Kettle Reboiler Bundle: Boiling Coefficient and Critical Heat Flux

Bundle boiling coefficient from the single-tube nucleate coefficient with Palen's bundle factor and natural convection, and the bundle critical heat flux.

Input parameters

Unit system: SI

Parameter	Value	Unit
Single-tube nucleate boiling coefficient	2,500.0	W/(m²·K)
Natural convection coefficient (hydrocarbons about 250)	300.00	W/(m²·K)
Bundle diameter	350.00	mm
Tube outside diameter	19.050	mm
Tube pitch	23.800	mm
Layout	Triangular (C_1 = 0.866)	
Number of tubes	120.00	
Critical heat flux of a single tube	450.00	kW/m²

Calculated results

Parameter	Value	Unit
Bundle boiling factor	1.5484	
Bundle boiling coefficient	4,170.9	W/(m²·K)
Bundle geometry parameter	0.15311	
Bundle CHF factor	0.47463	
Bundle critical heat flux	213.58	kW/m²

Notes for this case

- Palen's bundle factor allows for the vapour-driven circulation that raises the average coefficient in a bundle; the bundle CHF is far lower than that of a single tube because vapour blankets the upper tubes. Design heat fluxes are usually kept well below the bundle CHF.

Formula and method

$$h_b = h_{nb} F_b + h_{nc}, \quad F_b = 1 + 0.1 \left[\frac{0.785 D_b}{C_1 (P_T / D_o)^2 D_o} - 1 \right]^{0.75}$$

$$\psi_b = \frac{D_b}{n_t D_o}, \quad \widehat{q_{c,bundle}} = \widehat{q_{c,tube}} \, \phi_b, \quad \phi_b = 3.1 \psi_b \ (\psi_b < 0.323)$$

Variables

h_{nb}	Single-tube nucleate boiling coefficient	W/(m²·K)
h_{nc}	Natural convection coefficient (hydrocarbons about 250)	W/(m²·K)
D_b	Bundle diameter	m
D_o	Tube outside diameter	m
P_T	Tube pitch	m
layout	Layout	-
n_t	Number of tubes	-

$\widehat{q_{c,tube}}$	Critical heat flux of a single tube	W/m²
F_b	Bundle boiling factor	-
h_b	Bundle boiling coefficient	W/(m²·K)
ψ_b	Bundle geometry parameter	-
ϕ_b	Bundle CHF factor	-
$\widehat{q_{c,bundle}}$	Bundle critical heat flux	W/m²

Method and standards

Palen's bundle boiling corrections.

Assumptions and limits

- Plain-tube kettle bundles; pure or near-pure fluids.

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/chemical/process-heat-exchangers/kettle-bundle-boiling

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Reopens the calculator with the inputs of this report.