Flashing Flow of Saturated Water (Homogeneous Equilibrium Model)

Critical (choked) mass flux and flow of saturated water flashing through an orifice or blowdown valve by the homogeneous equilibrium model (isentropic, IF97).

Method: Homogeneous equilibrium model: G = max √(2(h₀ − h(p, s₀)))/v(p, s₀) along the isentrope (Collier and Thome, Convective Boiling and Condensation, 3rd ed., Oxford, 1994); properties from IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream pressure, saturated water (absolute)	46.000	bar
Back pressure (absolute)	1.0132	bar
Orifice or valve throat diameter	20.000	mm
Discharge coefficient	0.80000	

Calculated results

Parameter	Value	Unit
Throat pressure at maximum flux	37.491	bar
Mass flux	19,844	kg/(m²·s)
Mass flow	17.955	t/h
Steam quality at the throat	3.3521	%

Notes for this case

• HEM assumes thermal and mechanical equilibrium; short orifices pass more than HEM predicts because flashing lags. A conservative low estimate for long valves and pipes.

Formula and method

$$G = \max_{p} \frac{\sqrt{2[h_0 - h(p, s_0)]}}{v(p, s_0)}, \quad \dot{m} = C_d G \frac{\pi d^2}{4}$$

Variables

p_0	Upstream pressure, saturated water (absolute)	Pa
p_b	Back pressure (absolute)	Pa
d	Orifice or valve throat diameter	m
C_d	Discharge coefficient	-
p_c	Throat pressure at maximum flux	Pa
G	Mass flux	kg/(m²·s)
$\dot{m}$	Mass flow	kg/s
x_c	Steam quality at the throat	-

Method and standards

Homogeneous equilibrium model: the saturated water expands isentropically and the mass flux is maximised over the throat pressure between the back pressure and the upstream pressure (coarse scan, then golden-section search). If the maximum would lie below the back pressure the flow is not choked and the throat is at the back pressure.

Assumptions and limits

- Saturated water upstream; equilibrium flashing. Subcooled water (for example downstream of a cooler) cannot be entered; it flows more.
- Upstream velocity neglected.

References

• Homogeneous equilibrium model: G = max √(2(h₀ − h(p, s₀)))/v(p, s₀) along the isentrope (Collier and Thome, Convective Boiling and Condensation, 3rd ed., Oxford, 1994); properties from IAPWS-IF97

Report details

Report reference	FCC-VTGY-N3B5 (the same inputs always give the same reference)
Generated	17 November 2026, 19:36 UTC
Calculator	Flashing Flow of Saturated Water (Homogeneous Equilibrium Model)
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/boilers-power-plant/steam/flashing-flow-hem

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Reopens the calculator with the inputs of this report.