Paris Session 2022

Missing standards for liquid filled insulation systems

SC D1 Materials and Emerging Test Techniques

PS2, Q2.04 - Is testing under high temperature representative enough for the determination of thermal index of insulating materials? (…)

Where are standards for performance and compatibility lacking?

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Summary

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

- Thermal evaluation of insulating liquids,
- Evaluation of chemical compatibility of materials.

Thermal evaluation of insulating liquids

- Standards for various liquids suggest higher operating temperatures, but the temperature limits are not provided.
- Thermal evaluation for insulation systems focuses on degradation of solid insulations - liquid (part of the insulation system) provides an environment for solids.
- IEC 60076-14 and IEEE C57.154 – accepted temperatures higher by +30°C for esters, +55°C for silicones, but no supporting data.
- New revision of IEEE C57.154 - reference to the liquid manufacturer data on acceptable temperatures. But no guidelines available on how to establish design limits for liquids.
- Developing CIGRE guidelines for aging and evaluation proposed in 2014, but the topic was considered too complex (too many factors to consider). Now, an active IEEE Working Group investigates aging factors for liquids.
  - Understanding of thermal aging,
  - Guidelines for accelerated aging tests,
  - Criteria for end-of-life determination,
  - Temperature limits for long-term and short-term operation.

IEC 60076-14 guidelines for liquid temperature

	Ester liquid				Silicone liquid			
Minimum required high-temperature solid insulation thermal class	130	140	155	180	130	140	155	180
Top liquid temperature rise (K)	90	90	90	90	115	115	115	115
Average winding temperature rise (K)	85	95	105	125	85	95	105	125
Hot-spot temperature rise (K)	100	110	125	150	100	110	125	150

IEEE C57.154 guidelines for liquid temperature

Table 3- Continuous temperature rise limits [a] for transformers with high-temperature insulation systems

	High-temperature insulation systems [b]			
Insulation system thermal class	130	140	155	180
Top liquid temperature rise [c], (°C)	75	85	95	115
Average winding temperature rise, (°C)				
Cooling classes: KN, KF, LN, LF,	75	85	95	115
Cooling classes: KD, LD	80	90	100	120
Hottest spot temperature rise, (°C)	90	100	115	140

[a] The temperature rises shown are based on a 30 °C average cooling media temperature as defined in IEEE Std C57.12.00. If the specified cooling media temperature is different from 30 °C, the temperature rise limits shall be adjusted accordingly.

[b] Essentially oxygen-free applications where the liquid preservation system helps prevent the ingress of air into the tank.

[c] Refer to liquid manufacturer's recommendation for specific values of maximum liquid operating temperatures.

Evaluation of chemical compatibility of materials

- ASTM D3455 - standard available today for compatibility evaluation with mineral oils; test procedure corresponds to temperature typical for mineral oil operation and is not specific on acceptance criteria for compatibility.
- New insulation systems require new guidelines.
- IEC 63177 “Test method for compatibility of construction materials with electrical insulating liquids”
  - 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.