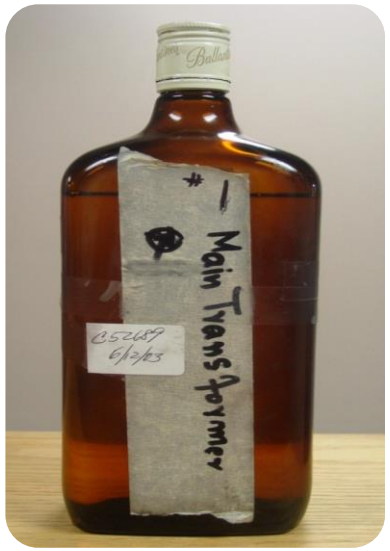
Sampling Considerations

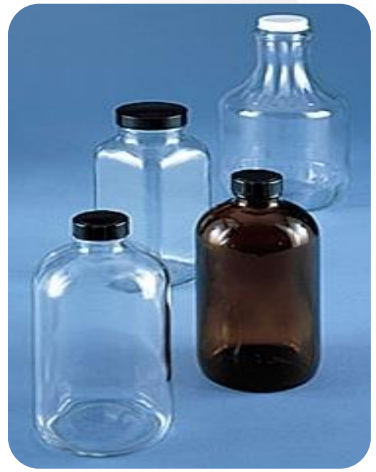


- There doesn’t appear to be any truly satisfactory wipe material available on the market.
- 100% Polypropylene wipes such as Kimtex 7622 are good, they offer additional protection from shipping box pulp fibres being plastic wrapped in portable pack sizes
- Probably the best method of cleaning switchgear is to use oil spray, preferably hot and a liquid vacuum cleaner. Which is similar to bulk tank cleaning procedure
- A plastic toothbrush can be great for cleaning those rougher surfaces

Sampling Containers

- Large enough for the tests required
- Does not contaminate the sample
- Seals the sample from external contamination
- Shields the sample from sunlight
- Prevents the loss or gain of properties or materials being tested for





