NAME : Carl Wolmarans
COUNTRY : South Africa
REGISTRATION NUMBER: 6231

GROUP REF.: A2
PREF. SUBJECT: PS2
QUESTION N°: 2.1

Alternative Insulating Liquid Prospects

There is a trade-off between a transformer design making use of the performance related advantages of a certain insulating liquid (optimisation, taylor-made design) and the benefits of mass standardisation and forward compatibility of transformer and component designs. Many alternative liquids are available with more varieties expected in the future.

Liquid Type	Main Advantages	Main Disadvantages
Traditional naphthenic mineral insulating oils	• Track Record • Component and Design approvals • Dielectric Properties • Cost-to-Performance ratio	• Crude oil based • Not usually readily Biodegradable • Standard flash point
Re-refined naphthenic mineral insulating oils	• Same Dielectric properties to the original oil • Sustainable (Circularity) • Re refining processes lead to improved quality compared to clay treatment (reclaimed oils)	• Not usually readily Biodegradable • Standard flash point
Gas-to-liquid (and similar highly refined or synthetic oils)	• IEC 60296 compatible • Sulphur Free	• Absence of aromatics leads to some dielectric differences • Component and design approvals generally required • Not usually readily Biodegradable • Standard flash point
Bio-Based Hydrocarbon (Low Viscosity)	• IEC 60296 compatible • Sustainable (Fully Bio-Based, residues) • Readily Biodegradable • Low viscosity, thermal design optimisation potential • Closer Dielectric behaviour to mineral oil than esters	• Absence of aromatics leads to some dielectric differences • Component and design approvals generally required • Standard flash point
Natural Esters	• Sustainable (Bio-based, but food crop competition should be considered) • Readily Biodegradable • High flash point • High temperature design option (*Disputed*) [1]	• Major dielectric and thermal design changes generally needed • Many variations between seed crops • Oxidation Stability and stray gassing draw backs • Component and design approvals generally required
Synthetic Esters	• Readily Biodegradable • High flash point • Better oxidation stability than natural esters • High temperature design option (*Disputed*) [1]	• Major dielectric and thermal design changes generally needed • Not fully bio-based • Component and design approvals generally required

[1] The direct transformer design relevance of reported paper ageing benefit aspects of esters at high temperature are somewhat under dispute. To be of use in transformer designs depends on trade-offs between liquid lifetime, stray gassing, short circuit design and no-load and load-loss capitalisation considerations.

Dielectric Design Suitability

A recent CIGRE TB 856 concerning the dielectric performance of insulating liquids shows the immense amount of design data which is based on (***aromatic containing***) mineral insulating oils. Alternative liquids do show some differences which have different impacts depending on the transformer designer's in-house philosophy and strategy. As outlined in IEC TR 60076-26 there is a great need for more standardised dielectric screening and liquid "approval" processes. One possible future strategy could be to screen and categorize new insulating liquid types by their chemistry and if big significant changes are detected dielectric screening tests can be done to categorise a liquid as similar to one already which is currently more well known.

Thermal Design Optimisation

Low viscosity liquids (such as bio-based hydrocarbon) offer a great potential for thermal design optimisation of transformers, but they require either a dedicated transformer design or a dual name plate approach so the end user can take advantage of the improved cooling. The dual nameplate approach may be best as it leaves open the door for the end user to use a traditional mineral insulating oil in the unit (as bio-based hydrocarbon meets IEC 60296 may properties are compatible with traditional oils).