Compressor Specific Power, Isothermal Efficiency and Air Cost

Specific power, isothermal and adiabatic efficiency and cost per m³ of free air of an air compressor from measured delivery, pressure and input power.

Method: Ideal isothermal and staged isentropic compression of air (definitions)

Input parameters

Unit system: SI

Parameter	Value	Unit
Measured free air delivery (at suction conditions, ISO 1217)	10.000	m³/min
Suction pressure (absolute)	101.33	kPa
Discharge pressure (absolute)	8.0000	bar
Suction temperature	30.000	°C
Measured electrical input	65.000	kW
Number of compression stages	2.0000	
Ratio of specific heats 1.4 for air; other gases from their data.	1.4000	
Electricity cost per kWh (currency)	8.0000	

Calculated results

Parameter	Value	Unit
Specific power (kW per m³/min)	6.5000	
Isothermal power	34.894	kW
Isothermal efficiency	53.684	%
Adiabatic efficiency (N stages, equal ratios)	62.447	%
Cost per m³ of free air	0.86667	

Notes for this case

- Efficiencies are package (wire-to-air) values including motor and drive. Good screw and centrifugal plants at 7 bar(g) run about 6–7 kW per m³/min.

Formula and method

$$SP = \frac{P_{in}}{\dot{V}_{FAD}}, \quad P_{iso} = p_1 \dot{V}_{FAD} \ln\frac{p_2}{p_1}, \quad P_{ad} = N\frac{\gamma}{\gamma-1} p_1 \dot{V}_{FAD}\left[\left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma N}} - 1\right]$$

Variables

$\dot{V}_{FAD}$	Measured free air delivery (at suction conditions, ISO 1217)	m³/s
γ	Ratio of specific heats	-
p_1	Suction pressure (absolute)	Pa
p_2	Discharge pressure (absolute)	Pa
T_1	Suction temperature	K
P_{in}	Measured electrical input	W
N	Number of compression stages	-
c_e	Electricity cost per kWh (currency)	-
SP	Specific power (kW per m³/min)	-

P_{iso}	Isothermal power	W
η_{iso}	Isothermal efficiency	-
η_{ad}	Adiabatic efficiency (N stages, equal ratios)	-
c_{air}	Cost per m³ of free air	-

Method and standards

Ideal compression work.

Assumptions and limits

- Ideal gas; equal stage ratios; a whole number of stages.
- Free air delivery at the suction pressure and temperature (ISO 1217), so $p_1\dot{V} = \dot{m}RT_1$ and the suction temperature cancels out of the ideal powers.

References

- Ideal isothermal and staged isentropic compression of air (definitions)

Report details

Report reference	FCC-0CNW-EHPW (the same inputs always give the same reference)
Generated	17 November 2026, 19:44 UTC
Calculator	Compressor Specific Power, Isothermal Efficiency and Air Cost
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/mechanical/compressors/compressor-specific-power-efficiency

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Reopens the calculator with the inputs of this report.