

BCAS Factsheet FCT601-1

Isentropic efficiency



What is isentropic efficiency?

Isentropic efficiency is a measure of how closely a real (actual) thermodynamic process, like compression, approaches the ideal, isentropic (reversible and adiabatic) process.

It is one of two measures of compressor performance. The other is specific power, see BCAS Factsheet FCT600-1 (Specific power). To understand the differences between isentropic efficiency and specific power see BCAS Factsheet FCT602-1 (Difference between isentropic efficiency and specific power).

Definition

For a compressor, isentropic efficiency (η_s) is defined as:

$$\eta_s = \text{Isentropic work input} / \text{actual work input}$$

In terms of temperatures this can be expressed as:

$$\eta_s = (T_{\text{out,ideal}} - T_{\text{in}}) / (T_{\text{out,actual}} - T_{\text{in}})$$

- T_{in} = Inlet temperature (K)
- $T_{\text{out,ideal}}$ = Outlet temperature for an ideal / isentropic compression
- $T_{\text{out,actual}}$ = Actual outlet temperature measured during the test

Where: $T_{\text{out,ideal}} = T_{\text{in}} \times (P_{\text{out}}/P_{\text{in}})^{\gamma-1/\gamma}$

- γ = Specific heat ratio (1.4 for air)
- P_{in} , P_{out} = inlet and outlet pressure (Pa or bar)

Units: Dimensionless, often represented as %

How is isentropic efficiency used?

It is a measure of the efficiency of the compression process

- A perfect (isentropic) compressor has $\eta_s = 100\%$
- A real compressor always has $\eta_s < 100\%$ because of friction, heat loss, turbulence, and mechanical losses

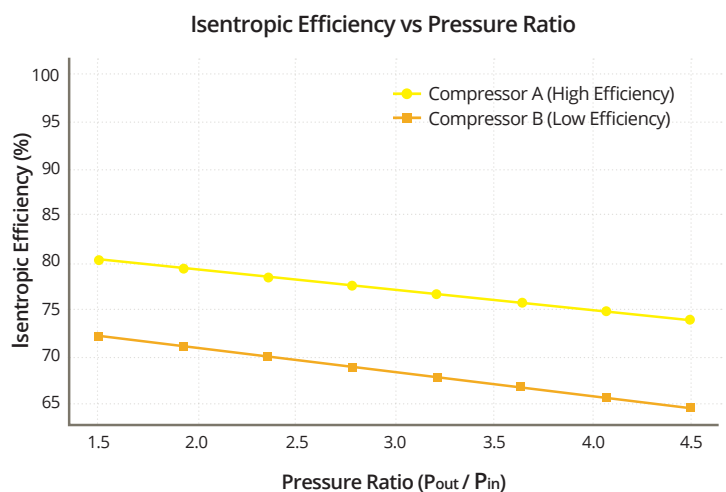
Typical η_s values

Compressor Type	Isentropic efficiency range
Centrifugal	70-85%
Screw	68-80%
Scroll	70-90%
Rotary vane	50-75%
Reciprocating	60-90%

Illustration

Isentropic efficiency quantifies how much more energy the real compressor uses compared to an ideal one. The closer to 1 (or 100%), the more efficient the compressor.

Here is a comparison of two compressors. This plot illustrates how real compressors become less efficient at higher pressure ratios due to increased thermal and mechanical losses.



- **Compressor A** starts at ~80% efficiency and drops slightly as the pressure ratio increases.
- **Compressor B** starts lower (~72%) and declines more sharply.