Visual Inspections

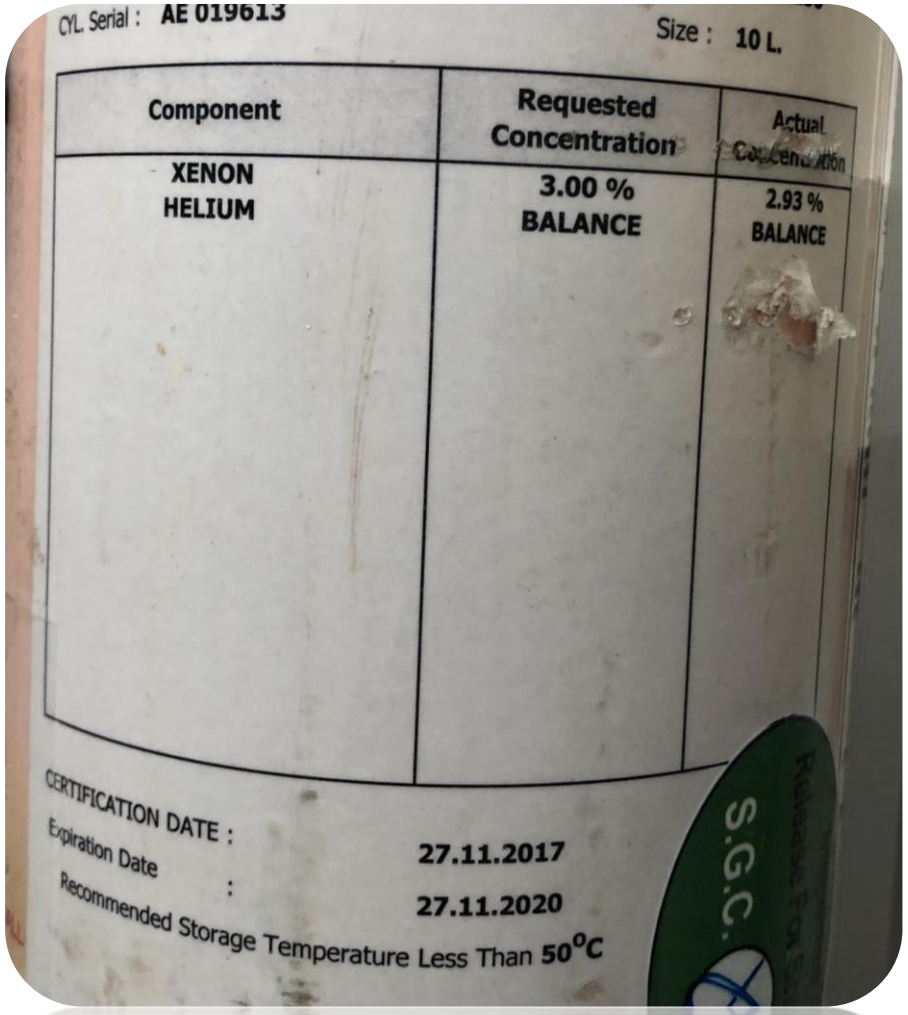
Visual Inspections

Laboratories

- Take time to understand your needs and shortlist potential labs based on them
- Assess lab staffing levels, samples per month per test kit owned, types of test they can conduct, if they outsource for some tests and for which tests and where they go to. Check these labs too.
- Audit your lab regularly don't just trust the data produced, does it make sense? Is it comparable to last time?
- Ensure the lab is testing to the latest standards
- Perform regular (annual) round robin tests to check reliability, repeatability, bias and accuracy of your chosen lab
- If turnaround time is important to you, make sure your lab is able to honour their times
- Can they provide expedited services (if so at what extra cost)

