Joule–Thomson Temperature Change on Throttling (Peng–Robinson)

Temperature after throttling a real gas at constant enthalpy using the Peng–Robinson departure function and ideal-gas heat capacity, with the JT coefficient.

Method: Isenthalpic expansion with Peng–Robinson enthalpy departure (Perry's Chemical Engineers' Handbook, 9th ed. (McGraw-Hill, 2019), sec. 2 and 4)

Input parameters

Unit system: SI

Parameter	Value	Unit
Upstream temperature	26.850	°C
Upstream pressure (absolute)	70.000	bar
Downstream pressure (absolute)	10.000	bar
Critical temperature	-82.590	°C
Critical pressure	45.990	bar
Acentric factor	0.011400	
Ideal-gas heat capacity (J/(mol·K)) Per mole: multiply a value in J/(kg·K) by the molar mass in kg/mol.	35.700	

Calculated results

Parameter	Value	Unit
Downstream temperature	-2.3657	°C
Temperature change	-29.216	K
Mean Joule–Thomson coefficient (K/bar)	0.48693	

Notes for this case

• Vapour-root Peng–Robinson with constant ideal-gas C_p°; do not use if the throttled stream condenses. Natural gas cools about 0.4–0.5 K per bar near ambient.

Formula and method

$$h(T_1,p_1)=h(T_2,p_2),\quad h-h^{ig}=RT(Z-1)+\frac{T\,da/dT-a}{2\sqrt{2}\,b}\ln\frac{Z+(1+\sqrt{2})B}{Z+(1-\sqrt{2})B}$$

Variables

T_1	Upstream temperature	K
p_1	Upstream pressure	Pa
p_2	Downstream pressure	Pa
T_c	Critical temperature	K
p_c	Critical pressure	Pa
ω	Acentric factor	-
C_p°	Ideal-gas heat capacity (J/(mol·K))	-
T_2	Downstream temperature	K
ΔT	Temperature change	K
μ_{JT}	Mean Joule–Thomson coefficient (K/bar)	-

Method and standards

Peng–Robinson departure function.

Assumptions and limits

- Pure gas; vapour root; constant C_p°, per mole in J/(mol·K). Pressures are absolute.
- The vapour root is taken from the analytic solution of the cubic. The calculation stops if the downstream temperature falls outside 0.3–1.2 times the upstream temperature, if the enthalpy balance does not close, or if the liquid is the stable phase downstream (condensation).

References

• Isenthalpic expansion with Peng–Robinson enthalpy departure (Perry's Chemical Engineers' Handbook, 9th ed. (McGraw-Hill, 2019), sec. 2 and 4)

Report details

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This calculator online

https://calc.firecad.com/chemical/physical-properties/joule-thomson-throttling

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