MariNH$_3$

Clean, green ammonia
engines for maritime

NH_3 Storage

28th June 2023

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H_2 vs NH_3

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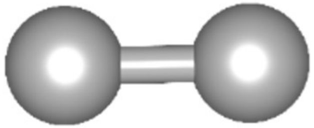

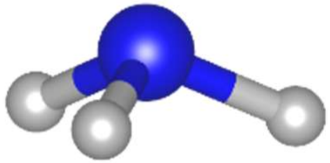

Nature of Molecule	Very light, non-polar	Polar, basic
Boiling Point	-252.9 °C	-33.3 °C
Storage within materials	Weak sorption if H-H bond intact, strong sorption if bond broken	Reasonable sorption when NH_3 molecule left intact

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Pure NH_3 Storage

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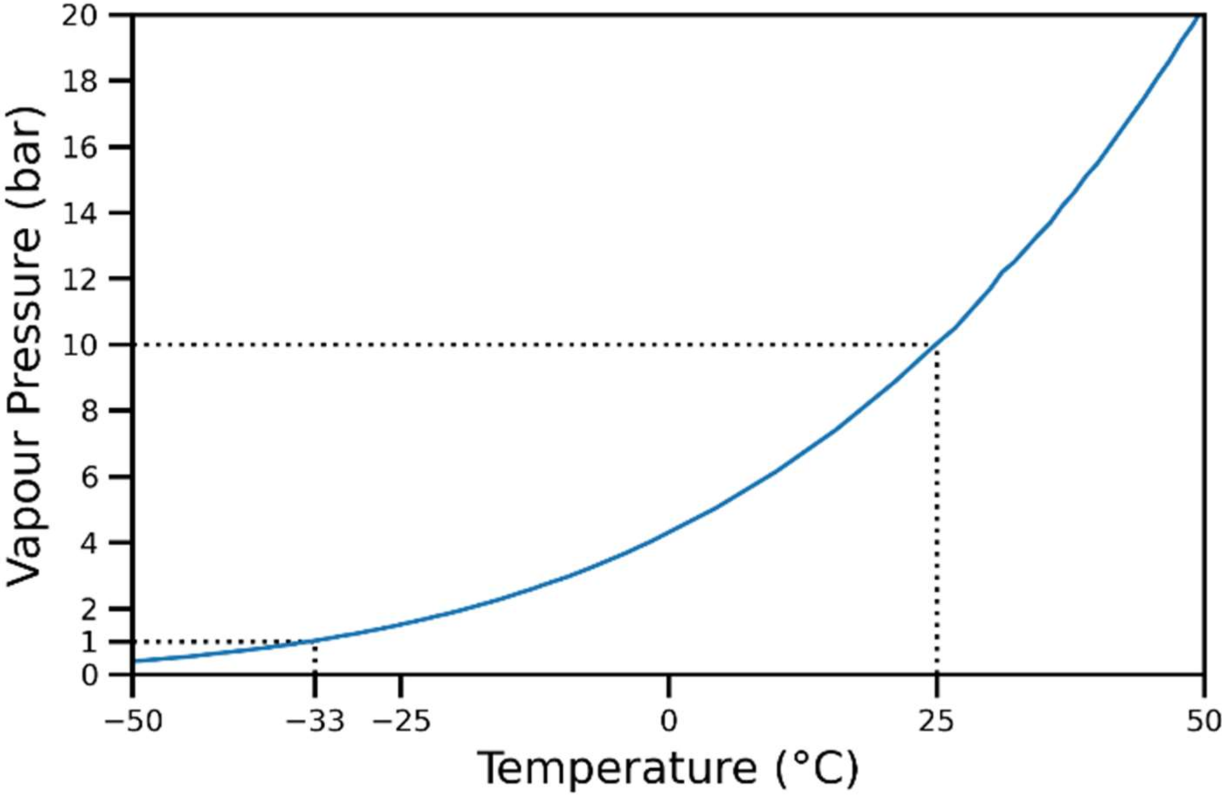

