

Table 8.10 Properties relevant to safety for hydrogen and two other commonly used gaseous fuels

	Hydrogen	Methane	Propane
Density, kg.m^{-3} at NTP	0.084	0.65	2.01
Ignition limits in air, volume% at NTP	4.0 to 77	4.4 to 16.5	1.7 to 10.9
Ignition temperature, $^{\circ}\text{C}$	560	540	487
Min. ignition energy in air, MJ	0.02	0.3	0.26
Max. combustion rate in air, m s^{-1}	3.46	0.43	0.47
Detonation limits in air, volume%	18 to 59	6.3 to 14	1.1 to 1.3
Stoichiometric ratio in air	29.5	9.5	4.0

Table 8.11 Comparative data for two cylinders used to store hydrogen at high pressure. The first is a conventional steel cylinder and the second a larger composite tank for use on a hydrogen-powered bus

	2 L steel, 200 bar	147 L composite, 300 bar
Mass of empty cylinder	3.0 kg	100 kg
Mass of hydrogen stored	0.036 kg	3.1 kg
Storage efficiency (% mass H ₂)	1.2%	3.1%
Specific energy	0.47 kWh kg ⁻¹	1.2 kWh kg ⁻¹
Volume of tank (approx.)	2.2 L (0.0022 m ³)	220 L (0.22 m ³)
Mass of H ₂ per litre	0.016 kg L ⁻¹	0.014 kg L ⁻¹

Table 8.12 Details of a cryogenic hydrogen container suitable for cars

Mass of empty container	51.5 kg
Mass of hydrogen stored	8.5 kg
Storage efficiency (% mass H ₂)	14.2%
Specific energy	5.57 kWh kg ⁻¹
Volume of tank (approx.)	0.2 m ³
Mass of H ₂ per litre	0.0425 kg L ⁻¹

Table 8.15 Data for comparing methods of storing hydrogen fuel

Method	Gravimetric storage efficiency, % mass hydrogen	Volumetric mass (in kg) of hydrogen per litre
Pressurised gas	0.7–3.0	0.015
Reversible metal hydride	0.65	0.028
Cryogenic liquid	14.2	0.040

Table 8.17 Speculative data for a hydrogen source, storing 40 L (32 kg) of methanol

Mass of reformer and tank	64 kg
Mass of hydrogen stored ^a	4.4 kg
Storage efficiency (% mass H ₂)	6.9%
Specific energy	5.5 kWh kg ⁻¹
Volume of tank + reformer	0.08 m ³
Mass of H ₂ per litre	0.055 kg L ⁻¹

^aAssuming 75% conversion of available H₂ to usable H₂.

Table 8.20 Data for comparing methods of storing hydrogen fuel. The figures include the associated equipment, for example, tanks for liquid hydrogen, or reformers for methanol

Method	Gravimetric storage efficiency, % mass H ₂	Volumetric mass (in kg) of H ₂ per litre	Comments
High pressure in cylinders	0.7–3.0	0.015	'Cheap and cheerful' widely used
Metal hydride	0.65	0.028	Suitable for small systems
Cryogenic liquid	14.2	0.040	Widely used for bulk storage.
Methanol	6.9	0.055	Low-cost chemical. Potentially useful in a wide range of systems
Sodium hydride pellets	2.2	0.02	Problem of disposing of spent solution.
NaBH ₄ solution in water	3.35	0.036	Very expensive to run.