Energy of a Pressure Vessel Burst (Brode, Isentropic, Isothermal)

Energy released when a gas-filled vessel bursts, by Brode's equation, isentropic and isothermal expansion and thermodynamic availability, and its TNT equivalent.

Method: Crowl and Louvar; Chemical Process Safety: Fundamentals with Applications; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Gas volume in the vessel	1.0000	m³
Burst pressure (absolute)	3,447.4	kPa
Ambient pressure	101.33	kPa
Heat capacity ratio of the gas	1.4000	

Calculated results

Parameter	Value	Unit
Brode's equation	8,365.1	kJ
Isentropic expansion	5,472.3	kJ
Isothermal expansion	12,159	kJ
Thermodynamic availability	8,813.0	kJ
TNT equivalent of Brode's energy	1.7851	kg

Notes for this case

- Ideal gas at ambient temperature. Brode is thought best for near-field blast and isentropic expansion for the far field; part of the energy goes into fragments, so about half is often used for blast effects. Liquids store far less energy; a vessel that bursts with liquid above its boiling point can BLEVE.
- A screening estimate for training and early design, not a hazard or risk study.

Formula and method

$$E_{Brode} = \frac{(P_2 - P_1)V}{\gamma - 1}, \quad E_{isentropic} = \frac{P_2 V}{\gamma - 1}\left[1 - \left(\frac{P_1}{P_2}\right)^{(\gamma-1)/\gamma}\right]$$

$$E_{isothermal} = P_2 V \ln\frac{P_2}{P_1}, \quad E_{avail} = P_2 V\left[\ln\frac{P_2}{P_1} - \left(1 - \frac{P_1}{P_2}\right)\right]$$

Variables

V	Gas volume in the vessel	m³
P_2	Burst pressure (absolute)	Pa
P_1	Ambient pressure	Pa
γ	Heat capacity ratio of the gas	-
E_{Brode}	Brode's equation	J
$E_{isentropic}$	Isentropic expansion	J
$E_{isothermal}$	Isothermal expansion	J
E_{avail}	Thermodynamic availability	J
m_{TNT}	TNT equivalent of Brode's energy	kg

Method and standards

Energy of explosion for a compressed ideal gas by the four methods given by Crowl and Louvar; TNT equivalent at 4,686 kJ/kg.

Assumptions and limits

- Ideal gas; ambient temperature.

References

- Crowl and Louvar
- Chemical Process Safety: Fundamentals with Applications
- 2nd ed. (Prentice Hall, 2002)
- ch. 6
- eqs. 6-28 to 6-31 (Brode; Crowl, thermodynamic availability)

Report details

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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/chemical/process-safety/pressure-vessel-burst-energy

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Reopens the calculator with the inputs of this report.