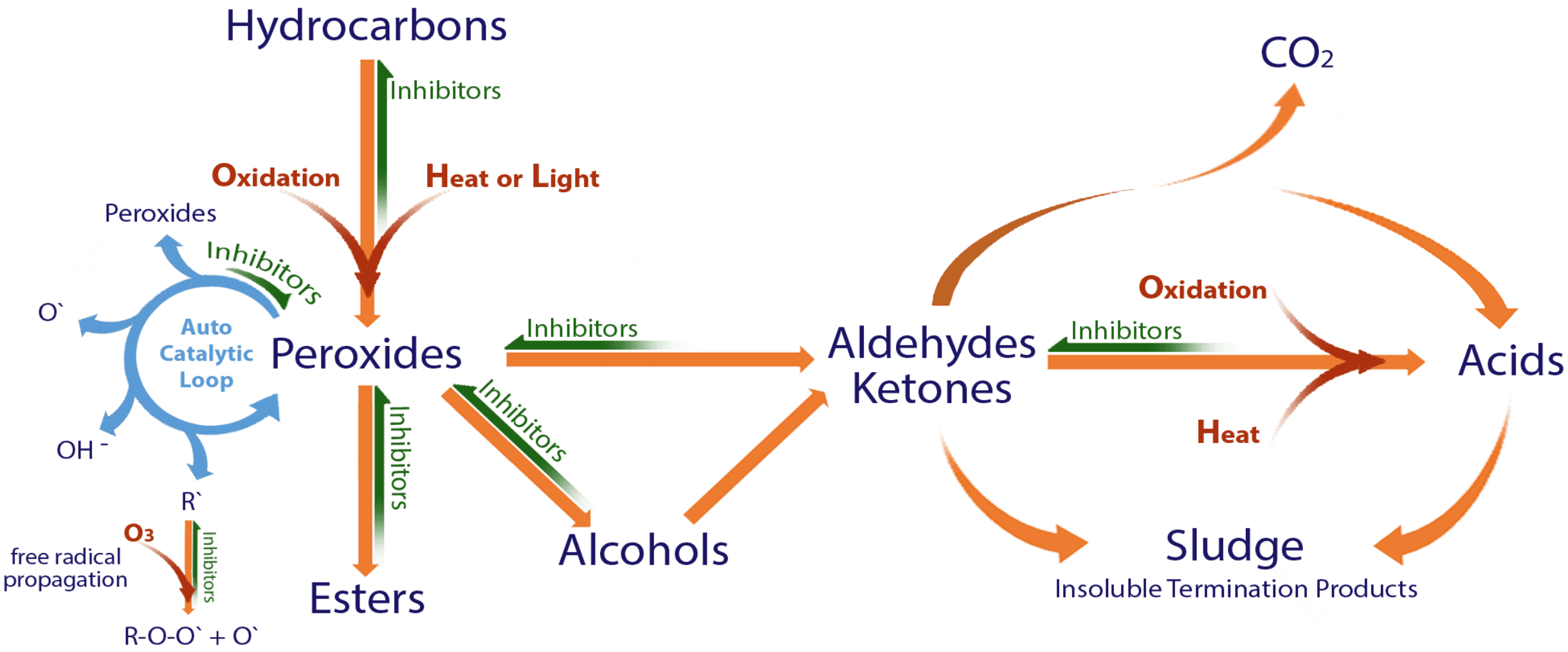
Laboratories

- Don’t be afraid to change labs if they are not cutting the mustard, but equally don’t expect your data to be the same. And be sure your new lab meets your expectations before you make the move. Note the changeover date in your records and take the new lab data as benchmark data ready for the next test.
- Check they can perform the tests you want on the dielectric fluid types you manage now and into the future. There may be extra costs for testing some fluid types like esters if they are a small lab
- Check reporting formats and advice meet your expectations and layout requirements
- Can they provide raw data as well as reports.
- Can they import your data directly into online data storage and visualization software



Doble / Morgan Schaffer Laboratories

Effect of Inhibitor on the Oil Oxidation Pathway



Inhibited Oils

Perception

Industry reluctant to use inhibitor due to historical incidents like DBDS
Must be a poor quality base oil (addressed IEC60296 ed. 4 onwards)
Mixed oils on site would make oil management difficult

Reality

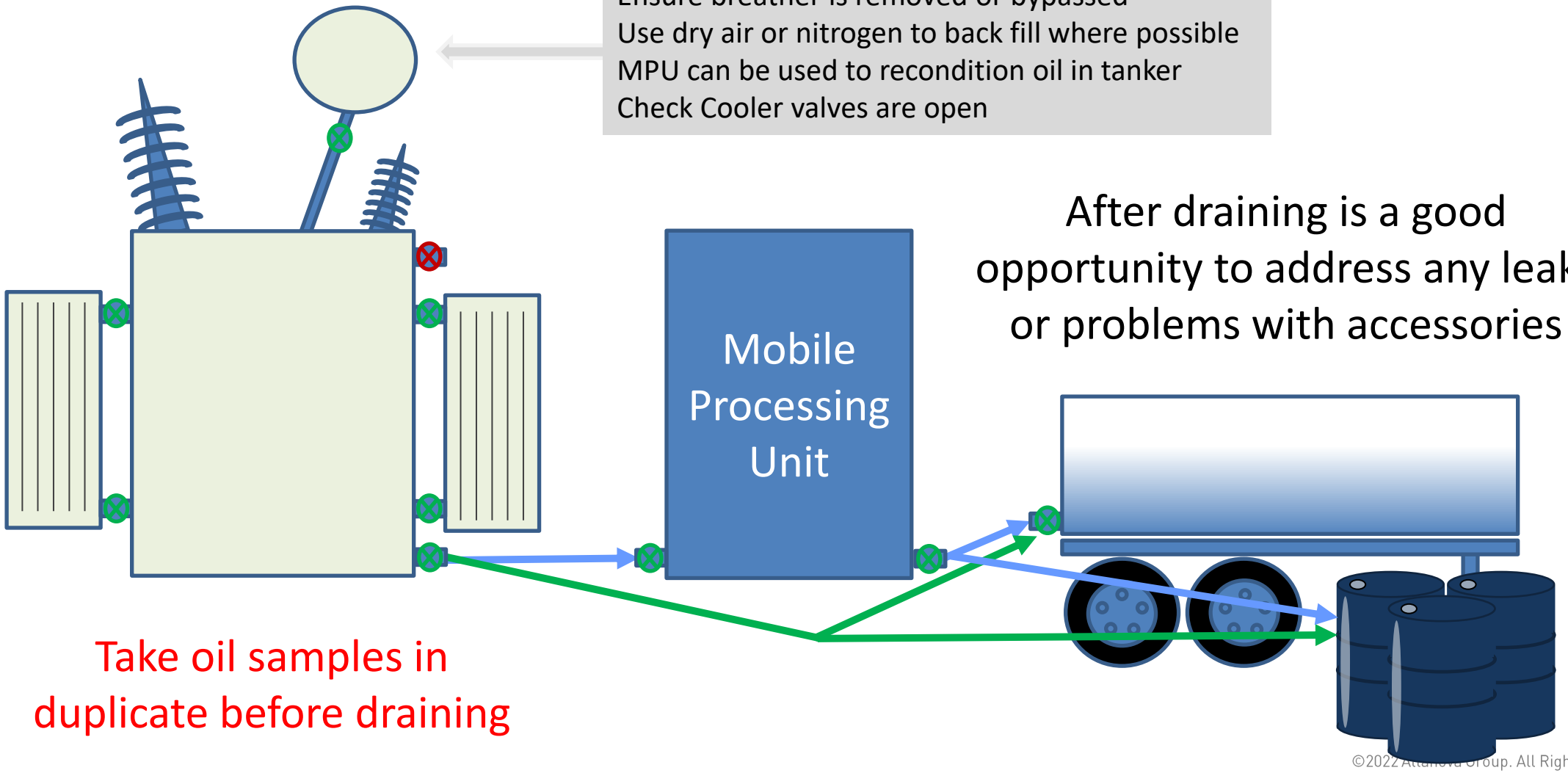
Inhibited oils exclusively used in the USA giving worry free longevity to the oils condition for decades without intervention
Can be used in Sealed and Free Breathing systems
Can be dosed mid life (better when oil quality is good, or after oil regeneration)
Small cost with big benefits

