



SIEMENS



PC57.154 – Hybrid insulation system  
and Ester liquid under certain  
conditions

Kurt Kaineder

## High-Temperature, Liquid-Immersed Transformers

**Table 3 —Maximum continuous temperature rise limits for transformers with hybrid insulation systems**

	Conventional system	Mixed hybrid insulation winding	Full hybrid insulation winding
<b>Thermal class</b>	120	130	130 / 140 / 155
Top liquid temperature rise [K]	65	65	65 / 65 / 65
Average winding temperature rise [K]	65	65	75 / 85 / 95
Hottest spot temperature rise [K]	80	90	90 / 100 / 115

# High-Temperature, Liquid-Immersed Transformers

## Mineral oil and Esters with different insulation systems

IEC 60076-2 give different average winding rises on cooling type:

### Table 1 – Temperature rise limits

Average winding (by winding resistance variation):

– ON.. and OF.. cooling systems	65K
– OD.. cooling system	70K

Items to be discussed:

- Effect of cooling type (*ON, OF, OD have different rises, gradient based on physics*)
- Effect of liquid temperature class (*effect of mixing materials with liquids – e.g. increased thermal class of solid insulation material in esters*)
- Effect of combination of Insulation systems, cooling type and liquid thermal class

# High-Temperature, Liquid-Immersed Transformers

## Suggested modifications on existing tables 3,..

	Conventional system	Mixed hybrid insulation winding	Full hybrid insulation winding
Thermal class insul.	120 130 <sup>a</sup>	130	130 / 140 / 155
Liquid thermal class <sup>b</sup>	105 <sup>c</sup> /125 <sup>c</sup> /140 <sup>c</sup>	105 <sup>c</sup> /125 <sup>c</sup> /140 <sup>c</sup>	105 <sup>c</sup> /125 <sup>c</sup> /140 <sup>c</sup>
Cooling type <sup>b</sup>	ON <sup>d</sup> /OF <sup>d</sup> /OD <sup>d</sup>	ON <sup>d</sup> /OF <sup>d</sup> /OD <sup>d</sup>	ON <sup>d</sup> /OF <sup>d</sup> /OD <sup>d</sup>
Top liquid temperature rise [K]	65 / ? <sup>e</sup>	65 / ? <sup>e</sup>	65 / 65 / 65 ? <sup>e</sup>
Average winding temperature rise [K]	65 / ? <sup>e</sup>	65 / ? <sup>e</sup>	75 / 85 / 95 ? <sup>e</sup>
Hottest spot temperature rise [K]	80 / ? <sup>e</sup>	90 / ? <sup>e</sup>	90 / 100 / 115 ? <sup>e</sup>

<sup>a</sup> proposed additional thermal class (ester with thermally upgraded material)

<sup>b</sup> proposed additional criteria / aspects on high temperature transformer application

<sup>c</sup> proposed additional thermal class of insulation liquid (work of TF 1)

<sup>d</sup> proposed additional cooling type

<sup>e</sup> proposed additional rise limits based on new set of criteria's combinations