Flammability Limits: Estimate and Effect of Temperature and Pressure

Lower and upper flammability limits of a CxHyOz fuel from stoichiometry (Jones), and the shift of the limits with temperature and of the upper limit with pressure.

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

Input parameters

Unit system: SI

Parameter	Value	Unit
Carbon atoms in the fuel molecule	3.0000	
Hydrogen atoms	8.0000	
Oxygen atoms	0	
Net heat of combustion (for the temperature effect)	2,043.5	kJ/mol
Temperature	100.00	°C
Pressure (absolute)	2,000.0	kPa

Calculated results

Parameter	Value	Unit
Stoichiometric fuel concentration in air	4.0217	%
Lower flammability limit at 25 °C, 1 atm	2.2119	%
Upper flammability limit at 25 °C, 1 atm	14.076	%
LFL at temperature T	2.0968	%
UFL at temperature T	14.191	%
UFL at pressure P (25 °C)	40.877	%

Notes for this case

- Jones' stoichiometric estimate (LFL = 0.55 C_st, UFL = 3.5 C_st) suits hydrocarbon vapours; measured limits are always better. The temperature and pressure formulas are approximate and hold only over limited ranges; the LFL changes little with pressure.
- A screening estimate for training and early design, not a hazard or risk study.

Formula and method

$$C_{st} = \frac{100}{1 + 4.773z}, \quad z = m + \frac{x}{4} - \frac{y}{2}, \quad LFL = 0.55 C_{st}, \quad UFL = 3.50 C_{st}$$

$$LFL_T = LFL_{25} - \frac{0.75}{\Delta H_c}(T - 25), \quad UFL_T = UFL_{25} + \frac{0.75}{\Delta H_c}(T - 25), \quad UFL_P = UFL + 20.6(\log P + 1)$$

Variables

m	Carbon atoms in the fuel molecule	-
x	Hydrogen atoms	-
y	Oxygen atoms	-
ΔH_c	Net heat of combustion (for the temperature effect)	J/mol
T	Temperature	K
P	Pressure (absolute)	Pa
C_{st}	Stoichiometric fuel concentration in air	-
LFL	Lower flammability limit at 25 °C, 1 atm	-
UFL	Upper flammability limit at 25 °C, 1 atm	-

LFL_T	LFL at temperature T	-
UFL_T	UFL at temperature T	-
UFL_P	UFL at pressure P (25 °C)	-

Method and standards

Jones' correlation with the stoichiometric concentration; temperature effect from Zabetakis (ΔH_c in kcal/mol, T in °C, limits in volume %); UFL with pressure in MPa absolute.

Assumptions and limits

- Hydrocarbon vapours; approximate.

References

- Crowl and Louvar
- Chemical Process Safety: Fundamentals with Applications
- 2nd ed. (Prentice Hall, 2002)
- ch. 6
- eqs. 6-4 to 6-11 (Jones; Zabetakis)

Report details

Report reference	FCC-HJ8T-STPA (the same inputs always give the same reference)
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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/flammability-limits-estimate

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Reopens the calculator with the inputs of this report.