



## Materials and components qualification

SC A2 PS2 Q2.5:

What is the experience of using alternative transformer technologies at higher temperatures?

What further work is needed on this subject?



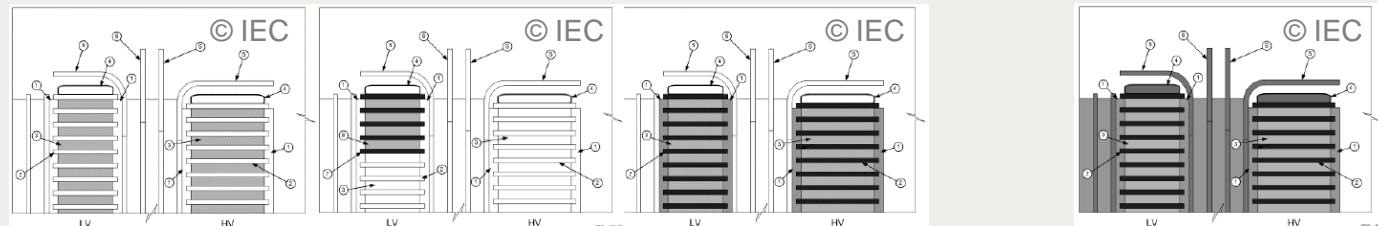
Tobias Stirl (Germany)

# High-temperature insulation systems

- IEC standard for insulation materials existing (IEC 60076-14:2013)
- Studies and publications existing to demonstrate capabilities and limits

Selected Options	Conventional	Semi Hybrid	Mixed Hybrid	Full Hybrid	High Temperature	High Temperature
T°C: Ambient / oil / winding (hot-spot)	40 / 60 / 65 (78)	40 / 60 / 75 (90)	40 / 60 / 65 (100)	40 / 60 / 105 (125)	40 / 90 / 105 (125)	40 / 90 / 95 (110)
Conductor insulation	Kraft paper	TUP	Material $\geq 155$ °C & Kraft paper	Material $\geq 155$ °C	Material $\geq 155$ °C	TUP
Solid insulation (e. g. cylinders, strips)	Pressboard	Pressboard	Material $\geq 155$ °C & Pressboard	Material $\geq 155$ °C & Pressboard	Material $\geq 155$ °C	Pressboard
Liquids	Mineral oil	Mineral oil	Mineral oil	Mineral oil	Natural ester	Natural ester
Weight 80 & 515 MVA	100 %	98 %	97 %	96 %	93 %	95 %
Costs 80 & 515 MVA	100 %	98 %	100 %	98 %	118 %	102 %

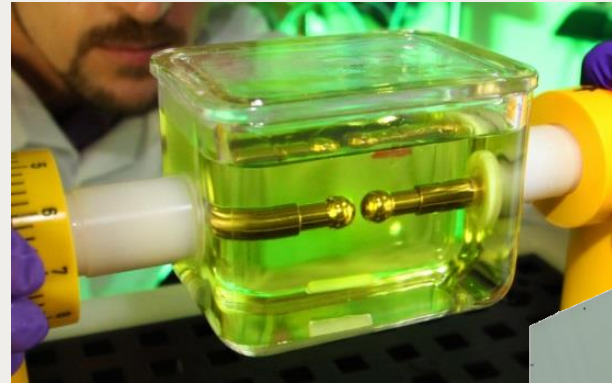
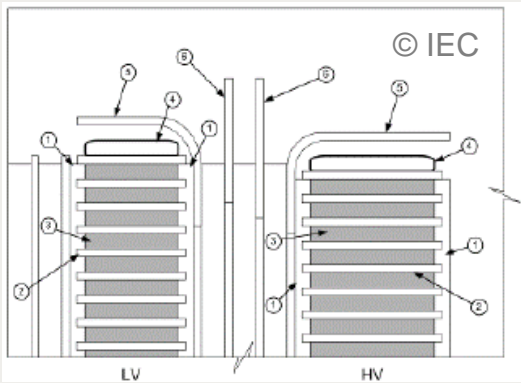
Design options for high-temperature transformers 80 MVA and 515 MVA



