Steam Nozzle Exit Velocity, Critical Pressure and Areas

Exit velocity of steam from a nozzle from the enthalpy drop, the critical (choked) pressure and throat mass flux found on the IF97 isentrope, and throat and exit areas for a flow.

Method: IAPWS-IF97 (water and steam); Isentropic nozzle flow (textbook)

Input parameters

Unit system: SI

Parameter	Value	Unit
Inlet pressure (absolute)	10.000	bar
Inlet steam	Superheated at the temperature below	
Inlet temperature (superheated)	250.00	°C
Exit pressure (absolute)	2.0000	bar
Nozzle efficiency	95.000	%
Approach velocity	0	m/s
Steam flow	3,600.0	kg/h

Calculated results

Parameter	Value	Unit
Isentropic enthalpy drop to the exit	315.75	kJ/kg
Actual enthalpy drop η Δh_s	299.96	kJ/kg
Exit velocity √(2 Δh + V_1^2)	774.54	m/s
Critical (throat) pressure	5.4468	bar
Critical pressure ratio	0.54468	
Throat velocity	513.59	m/s
Throat area for the flow	722.35	mm²
Exit area for the flow	1,110.9	mm²
Dryness at the exit (1 when superheated)	97.139	%

Notes for this case

- The exit pressure is below the critical pressure: the nozzle must be convergent–divergent.
- The expansion enters the wet region: equilibrium expansion on the IF97 isentrope is assumed; real nozzles supersaturate and pass slightly more flow.

Formula and method

$$V_2 = \sqrt{2\,\eta_n\,\Delta h_s + V_1^2} = 44.72\sqrt{\eta_n\,\Delta h_s\ [\mathrm{kJ/kg}]}\quad (V_1 = 0)$$

$$G = \rho\sqrt{2(h_0 - h)}\ \text{ on }\ s = s_1,\quad p_c : G = G_{max}$$

$$A_t = \frac{\dot{m}\,v_t}{V_t},\quad A_2 = \frac{\dot{m}\,v_2}{V_2}$$

Variables

p_1	Inlet pressure (absolute)	Pa
inlet	Inlet steam	-

T_1	Inlet temperature (superheated)	K
p_2	Exit pressure (absolute)	Pa
η_n	Nozzle efficiency	-
V_1	Approach velocity	m/s
$\dot{m}$	Steam flow	kg/s
Δh_s	Isentropic enthalpy drop to the exit	J/kg
Δh	Actual enthalpy drop η Δh_s	J/kg
V_2	Exit velocity √(2 Δh + V₁²)	m/s
p_c	Critical (throat) pressure	Pa
p_c/p_1	Critical pressure ratio	-
V_t	Throat velocity	m/s
A_t	Throat area for the flow	m²
A_2	Exit area for the flow	m²
x_2	Dryness at the exit (1 when superheated)	-

Method and standards

Steady adiabatic flow: kinetic energy gained equals enthalpy lost. The critical (choked) pressure is where the mass flux on the IF97 isentrope is greatest.

Assumptions and limits

- Equilibrium expansion; supersaturation not modelled.
- Nozzle efficiency applied to the whole drop. For a convergent nozzle (exit above the critical pressure) the throat is the exit, so the throat values equal the exit values at the actual state.
- With an approach velocity the flux uses the stagnation enthalpy h_0, while the critical pressure ratio is referred to the static inlet pressure, not the stagnation pressure used in some textbooks.
- The critical pressure is searched between 0.2 and 0.999 p_1; a result at the edge is flagged.

References

IAPWS-IF97 (water and steam), Isentropic nozzle flow (textbook)

Report details

Report reference	FCC-K9R5-ZY41 (the same inputs always give the same reference)
Generated	23 November 2026, 17:43 UTC
Calculator	Steam Nozzle Exit Velocity, Critical Pressure and Areas
Method last reviewed	12 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/boilers-power-plant/steam-turbines/steam-nozzle-velocity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.