Paris Session 2022

High temperature insulation

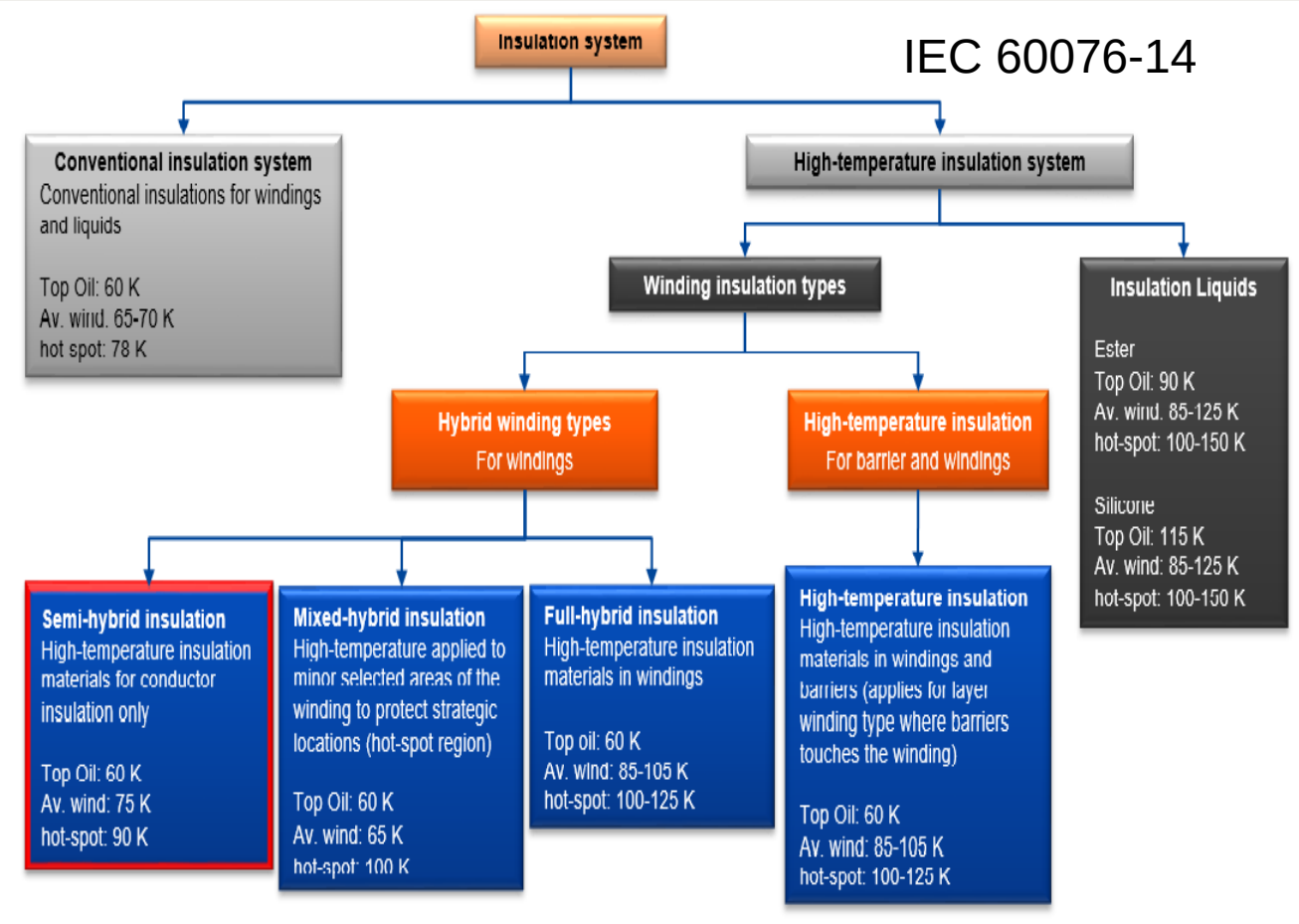
A2 PS2 Q2.5

There seem to be conflicting opinions concerning the use of some alternative transformer technologies at higher temperatures, especially ester-immersed transformers. What is the experience of using alternative transformer technologies at higher temperatures? What further work is needed on this subject?

Ahmed Gamil-Germany

A2 - PS2- Question 2.5

- Thermal degradation of insulation material is the main influencing factor to determine the transformer lifetime. The heat generated in the winding conductors is transferred to the insulation fluid result in changing the insulation paper properties over time. For the time of using mineral liquids, the main function of High Temperature Insulation Materials (HTIM) is to keep the heat inside the conductor by increasing the current density and at the same time decreasing the rate of degradation. This allows more compact design.
- With increase the need of climate protection again the pollution resulting from transformer leak or fire accidents, new insulation fluids have been introduced to the market offering biodegradability and higher firing point. From transformer technology point of view, the focus is always comparing the new fluids with mineral oil mainly based on thermal and dielectric properties.
- The advantage of using HTIM technology in transformers is that there is a variety of solutions offering a flexibility in design for optimization between thermal performance and design cost.



