Film Boiling on a Horizontal Tube (Bromley) with Radiation

Film boiling coefficient on a horizontal tube by Bromley's equation, the radiative coefficient and their combination, with the resulting heat flux.

Input parameters

Unit system: SI

Parameter	Value	Unit
Tube outside diameter	10.000	mm
Wall temperature	726.85	°C
Saturation temperature	100.00	°C
Liquid density at T_sat	958.00	kg/m³
Vapour density (film temperature)	0.36000	kg/m³
Vapour thermal conductivity	0.055000	W/(m·K)
Vapour viscosity	0.026000	mPa·s
Vapour specific heat	2.1000	kJ/(kg·K)
Latent heat	2,257.0	kJ/kg
Wall emissivity	90.000	%

Calculated results

Parameter	Value	Unit
Wall superheat	626.85	K
Bromley Nusselt number	36.706	
Film boiling coefficient	201.89	W/(m²·K)
Radiative coefficient	79.834	W/(m²·K)
Combined coefficient (exact)	264.37	W/(m²·K)
Combined coefficient, h_fb + 0.75 h_r	261.76	W/(m²·K)
Heat flux	165.72	kW/m²

Notes for this case

- Bromley's equation with the Sadasivan–Lienhard 0.76 coefficient; vapour properties at the film temperature, liquid density at saturation. A single tube is somewhat conservative for bundles.

Formula and method

$$\frac{h_{fb} D_o}{k_V} = 0.62 \left[\frac{g \rho_V (\rho_L - \rho_V) D_o^3 (\lambda + 0.76 c_{p,V} \Delta T_e)}{k_V \mu_V \Delta T_e} \right]^{1/4}$$

$$h_r = \frac{\varepsilon \sigma_{SB} (T_w^4 - T_{sat}^4)}{T_w - T_{sat}}, \quad h_t^{4/3} = h_{fb}^{4/3} + h_r h_t^{1/3}$$

Variables

D_o	Tube outside diameter	m
T_w	Wall temperature	K
T_{sat}	Saturation temperature	K
ρ_L	Liquid density at T_sat	kg/m³

ρ_V	Vapour density (film temperature)	kg/m³
k_V	Vapour thermal conductivity	W/(m·K)
μ_V	Vapour viscosity	Pa·s
$c_{p,V}$	Vapour specific heat	J/(kg·K)
λ	Latent heat	J/kg
ε	Wall emissivity	-
ΔT_e	Wall superheat	K
$h_{fb} D_o / k_V$	Bromley Nusselt number	-
h_{fb}	Film boiling coefficient	W/(m²·K)
h_r	Radiative coefficient	W/(m²·K)
h_t	Combined coefficient (exact)	W/(m²·K)
$h_t{}'$	Combined coefficient, h_fb + 0.75 h_r	W/(m²·K)
$\widehat{q}$	Heat flux	W/m²

Method and standards

Laminar vapour-film analysis for a horizontal cylinder plus wall radiation.

Assumptions and limits

- Saturated pool film boiling on a single horizontal tube.

Report details

Report reference	FCC-Y63S-Q8M8 (the same inputs always give the same reference)
Generated	23 November 2026, 18:09 UTC
Calculator	Film Boiling on a Horizontal Tube (Bromley) with Radiation
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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/film-boiling-bromley-tube

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Reopens the calculator with the inputs of this report.