Transformer Hot-Spot Temperature and Insulation Ageing

Steady top-oil and hot-spot temperature of an oil-filled transformer at a load and ambient, the ageing acceleration factor and loss of life over a period.

Method: Thermal model and Arrhenius ageing of transformer insulation; Transformer loading guide practice (Arrhenius ageing, ultimate temperature rises)

Input parameters

Unit system: SI

Parameter	Value	Unit
Ambient temperature	30.000	°C
Load (per unit of rating)	1.1000	
Rated top-oil rise	55.000	K
Rated hot-spot rise over top oil	25.000	K
Ratio of load loss to no-load loss at rated load	6.0000	
Oil exponent	0.90000	
Winding exponent	0.80000	
Duration at this condition	24.000	h
Normal insulation life	180,000	h

Calculated results

Parameter	Value	Unit
Top-oil temperature	93.835	°C
Hot-spot temperature	122.95	°C
Ageing acceleration factor	3.6010	
Equivalent ageing time	86.424	h
Loss of life	0.048014	%

Notes for this case

• Ultimate (steady) temperatures: Δθ_TO = Δθ_TO,R((K²R + 1)/(R + 1))ⁿ, Δθ_H = Δθ_H,R·K^(2m); ageing F_AA = exp(15000/383 − 15000/(θ_H + 273)) relative to 110 °C hot spot for thermally upgraded paper. Short overloads are less severe than this steady value because oil heats with a time constant of hours.

Formula and method

$$\theta_H = \theta_a + \Delta\theta_{TO,R}\left(\frac{K^2R+1}{R+1}\right)^n + \Delta\theta_{H,R}K^{2m}, \quad F_{AA} = e^{\frac{15000}{383}-\frac{15000}{\theta_H+273}}$$

Variables

θ_a	Ambient temperature	K
K	Load (per unit of rating)	-
$\Delta\theta_{TO,R}$	Rated top-oil rise	K
$\Delta\theta_{H,R}$	Rated hot-spot rise over top oil	K
R	Ratio of load loss to no-load loss at rated load	-
n	Oil exponent	-
m	Winding exponent	-
t	Duration at this condition	s

L_n	Normal insulation life	s
θ_{TO}	Top-oil temperature	K
θ_H	Hot-spot temperature	K
F_{AA}	Ageing acceleration factor	-
t_{eq}	Equivalent ageing time	s
LOL	Loss of life	-

Method and standards

Ageing model.

Assumptions and limits

- Steady state; thermally upgraded paper.

References

Thermal model and Arrhenius ageing of transformer insulation, Transformer loading guide practice (Arrhenius ageing, ultimate temperature rises)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

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