Choked (Critical) Gas Flow Through an Orifice or Leak

Mass flow of a gas through an orifice, nozzle or leak when choked (sonic), from the upstream pressure and temperature, area, discharge coefficient and γ.

Method: Isentropic nozzle at sonic throat: ṁ = C_d A p₀ √(γ/(R T₀)) (2/(γ+1))^((γ+1)/(2(γ−1)))

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream pressure (absolute)	7.0000	bar
Upstream temperature	20.000	°C
Orifice diameter	3.0000	mm
Discharge coefficient	0.62000	
Ratio of specific heats	1.4000	
Molar mass	28.960	kg/kmol
Downstream pressure (absolute)	1.0132	bar

Calculated results

Parameter	Value	Unit
Critical pressure ratio	0.52828	
Mass flow (choked, or subsonic when not choked)	26.066	kg/h
Free air or gas at 0 °C, 101.325 kPa	20.174	Nm³/h

Notes for this case

- Ideal gas with constant γ: for steam near saturation, or gases at high pressure, the real-gas flow differs by a few per cent.

Formula and method

$$\dot{m} = C_d A p_0 \sqrt{\frac{2\gamma}{(\gamma-1)RT_0}\left[\left(\frac{p_b}{p_0}\right)^{2/\gamma} - \left(\frac{p_b}{p_0}\right)^{(\gamma+1)/\gamma}\right]} \quad \left(\frac{p_b}{p_0} > \frac{p^*}{p_0}\right)$$

$$\dot{m} = C_d A p_0 \sqrt{\frac{\gamma}{RT_0}}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}}, \quad \frac{p^*}{p_0} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

Variables

p_0	Upstream pressure (absolute)	Pa
T_0	Upstream temperature	K
d	Orifice diameter	m
C_d	Discharge coefficient	-
γ	Ratio of specific heats	-
M	Molar mass	kg/kmol
p_b	Downstream pressure (absolute)	Pa
p^*/p_0	Critical pressure ratio	-
$\dot{m}$	Mass flow (choked)	kg/s
Q_N	Free air or gas at 0 °C, 101.325 kPa	Nm³/s

Method and standards

Sonic flow at the throat.

Assumptions and limits

- Ideal gas, isentropic to the throat, constant γ; steam near saturation and high-pressure gases deviate by a few per cent.
- When not choked the subsonic isentropic nozzle flow is shown.

References

- Isentropic nozzle at sonic throat: $\dot{m} = C_d A p_0 \sqrt{\gamma/(R T_0)} (2/(\gamma+1))^{((\gamma+1)/(2(\gamma-1)))}$

Report details

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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/fluid-mechanics/choked-flow-orifice

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.