Refrigerated storage

Pressurised storage

Semi-refrigerated storage

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Pressurised NH_3 Storage

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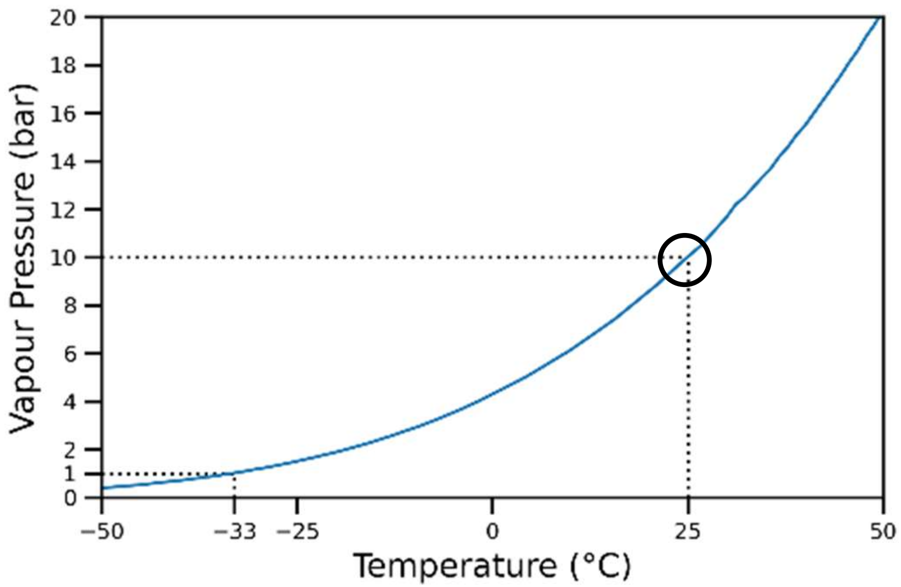

Pressurised NH_3 Storage tank

Design pressure: 21.6 bar
Design temperature: 50 °C

Capacity: 50 tons

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Refrigerated NH_3 Storage

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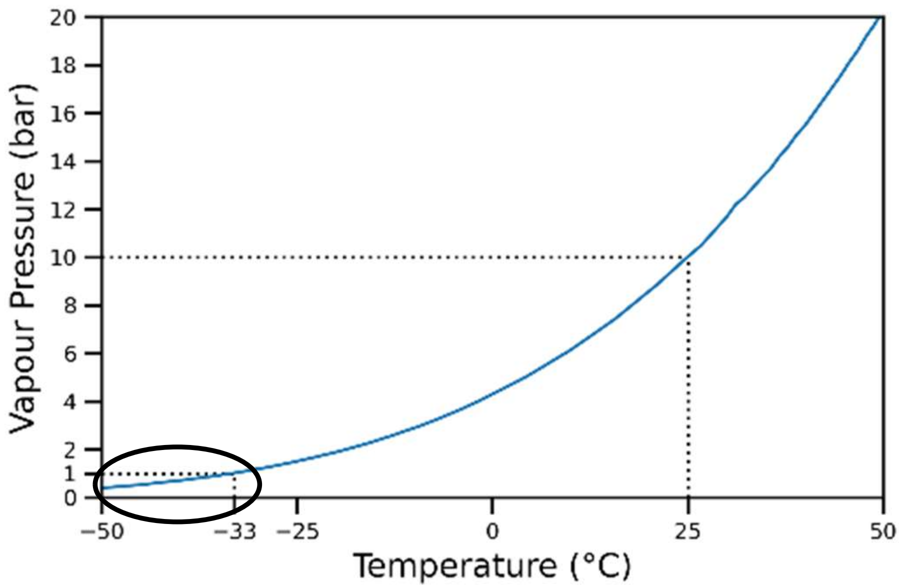

Refrigerated NH_3 storage tank

Capacity: 10,000 tons

Double-walled to allow for effective insulation

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Semi-Refrigerated NH_3 Storage

