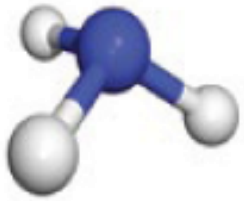
Issues affecting safety risks with ammonia storage, transport and distribution

John Mott

Ammonia Safety and Training Institute (ASTI)

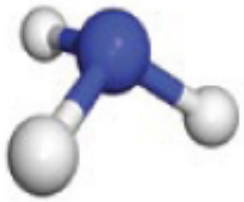


ASTI is a non-profit training organization based in California

The ASTI mission is to make ammonia the safest handled industrial chemical in the world

ASTI have trained many thousands of people on four continents over the last 30+ years

Most of the trainees are emergency responders, regulators and industry people



https://ammonia-safety.com

Safety with Ammonia

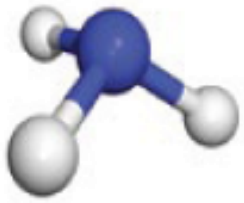
Ammonia has a very pungent odour

Toxic in high concentrations - IDLH 300 ppm

Self Alarming - will drive you away at 1/10 of the level that can harm you

Very difficult to ignite ammonia-air mixtures in open air

Narrow flammability range of 15% LFL to 28% UFL



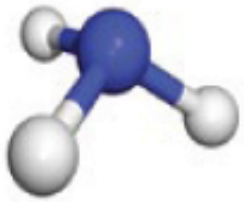
Acute Exposure Guideline Levels

	10 min	30 min	60 min	4 hr	8 hr
AEGL 1	30	30	30	30	30
AEGL 2	220	220	160	110	110
AEGL 3	2,700	1,600	1,100	550	390

AEGL 1 Minor Exposure Low Exposure

AEGL 2 Moderate Exposure

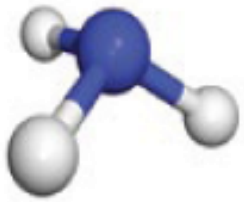
AEGL 3 Acute Exposure



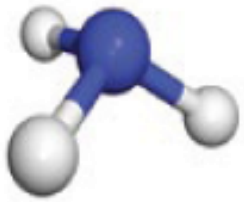
Indoors / Outdoors

Refrigeration industry uses Ammonia in enclosed spaces and this raises the hazard and risk profile.

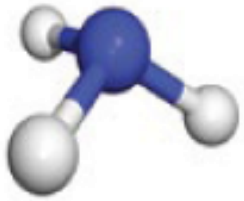
Other industries use Ammonia outdoors.
Almost impossible to ignite
Very few injuries are experienced



Storage at atmospheric pressure compared with storage under pressure



Release under pressure results in an aerosol and potentially a dense gas cloud which can be heavier than air.