Maintaining Oil

- Oil processing, regeneration and oil changes are not risk free activities and should be considered last resort options when several oil quality parameters are out of limit
- Don’t process oil just to remove gasses unless their presence poses a threat to the safe operation of the equipment.
- Take samples before (benchmark), after (confirmatory) and 3 months post treatment (new benchmark)
- Always use a reputable contractor, who mitigates for the known processing risks
- Ensure sufficient temperature is reached for the objective, without exceeding 90˚C (e.g. sludge aniline point is around 82˚C)
- Ensure apparatus is clearly marked with the oil type within, close to the rating plate for ease of identification use colour coding. Labelling new and waste oil drums in a similar manner will make clear which drums are intended for which purpose and where they should be stored.

Oil changes

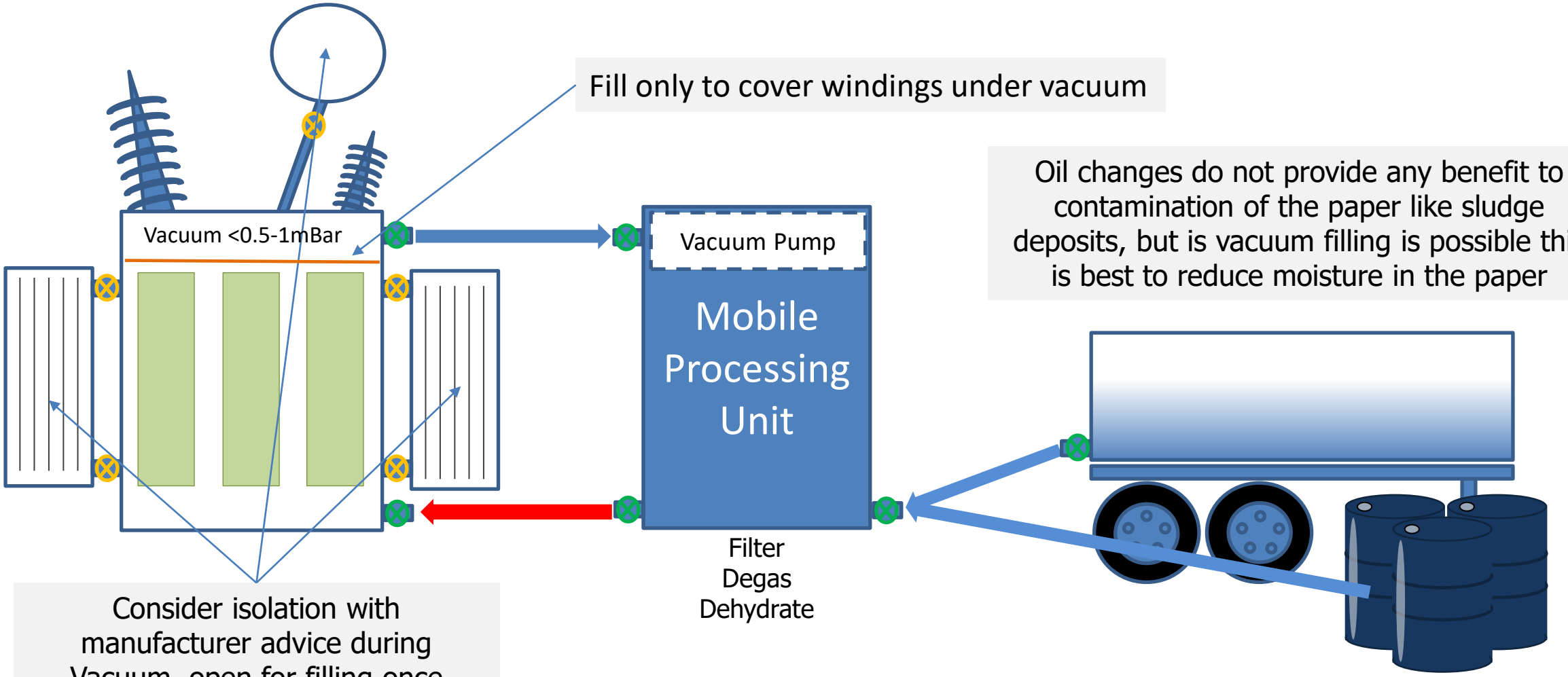
Ensure breather is removed or bypassed
Use dry air or nitrogen to back fill where possible
MPU can be used to recondition oil in tanker
Check Cooler valves are open