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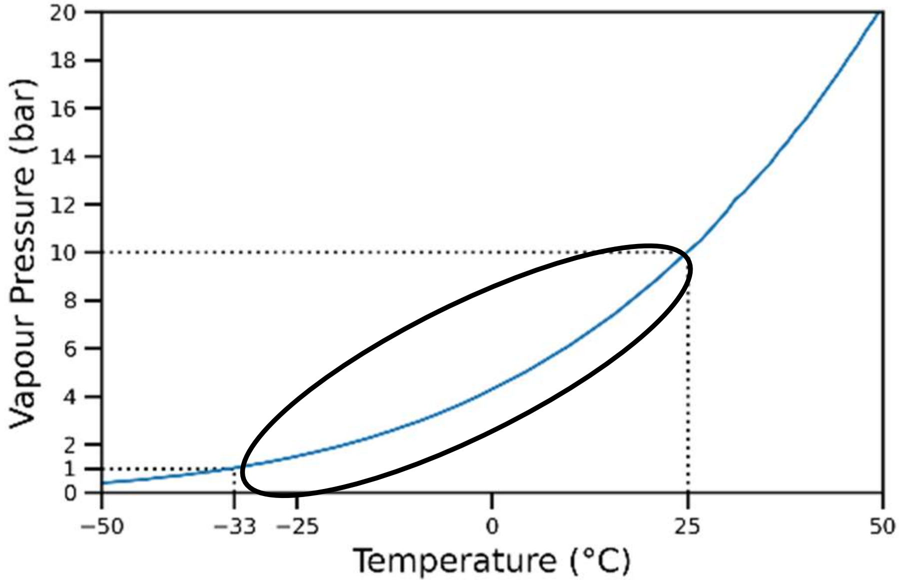

Intermediate pressures and temperatures

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Safety Implications of NH_3

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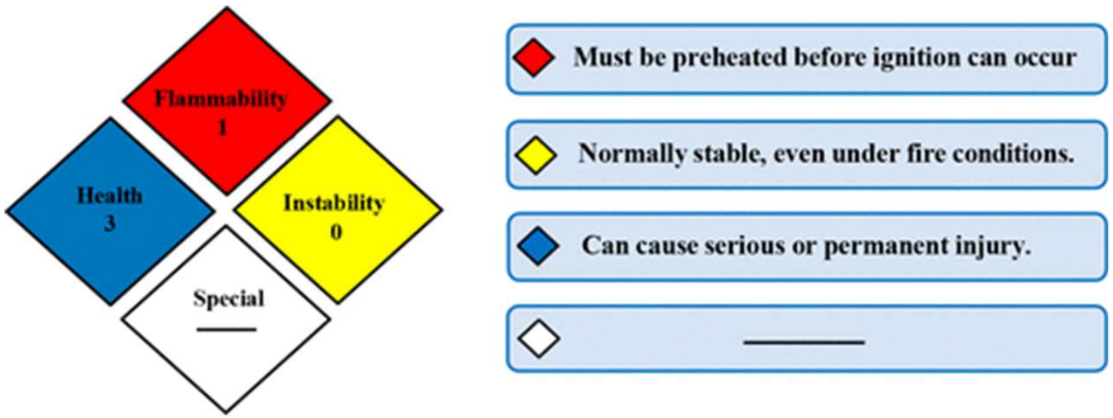

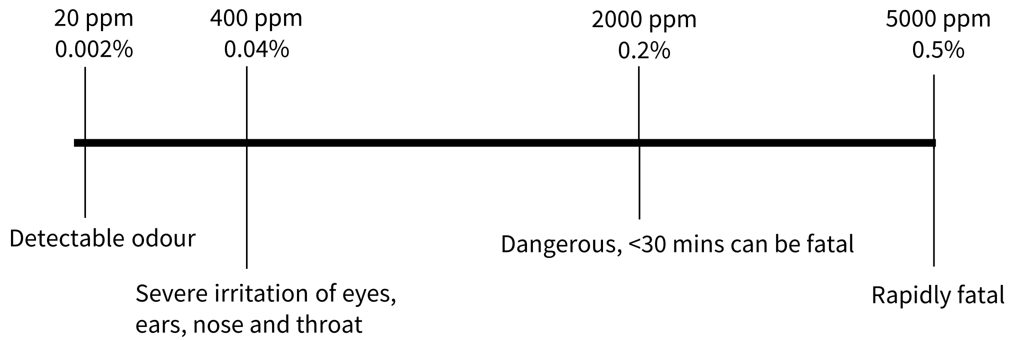

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Dynamics of Pressurised NH_3 Leakage

