Nucleate Boiling: Mostinski, Palen, Cooper and Stephan–Abdelsalam

Nucleate pool boiling coefficient and heat flux from the wall superheat by Mostinski (with Palen's pressure factor), Cooper and Stephan–Abdelsalam correlations.

Input parameters

Unit system: SI

Parameter	Value	Unit
Wall superheat T_w − T_sat	10.000	K
Saturation temperature	99.970	°C
System pressure	101.33	kPa
Critical pressure	22,064	kPa
Molar mass	18.015	kg/kmol
Liquid density	958.40	kg/m³
Vapour density	0.59800	kg/m³
Liquid thermal conductivity	0.67900	W/(m·K)
Liquid specific heat	4.2160	kJ/(kg·K)
Surface tension	58.900	mN/m
Latent heat	2,257.0	kJ/kg
Contact angle (water 45°, organics and refrigerants 35°, cryogens 1°)	45.000	°

Calculated results

Parameter	Value	Unit
Reduced pressure	0.004592	
Mostinski pressure factor	0.72706	
Mostinski coefficient	8,501.7	W/(m²·K)
Mostinski heat flux	85.017	kW/m²
Palen's pressure factor	0.49108	
Mostinski coefficient with Palen's F_P	2,298.5	W/(m²·K)
Heat flux with Palen's F_P	22.985	kW/m²
Cooper coefficient	8,644.7	W/(m²·K)
Cooper heat flux	86.447	kW/m²
Departure bubble diameter	2.3267	mm
Stephan–Abdelsalam coefficient	6,274.9	W/(m²·K)
Stephan–Abdelsalam heat flux	62.749	kW/m²

Notes for this case

- Each correlation is written in heat flux and solved for the coefficient with q = h ΔT_e. Predictions for the same case can differ by a factor of ten or more (surface condition dominates); Palen's F_P is the conservative design choice.

Formula and method

$$h_{nb} = 0.00417 P_c^{0.69} \widehat{q^{0.7}} F_P, \quad F_P = 1.8 P_r^{0.17} + 4 P_r^{1.2} + 10 P_r^{10}$$

$$F_P{}' = 2.1 P_r^{0.27} + \left[9 + (1 - P_r^2)^{-1}\right] P_r^2, \quad h_{Cooper} = 55 \widehat{q^{0.67}} P_r^{0.12} (-\log_{10} P_r)^{-0.55} M^{-0.5}$$

$$\frac{h d_B}{k_L} = 0.23 Z_1^{0.674} Z_2^{0.35} Z_3^{0.371} Z_4^{0.297} Z_5^{-1.73}, \quad d_B = 0.0146\,\theta \left[\frac{2\sigma}{g(\rho_L - \rho_V)}\right]^{1/2}$$

Variables

ΔT_e	Wall superheat T_w − T_sat	K
T_{sat}	Saturation temperature	K
P	System pressure	Pa
P_c	Critical pressure	Pa
M	Molar mass	kg/kmol
ρ_L	Liquid density	kg/m³
ρ_V	Vapour density	kg/m³
k_L	Liquid thermal conductivity	W/(m·K)
$c_{p,L}$	Liquid specific heat	J/(kg·K)
σ	Surface tension	N/m
λ	Latent heat	J/kg
θ	Contact angle (water 45°, organics and refrigerants 35°, cryogens 1°)	rad
P_r	Reduced pressure	-
F_P	Mostinski pressure factor	-
h_{nb}	Mostinski coefficient	W/(m²·K)
$\widehat{q}$	Mostinski heat flux	W/m²
$F_P{}'$	Palen's pressure factor	-
$h_{nb}{}'$	Mostinski coefficient with Palen's F_P	W/(m²·K)
$\widehat{q}'$	Heat flux with Palen's F_P	W/m²
h_{Cooper}	Cooper coefficient	W/(m²·K)
$\widehat{q_{Cooper}}$	Cooper heat flux	W/m²
d_B	Departure bubble diameter	m
h_{SA}	Stephan–Abdelsalam coefficient	W/(m²·K)
$\widehat{q_{SA}}$	Stephan–Abdelsalam heat flux	W/m²

Method and standards

Corresponding-states and dimensionless nucleate pool boiling correlations (P_c in kPa).

Assumptions and limits

- Pure fluids, nucleate regime below the critical heat flux.

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/mechanical/heat-transfer/nucleate-boiling-mostinski-stephan-abdelsalam

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.