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#### Question 2.04

Is testing under high temperature representative enough for the determination of thermal index of insulating materials? Are the acceleration factors used for high temperature accelerated tests for different insulation systems well documented? How shall the change of properties and chemical characteristics of the insulating liquid itself be considered under such conditions? Can diagnostics as DGA be transposed from old insulation systems to new ones? How can dielectric performance (e.g. withstand voltages) of an insulation system/design be qualified? **Where are standards for performance and compatibility lacking?**

#### Answer

There are at least two areas where industry standards are missing with regard to evaluation of liquid immersed insulation systems:

1. Thermal evaluation of insulating liquids.
2. Evaluation of chemical compatibility of materials.

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Standards for various liquids (e.g. natural or synthetic esters) suggest that those liquids could operate at temperatures higher than conventional mineral oils. But there is no indication of what could be the temperature limits to be used by equipment designer. Thermal evaluation methods for insulation systems mainly focus on degradation of solid insulations, while liquid being part of the insulation system is only considered as the background environment for solids.

IEC 60076-14 and IEEE C57.154 for transformers using high temperature insulation systems suggested temperatures higher by 30°C for ester operation and 55°C for silicones, but it was a guess supported by application experience, only. This recommendation will be deleted in the new revision of IEEE C57.154, with a reference to the liquid manufacturer data on acceptable temperatures. But liquid manufacturers do not have the guidelines on how to establish design limits for liquids.

We proposed developing CIGRE guidelines for aging and evaluation of liquids in 2014, but the topic was considered too complex at that time (too many factors to consider). Now, an active IEEE Working Group investigates aging factors for liquids:

- Understanding of long-term thermal aging behavior of liquids,
- Guidelines for accelerated aging tests,
- Criteria for end-of-life determination,
- Temperature limits for long-term and short-term operation.

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ASTM D3455 “*Standard Test Methods for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin*” is the standard available today for compatibility evaluation with mineral oils. Test procedure corresponds to temperature typical for mineral oil operation. The document is not specific on acceptance criteria for material compatibility.

New insulation systems require new guidelines.

IEC 63177 “*Test method for compatibility of construction materials with electrical insulating liquids*” is a new standard under development to cover wide range of insulation systems. Test procedure will include testing at temperatures close to insulation system thermal class.

It must be noted that it is a standard for chemical compatibility of material combinations and NOT for thermal lifetime evaluations of insulation systems.