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0 seconds

5 seconds

20 seconds

60 seconds

Jack Rabbit Tests

1 ton pressurised ammonia spill

Density of air: 1.29 kg/m³

Density of ammonia: 0.73 kg/m³

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Temperature of Ammonia-Air Mixtures

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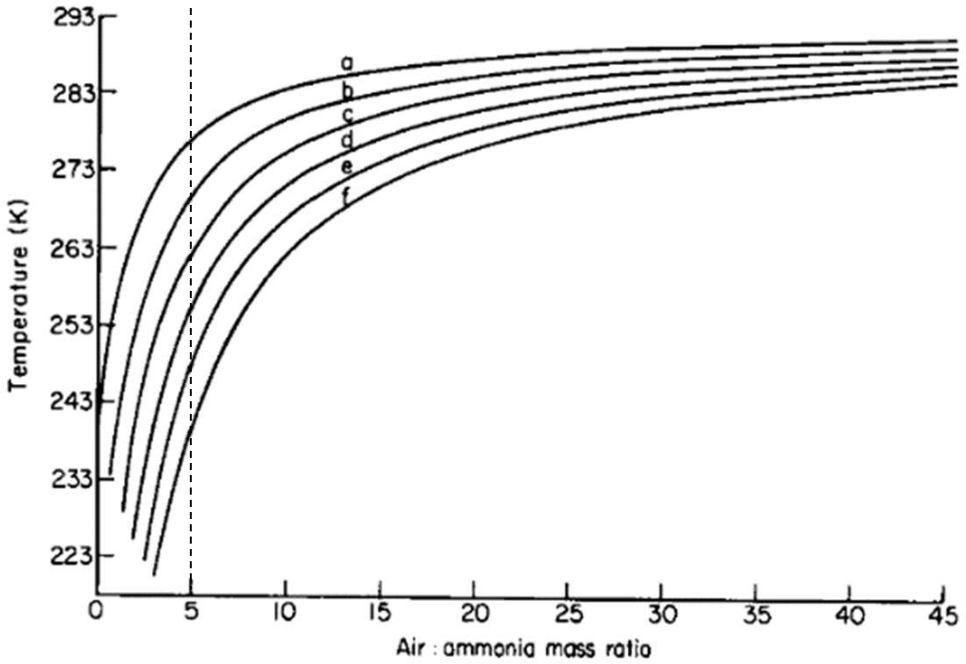

Aerosolised ammonia fraction (%)	Temperature at 5:1 air:ammonia ratio (°C)
a: 0%	3
b: 4%	-4
c: 8%	-11
d: 12%	-18
e: 16%	-25
f: 20%	-33

When more than ~8% of ammonia is expelled as an aerosolised liquid, the density of ammonia-air mixtures will initially be greater than air.

Dynamics of Pressurised NH_3 Leakage

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May 1976

Houston, Texas

Tanker truck carrying 7,000 gallons (~20 tons) of pressurised ammonia crashes through a freeway barrier and falls to the ground, exploding on impact.

This photo is taken around a minute after the crash.

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Refrigerated vs Pressurised NH_3 Leakages

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Refrigerated	Pressurised
Slow mixing of ammonia gas with atmosphere.	Rapid release and expansion of ammonia gas into the atmosphere.
Slow evaporation of liquid due to limited thermal energy.	Vigorous boiling of liquid due to greater thermal energy. Concurrent aerosolization due to vigorous boiling.
Ammonia-air mixtures released are closer to room temperature, removing possible cold burn issues. They are also lighter than air, leading to faster dispersion.	Ammonia-air mixtures released can reach super cold temperatures due to aerosol evaporation, leading to hazardous cold burns and dense mixtures which settle on the ground and disperse slowly.

Much better safety outcomes for refrigerated ammonia leakages

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Refrigerated vs Pressurised

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Refrigerated	Pressurised
Better safety outcomes	Worse safety outcomes
Requires active cooling – More expensive for long term storage	No energy use during storage
Suitable for larger capacities, into the thousands of tons range	Generally used for less than 300 ton tanks for safety reasons
More common in modern day for safety reasons	Less common

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