Critical Heat Flux: Macbeth (Tubes) and Mostinski (Pool)

Critical heat flux for boiling in a tube (Macbeth: pressure, diameter, mass velocity, quality) and in a pool (Mostinski), with a design allowance.

Method: Ganapathy; Steam Plant Calculations Manual; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Pressure (absolute)	68.948	bar
Tube inside diameter	38.100	mm
Mass velocity inside the tube	813.74	kg/(m²·s)
Steam quality	20.000	%
Design reduction from the correlation	30.000	%

Calculated results

Parameter	Value	Unit
Latent heat	1,511.9	kJ/kg
Critical heat flux in the tube (Macbeth)	7,684.4	kW/m²
Critical heat flux in pool boiling (Mostinski)	3,850.9	kW/m²
Allowable tube heat flux after the reduction	5,379.0	kW/m²

Notes for this case

- Laboratory correlations: real boilers allow 20–30 % less (roughness, water quality, deposits); boiler makers use their own DNB data. Macbeth here is Ganapathy's simplified form.

Formula and method

$$q_c = 0.00633 \times 10^6 \, h_{fg} \, d_i^{-0.1} \left(\frac{G}{10^6}\right)^{0.51} (1 - x) \quad (\mathrm{Btu/(ft^2\,h)};\ h_{fg}\ \mathrm{Btu/lb},\ d_i\ \mathrm{in},\ G\ \mathrm{lb/(ft^2\,h)})$$

$$q_c = 803\, p_c \left(\frac{p}{p_c}\right)^{0.35} \left(1 - \frac{p}{p_c}\right)^{0.9} \quad (p\ \mathrm{psia}), \qquad q_{allow} = q_{c,Macbeth}(1 - m)$$

Variables

p	Pressure (absolute)	Pa
d_i	Tube inside diameter	m
G	Mass velocity inside the tube	kg/(m²·s)
x	Steam quality	-
m	Design reduction from the correlation	-
h_{fg}	Latent heat	J/kg
$q_{c,Macbeth}$	Critical heat flux in the tube (Macbeth)	W/m²
$q_{c,Mostinski}$	Critical heat flux in pool boiling (Mostinski)	W/m²
q_{allow}	Allowable tube heat flux after the reduction	W/m²

Method and standards

Macbeth and Mostinski correlations (US units, converted).

Assumptions and limits

- Water; subcritical. The data range of the Macbeth correlation is not checked: at high mass velocity and low quality it can give very high values, so use the maker's DNB data for design.

- Unit conversions: 1 Btu/(ft²·h) = 3.154591 W/m², 1 Btu/lb = 2326 J/kg, 1 in = 0.0254 m, 1 lb/(ft²·h) = 1.356230 × 10^{-3} kg/(m²·s), 1 psi = 6894.757 Pa.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1994)
- Q4.47a (Macbeth correlation) and Q4.47b (Mostinski, pool boiling); IAPWS-IF97 latent heat

Report details

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Release checks	2 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/critical-heat-flux-macbeth-mostinski

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.