Challenge: Complex discussions between materials suppliers, transformer OEM and user

# Experiences

- Example of a transformer with a high-temperature insulation system



10 MVA/110 kV/16,7 Hz “Green Transformer”

- Semi-hybrid insulation winding
- Thermal design in accordance with IEC 60076-14
- Natural ester
- Hermetic design (expandable radiators)
- Others:
  - Losses lower than required according to EN 50708
  - Noise reduction
  - Successful short-circuit tested

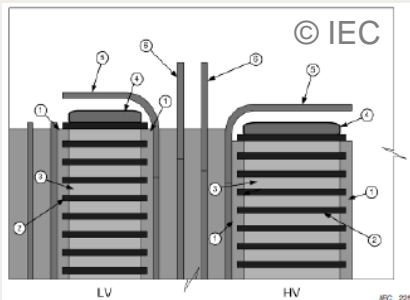
Solution developed in close cooperation between transformer OEM and user

# Further work

- All insulation materials and components shall be capable for higher temperatures

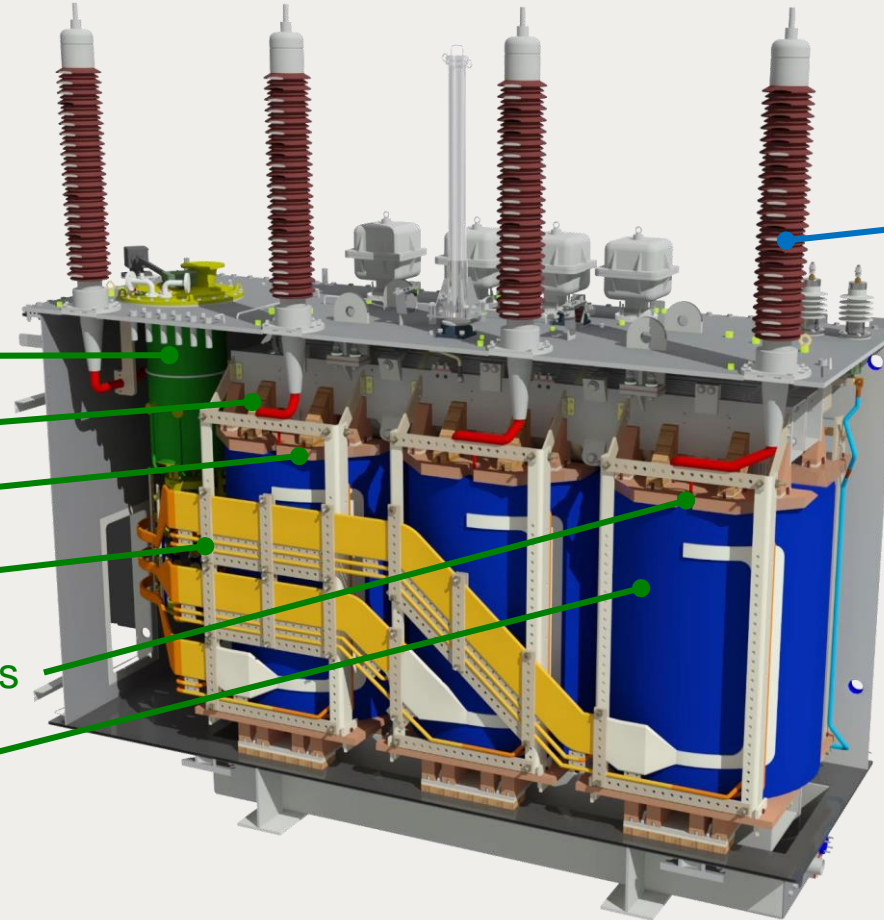
## Available solutions

- Conductor insulation
- Spacer
- Liquid (Ester)



## Recent developments

- Tap Changer
- Support blocks
- Platforms
- Support bars
- Moulded parts/angle rings
- Large barriers/cylinders



## Limits & Gaps

Further work  
Bushings

DGA

## Drawbacks

- Higher losses
- Higher costs