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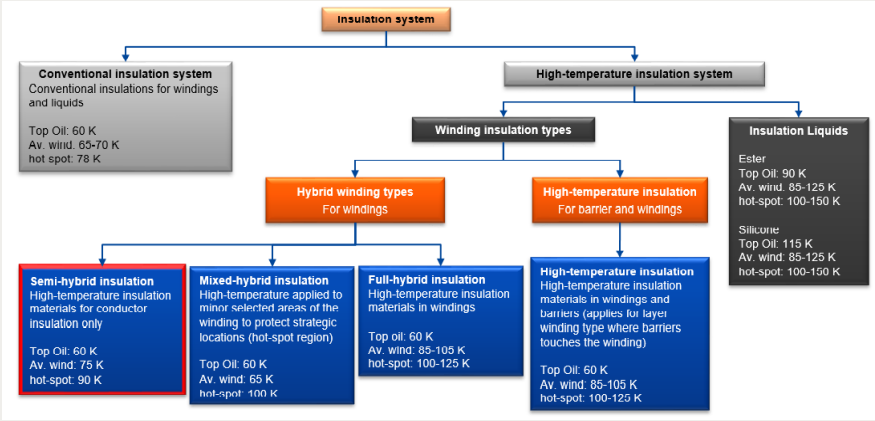
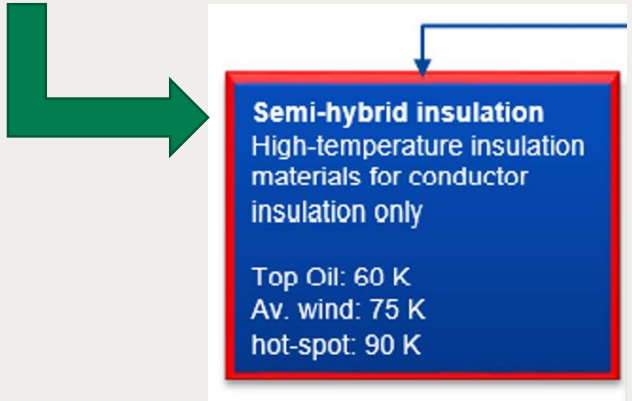
Case study using “Semi-hybrid insulation”

- The specified maximum continuous temperature rise limits for transformers with semi hybrid insulation system according to IEC 60076-14 is 60/75/90 for top liquid, average winding and hot spot temperature rise, respectively. Several case studies have been done investigating the differences between the semi hybrid, mixed hybrid und full hybrid insulation systems.
- The most economical solution is in most of the cases was the semi hybrid insulation system by using conventional insulation liquids, as the maximum temperature rise of the liquid is limited to 60 K.
- The investigations have shown that the maximum allowed hot spot rise of 100 K of the full hybrid insulation system does not justify the additional material costs, as the cooling system must be designed to a maximum liquid temperature rise of 60 K in both cases.
- By using ester insulation fluid, the top liquid temperature rise can be increased to 90 K. This would result in a considerably smaller cooling footprint, but it would require HTIM materials not only inside the windings (OLTC at high temperature, winding cylinders, clamping rings, etc.).

IEC 60076-14





A2 - PS2- Question 2.5

Case study results of comparing designs with different fluids

- Design: 63MVA, 140 kV
- P0 & Pk are kept the same for all variances
- Based on fluid properties:
  - Electrical distance was optimized
  - Cooling system was optimized

Design (63MVA-140kV)	Mineral oil (Reference)	Bio based hydrocarbon fluid	Synthetic ester fluid	Deviation Bio based Fluid-Ref.	Deviation Synthetic ester Fluid-Ref.
Core [kg]	23839	23839	24700	0%	3,48%
Winding [kg]	11286	11286	11511	0%	1,95%
Fluid [kg]	11824	11601	15877	-1,92%	25,52%
gr [K]	LV: 23,4 HV: 24,3	LV: 21,0 HV: 21,9	LV: 23,5 HV: 24,9	LV: -2,4K HV: -2,4K	LV: +0,1K HV: +0,6K
Top-oil [K] **Guar.: 60K**	57,9	56,8	57,5	-0,4K	-0,4K
HS[K] **Guar.: 90K**	89,4	85,3	89,9	-4,1K	+0,5K

Conclusion:

- There is no unique solution which would satisfy the market requirements and offer an optimized design from safety and cost point of view. However, there are a flexibility in technology which always give a chance to reach a comprise between OEM and his client.