Air Compressor Power (Isothermal and Adiabatic)

Shaft power of an air or gas compressor from free air delivery and pressure ratio, by isothermal and multi-stage adiabatic compression, with specific power.

Method: Thermodynamics of ideal-gas compression (isothermal and isentropic)

Input parameters

Unit system: SI

Parameter	Value	Unit
Inlet volume flow at p_1 and T_1 (free air delivery for an air compressor)	20.000	m³/min
Inlet pressure (absolute)	1.0132	bar
Discharge pressure	7.0000	bar g
Isentropic exponent 1.4 for air; about 1.3 for natural gas and CO_2.	1.4000	
Number of stages	2 stages, intercooled	
Isentropic efficiency (shaft basis)	80.000	%

Calculated results

Parameter	Value	Unit
Shaft power	101.57	kW
Ideal adiabatic power	81.257	kW
Isothermal power	69.844	kW
Isothermal efficiency	68.764	%
Pressure ratio per stage	2.8122	
Specific power (kW per m³/min of FAD)	5.0785	

Formula and method

$$r_s = \left(\frac{p_2}{p_1}\right)^{1/z} \qquad P_{is} = z\,\frac{k}{k-1}\,p_1\dot{V}_1\left(r_s^{(k-1)/k}-1\right) \qquad P_{sh} = \frac{P_{is}}{\eta_{is}}$$

$$P_{iso} = p_1\dot{V}_1\ln\frac{p_2}{p_1} \qquad \eta_{iso} = \frac{P_{iso}}{P_{sh}} \qquad SP = \frac{P_{sh}}{\dot{V}_1}$$

Variables

$\dot{V}_1$	Inlet volume flow at p_1 and T_1 (free air delivery for an air compressor)	m³/s
p_1	inlet pressure	Pa
p_2	discharge pressure	Pa
k	isentropic exponent	–
z	number of stages	–
η_{is}	isentropic efficiency (shaft)	–
P_{sh}	shaft power	W
P_{is}	ideal adiabatic power	W
P_{iso}	isothermal power	W
η_{iso}	isothermal efficiency	–
r_s	pressure ratio per stage	–

SP	specific power	kW per m³/min

Method and standards

Ideal-gas compression with equal pressure ratios per stage and perfect intercooling to inlet temperature; shaft power from the isentropic efficiency.

Assumptions and limits

- Ideal gas; equal stage ratios; perfect intercooling; motor and drive losses not included.
- $\dot{V}_1$ is the volume flow at the inlet pressure and temperature (for an air compressor, its free air delivery to ISO 1217).
- A discharge pressure entered as gauge is converted with the standard atmosphere; when p_1 is not 1.01325 bar enter it as absolute (a note appears).

References

- Thermodynamics of ideal-gas compression (isothermal and isentropic)

Report details

Report reference	FCC-PJ07-6K5V (the same inputs always give the same reference)
Generated	17 November 2026, 19:44 UTC
Calculator	Air Compressor Power (Isothermal and Adiabatic)
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 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/compressors/compressor-power

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.