After draining is a good opportunity to address any leaks or problems with accessories

Take oil samples in duplicate before draining

Oil changes



Pulling Vacuum

- Most effective way to dry paper prior to refilling
- However is potentially very dangerous
- Clear all personnel from the local area during vacuum pulling
- Double check rating plates and general condition of the transformer and accessories for Vacuum withstand, if cannot get < 0.5mBar then its not going to be effective.
- Consult with manufacturer or design consultant
- If there is any tank or accessory damage do not pull vacuum unless they can be isolated with a vacuum rated valve in sound condition

Vacuum Withstand

Video © Mythbusters

Tank withstand – Full Vacuum
<0.5mBar when undamaged

After damage
Tank failure @ 270mBar;
This partial vacuum is not good enough for moisture removal

There is no way of knowing what the vacuum withstand will be after damage or deterioration of components has occurred

Storage and Disposal of Oil

- As soon as unused oil is put into the transformer the IEC60296 new oil standard no longer applies. Now the oil is classed as ‘in-service’, and should be maintained under IEC60422. Similar conditions and standards exist for other oil types like esters
- As soon as ‘in-service’ oil is removed from a transformer, it is classed as hazardous waste oil even if stored temporarily and needs to be stored / disposed of in accordance with the oil waste management legislation applicable to your location

Storage and Disposal of Oil

- Company registration onto hazardous waste scheme
- Waste oil to be stored securely and positioned where it won't get damaged, or surrounded by bollards or barriers
- Fixed tanks must be bunded
- Record the PCB content of the waste
- To be stored in suitable containers that prevent leaks
- Clearly labelled with the type of waste they contain
- Are sealed when not in use
- If outdoors, have waterproof covers
- Stored so they don't contaminate each other
- Stored away from other forms of waste

Storage and Disposal of Oil

- Stored on a bund appropriate for the size of container minimum 110% of total volume of the largest container, or 25% the total volume where 4 or more oil containers are stored
- Have the appropriate consignment/waste notes completed upon transfer via a specialist waste carrier. These must be signed and copies retained for 2 years
- Waste Oil volumes stored over 3000L will require individual site licences
- Storage for drums and IBC should be marked ‘UN’ as they will meet design standards
- Waste oil needs to be stored in appropriate containers, labelled clearly and segregated from other oil products

Resources

- Cigre 413 Insulating Oil regeneration and Dehalogenation
- Cigre 445 Guide for Transformer Maintenance
- Doble Reference Book (Insulating Liquids and Gases)
- ASTM D923-2015: Standard Practice for Sampling Electrical Insulating Liquids (added part on sampling network switches)
- IEC 60475: Method of Sampling Liquid Dielectrics
- IEC 60567: Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment and for the Analysis of Free and Dissolved Gas
- IEC 60296 – New Mineral Oils
- IEC 60422 – Maintaining Mineral Oils In Service
- IEEE c57.104:2019 – DGA interpretation

Summary

- Oils will deteriorate if not carefully stored and handled properly
- Sample the new oil, test and if in any doubt test again, mistakes can be costly, are generally irreversible and endanger life
- Flush filling equipment with clean oil prior to oil insertion into electrical equipment; 25L should suffice but the actual ideal flushing volume will depend on hose length and diameter
- Label and Discard part used drums to prevent accidental reuse many months later
- Utilise bulk storage and temporary storage, but regulate and monitor to prevent oil contamination
- Sample regularly, in particular where there is an incipient issue or maintenance scheduled
- Store and Dispose of oil in accordance with local legislation using a licenced waste contractor

Thanks for Listening

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