Nucleate Boiling Coefficient (Cooper Correlation)

Pool nucleate boiling heat-transfer coefficient and wall superheat for water from the reduced pressure, molar mass and heat flux by Cooper's correlation.

Method: Cooper (1984); h = 55 p_r^0.12 (−log₁₀ p_r)^−0.55 M^−0.5 q^0.67 (W/m²K, q in W/m²); p_c entered (water 22.064 MPa, IAPWS-IF97)

Input parameters

Unit system: SI

Parameter	Value	Unit
Pressure (absolute)	70.000	bar
Heat flux	150.00	kW/m²
Molar mass of the fluid	18.015	kg/kmol
Critical pressure of the fluid 22.064 MPa (220.64 bar) for water (IAPWS-IF97); enter the fluid's own value for other fluids.	220.64	bar

Calculated results

Parameter	Value	Unit
Reduced pressure p/p_c	0.31726	
Boiling coefficient	48,634	W/(m²·K)
Wall superheat	3.0843	K

Notes for this case

• Cooper's form for a surface roughness of about 1 µm. For water keep M = 18.015 kg/kmol and p_c = 22.064 MPa (IAPWS); for other fluids enter their own M and p_c.

Formula and method

$$p_r = \frac{p}{p_c}, \quad h = 55\, p_r^{0.12} (-\log_{10} p_r)^{-0.55} M^{-0.5} q^{0.67}$$

Variables

p	Pressure (absolute)	Pa
q	Heat flux	W/m²
M	Molar mass of the fluid	kg/kmol
R_p	surface roughness (taken as 1 µm)	µm
p_c	Critical pressure of the fluid (water 22.064 MPa)	Pa
p_r	Reduced pressure p/p_c	-
h	Boiling coefficient	W/(m²·K)
ΔT_{sat}	Wall superheat	K

Method and standards

Cooper (1984) pool boiling correlation. Its full form has the exponent of p_r as 0.12 − 0.2 log₁₀ R_p, with R_p the surface roughness in µm; here R_p = 1 µm, so the exponent is 0.12.

Assumptions and limits

- Nucleate regime, below CHF. The heat flux is not checked against the critical heat flux: check it with the Zuber CHF calculator.
- Surface roughness about 1 µm (commercial tubes).
- Pressure below the fluid's critical pressure; defaults are for water.

References

• Cooper (1984)
• h = 55 p_r^0.12 (−log₁₀ p_r)^−0.55 M^−0.5 q^0.67 (W/m²K, q in W/m²); p_c entered (water 22.064 MPa, IAPWS-IF97)

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

https://calc.firecad.com/boilers-power-plant/boiler-pressure-parts/nucleate-boiling-cooper

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.