

1. COMPARISON OF PROPERTIES OF AMMONIA, PROPANE, METHANE & H2 FUELS

PROPERTIES	UNITS	AMMONIA* NH ₃	PROPANE C ₃ H ₈	METHANE CH ₄	HYDROGEN H ₂
Molecular weight in	g/mol	17.031	44.096	16.042	2.016
Liquid density in	kg/m ³ (lb/gal)	682 (5.02)	509 (4.24)	415(3.46)	67.8 (0.565)
Solubility in water in	weight %	1 @ 25°C	2 @20°C	3 @2°C	0.0016@20°C
Boiling temp. in	°C (°F)	-33.4 (-28.1)	-42 (-43.6)	-161.6 (-259)	-252.9(-423)
Critical temp. in	°C (°F)	132.3 (270)	96.6 (206)	-82.7 (-107)	-240.2(-400)
Critical pressure in	bar (psia)	113 (1639)	42.5 (109)	45.96 (666)	12.93 (187)
Vapor pressure at 25°C (77°F) in bar (psia)		10.0 (145)	10.0 (145)		1 @ 20 K
37.8 °C (100 °F) in bar (psia)			12.2 (177)	345 (5000)	
50°C (122°F) in bar (psia)		21.3 (308)	18 (261)		
Heat of vaporization in	kJ/kg	1374	425.31	510	448
Lower heating value in	kWh/kg	5.27	11.1	13.95	33.36
	Btu/(liq.gal)	46500	78988	74736	444597
	Btu/lb	8171	18600	21600	251197
Higher heating value in	kWh/kg	6.23	12.9	15.27	39.42
	Btu/(liq.gal)	55000	91690	81829	525360
(EPA Threshold Quantities (TQ)) \ \	Btu/lb	9666	21591	23650	296828
TQ w/o CA Risk Management Plan in	lb	58,000			10,000
Conc. in 25°C air, compl. combust.	in vol.%	22	4.0	9.5	29.5
Flash temp.	°C (°F)	11 (51.8)	-104 (-155)	-188 (-306)	-253(-423)
Auto-ignition temperature in	°C (°F)	651 (1204)	470,540(1004)	595 (1103)	585(1085)
Flammability (LEL to HEL) in air in	vol %	15 to 28	2.1 to 9.5	4 to 15	4 to 75
Maximum flame velocity in	cm/s	6.3***	41	39	300
Octane number	--	120 - 180	110	122RON,135MON	130 -140
Toxicity: IDLH, 30 min exposure in	vol ppm	300	2100**	4000**	40,000
OSHA 8-hour exp. limit in	vol ppm	25	1000		
Odor limit in	vol ppm	5	>10000	odorless	odorless
Consumption --					
US consumption in1999 in	million tons/y	19.34	41.55		~15
US propane vehicles in use	number		190,000		
US retail price in 2009 in	\$/gal (\$/10 ⁶ Btu)	1.71-2.85	2.20 (24)	0.82 (10) [nat.gas]	
	\$/ton(Kona)	4667	1038	474	

Ammonia --

- Is the second most produced chemical in the world: 109 million tons (38 bill.gal) per year in 2004
- Was mixed with city gas and used during World War II to power buses in Belgium
- Was used to fuel a 1981 Chevrolet Impala after a Canadian company made the needed conversion adjustments. In 2007 U of Michigan demonstrated an [NH3-fueled pick-up truck](#).
- NASA's X-15 set speed and altitude records burning ammonia
- Is used as a household cleaning solution, as a 5-10 weight % aqueous solution
- Is used and is effective as an antimicrobial agent for animal feed
- Is currently used commercially to reduce or cut microbial contam. in beef processing
- Reduces NOx emissions and ozone formation via Selective Catalytic Reduction (SCR) in ~100 GW worth of coal-fired power plants in the US
- Storage: 1) Liquid anhydrous NH₃, 2) Aq. solution, or 3) Solid urea H₂N-CO-NH₂. Urea solubility in water is 108 g/100 cm³

* http://en.wikipedia.org/wiki/Ammonia#cite_note-19, <http://en.wikipedia.org/wiki/Propane>

** non-toxic asphixiant but new IDHL was set at 10% of LEL

*** <http://www.galcit.caltech.edu/EDL/publications/reprints/flimits.pdf>

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