Peng–Robinson Equation of State: Z and Density

Compressibility factor and density of a pure component by the Peng–Robinson equation of state from critical constants and acentric factor, vapour and liquid roots.

Method: Peng and Robinson (1976); A new two-constant equation of state; …

Input parameters

Unit system: SI

Parameter	Value	Unit
Temperature	26.850	°C
Pressure (absolute)	50.000	bar
Critical temperature	-82.590	°C
Critical pressure	45.990	bar
Acentric factor	0.011000	
Molar mass	16.043	kg/kmol

Calculated results

Parameter	Value	Unit
Largest root (vapour-like)	0.90177	
Smallest root (liquid-like)	0.90177	
Density at the largest root	35.662	kg/m³
Density at the smallest root	35.662	kg/m³

Notes for this case

- One real root: a single phase (or supercritical); both outputs show it.

Formula and method

$$p = \frac{RT}{v-b} - \frac{a\alpha}{v^2+2bv-b^2}, \quad Z^3 + (B-1)Z^2 + (A-3B^2-2B)Z + (B^3+B^2-AB) = 0$$

Variables

T	Temperature	K
p	Pressure (absolute)	Pa
T_c	Critical temperature	K
p_c	Critical pressure	Pa
ω	Acentric factor	-
M	Molar mass	kg/kmol
Z_v	Largest root (vapour-like)	-
Z_l	Smallest root (liquid-like)	-
ρ_v	Density at the largest root	kg/m³
ρ_l	Density at the smallest root	kg/m³

Method and standards

Peng–Robinson cubic.

Assumptions and limits

- Pure component.
- With three roots the page compares the Peng–Robinson fugacity coefficients of the largest and smallest roots, ln φ = Z − 1 − ln(Z − B) − A/(2√2 B) ln[(Z + (1 + √2)B)/(Z + (1 − √2)B)], and names the stable phase.

References

- Peng and Robinson (1976)
- A new two-constant equation of state
- Ind. Eng. Chem. Fundam. 15(1); $a = 0.45724\ R^2T_c^2/p_c\ \alpha$
- $b = 0.07780\ RT_c/p_c$
- $\kappa = 0.37464 + 1.54226\omega - 0.26992\omega^2$

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/chemical/gas-mixtures/peng-robinson-z

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Reopens the calculator with the inputs of this report.