Ammonia as a Hydrogen Carrier: Mass, Volume and Cracking Heat

Ammonia needed to deliver hydrogen after cracking, the heat to crack it, liquid storage volume and the share of the hydrogen energy used for cracking.

Method: Ammonia decomposition stoichiometry and enthalpy

Input parameters

Unit system: SI

Parameter	Value	Unit
Hydrogen to deliver	1,000.0	t
Cracking conversion and recovery	98.000	%
Liquid ammonia density (682 kg/m³ at −33 °C)	682.00	kg/m³
Liquid hydrogen density for comparison (70.8 kg/m³)	70.800	kg/m³

Calculated results

Parameter	Value	Unit
Ammonia needed	5,746.9	t
Hydrogen mass fraction of ammonia	17.756	%
Heat of cracking (25 °C reaction enthalpy)	15,488	GJ
Cracking heat as a share of the hydrogen LHV	12.912	%
Liquid ammonia volume	8,426.5	m³
Liquid hydrogen volume for the same hydrogen	14,124	m³

Notes for this case

• $2NH_3 \rightarrow N_2 + 3H_2$, ΔH = +45.9 kJ per mol NH_3 (NIST-JANAF) at 25 °C; the cracker also needs heat to warm the gas to 500–900 °C, partly recovered. Ammonia stores about 1.5 times more hydrogen per litre than liquid hydrogen and is liquid at −33 °C or 8.6 bar.

Formula and method

$$2NH_3 \rightarrow N_2 + 3H_2, \quad m_{NH_3} = \frac{m_{H_2}}{1.5X}\frac{M_{NH_3}}{M_{H_2}}, \quad Q = -\Delta_f H_{NH_3} n_{NH_3}$$

Variables

m_{H_2}	Hydrogen to deliver	kg
X	Cracking conversion and recovery	-
ρ_{NH_3}	Liquid ammonia density (682 kg/m³ at −33 °C)	kg/m³
ρ_{LH_2}	Liquid hydrogen density for comparison (70.8 kg/m³)	kg/m³
m_{NH_3}	Ammonia needed	kg
w_{H_2}	Hydrogen mass fraction of ammonia	-
Q_{crack}	Heat of cracking (25 °C reaction enthalpy)	J
Q/E_{H_2}	Cracking heat as a share of the hydrogen LHV	-
V_{NH_3}	Liquid ammonia volume	m³
V_{LH_2}	Liquid hydrogen volume for the same hydrogen	m³

Method and standards

Hydrogen carrier comparison.

Assumptions and limits

- Reaction enthalpy at 25 °C; liquid densities at storage conditions.

References

Ammonia decomposition stoichiometry and enthalpy

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/environmental/hydrogen-fuel-cells/ammonia-hydrogen-carrier

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Reopens the calculator with the inputs of this report.