

Question 2.3: What maintenance challenges exist for alternative technologies, especially for demanding applications? Is there any significant difference from the maintenance challenges for conventional oil-immersed transformers

### **LIQUID TESTS IN SERVICE – SIMILARITIES AND DIFFERENCES**

There are a number of international standards intended to guide the user through the maintenance of liquid filled electrical equipment (Table 1). However, there is not only one single solution, since different experiences may exist depending on design, type of installation, historical records, but also type of insulating liquid.

E.g. ester insulating liquids differ to mineral oils, but also to silicones on

- Chemical composition
- Biodegradability (Figure 1)
- Some electrical and dielectrical properties (Figure 2)
- Flammability
- Environmental properties

Maintenance of electrical equipment is focused on:

- Keeping the equipment in service in a reliable shape
- Preventing preliminary ageing

For this purpose not single standards or guidances but a combination of those are to be utilized. This is common for all liquid insulated equipment.

- e.g. no maintenance can be carried out only on gas-in-oil analysis or only on oil values, but on combination of both. Experience shows clearly that faults have similar manifestation in the gas-in-oil analysis although the chemical composition may be different
- there are parameters, which are crucial for operation, e.g. breakdown voltage and others, which are important for early ageing recognition, e.g. acidity, DDF, interfacial tension

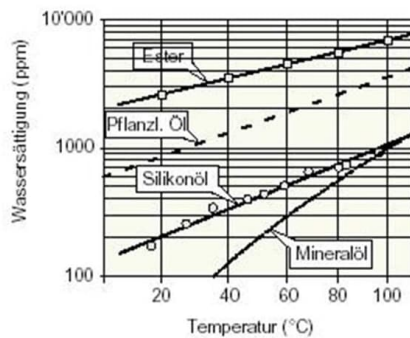
Some parameters which are of no real importance for mineral oil may be very important for the monitoring of natural esters, e.g. viscosity. Fire point may be important in case of esters for the identification of mixtures with mineral oils

Some other simple parameters, like refraction index, not really used for mineral oil, can be very useful for this purpose as well.

Table 1. Some specifications for new and used insulating liquids

	Mineral oil	Silicone liquids	Synthetic ester	Natural ester
<b>New liquids</b>	IEC 60296 ASTM D3487 IEEE 57.106 IEEE 57.121	IEC 60836 ASTM D4652 IEEE 57.111	IEC 61099	ASTM D6871 IEEE 57.147 IEC 62770
<b>Liquids in service</b>	IEC 60422 IEEE 57.106	IEC 60944 IEEE 57.111	IEC 61203	IEC 62975 IEEE 57.147
<b>DGA</b>	IEEE C57.104 IEC 60567 IEC 60599			

**Water saturation**  
(schem. representation)



**biol. degradation rate**  
(schem. Representation)

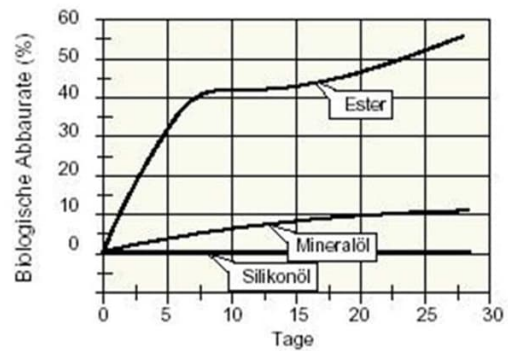
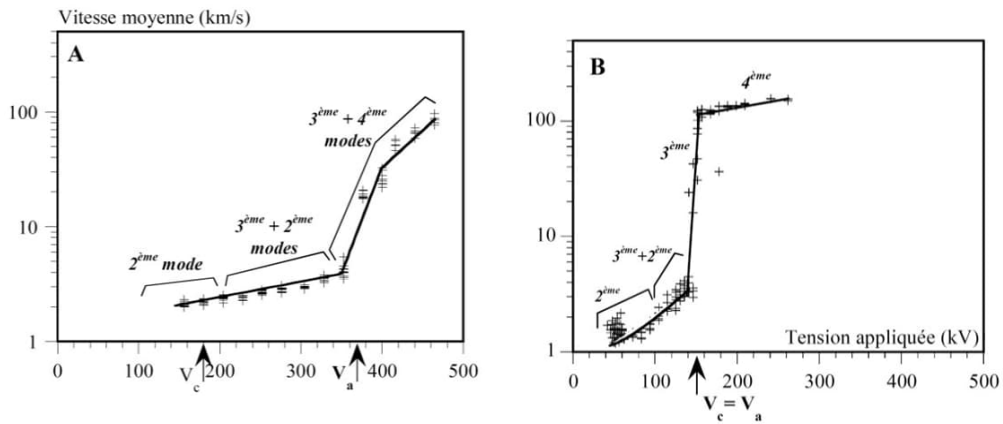


Figure 1 : Moisture uptake and biodegradability of different insulating liquids



mineral oil

$U_{BD}$

$U_a$

ester

$U_{BD} \approx U_a$

Lesaint – L. Lundgaard, Tutorial Cigre D1 Workspot 2014, Brasil

Figure 2: Difference between insulating liquids in electrical properties