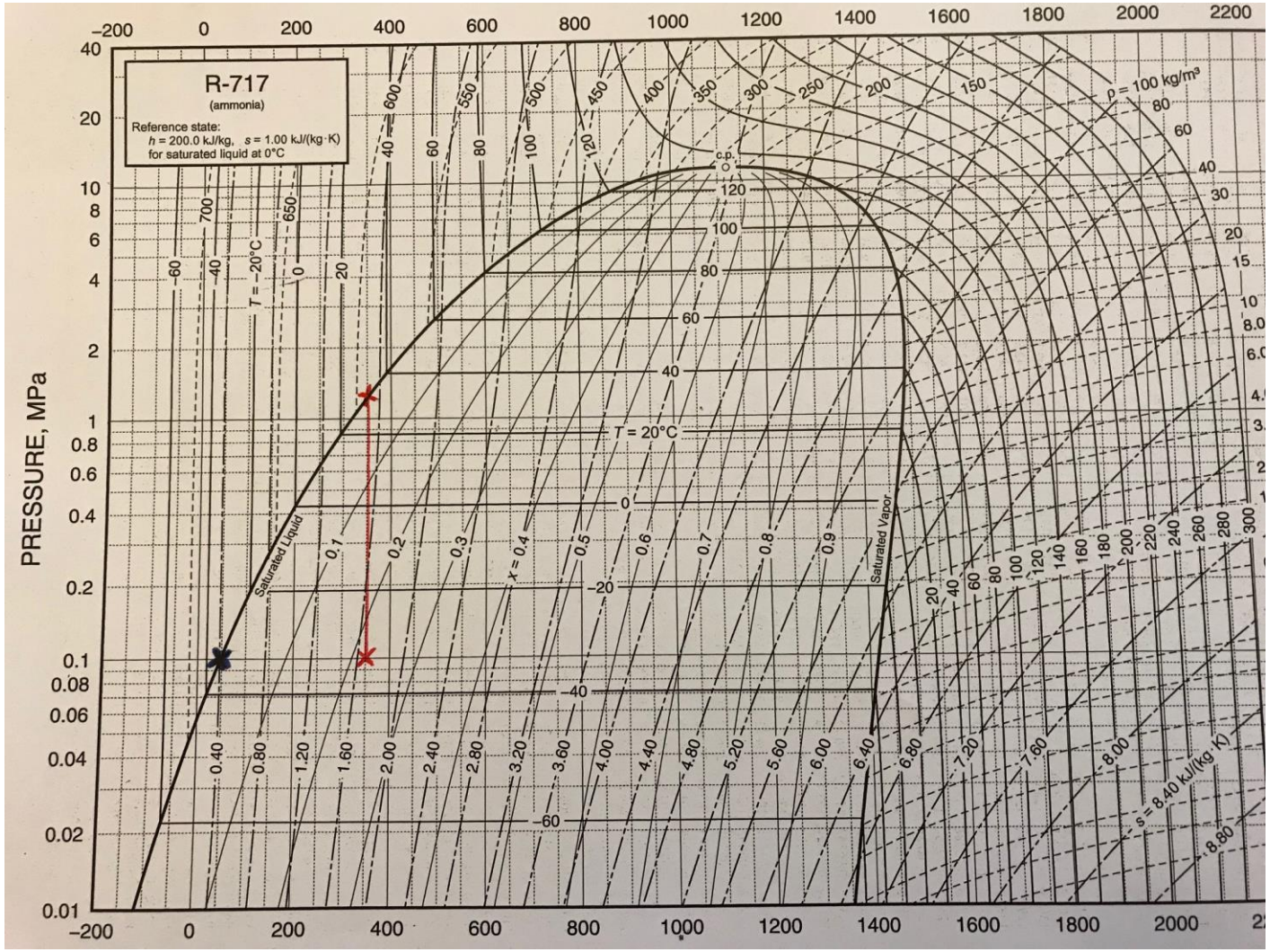


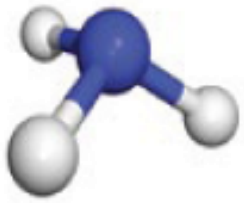
Rail Transport

Barge

Road Transport

Nurse Tanks


R-717
(ammonia)
Reference state:
h = 200.0 kJ/kg, s = 1.00 kJ/(kg·K)
for saturated liquid at 0°C
PRESSURE, MPa
Saturated Liquid
Saturated Vapor
C.P.
T = 20°C
T = −20°C
x = 0.4
ρ = 100 kg/m³
s = 8.40 kJ/(kg·K)



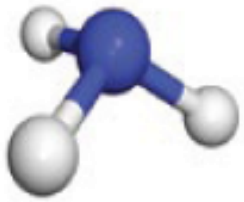
Release of saturated liquid under pressure

The Pressure reduction at the point of release is vertically down the red line to atmospheric pressure and arrives at a dryness fraction of 0.22

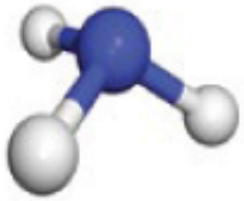
This means that 22% of the mass flow will instantaneously turn to flash gas at the point of release

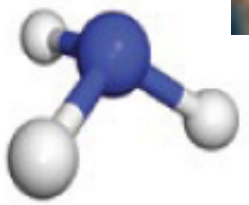
The volume ratio of liquid to gas at atmospheric pressure and -33C is a factor of 766

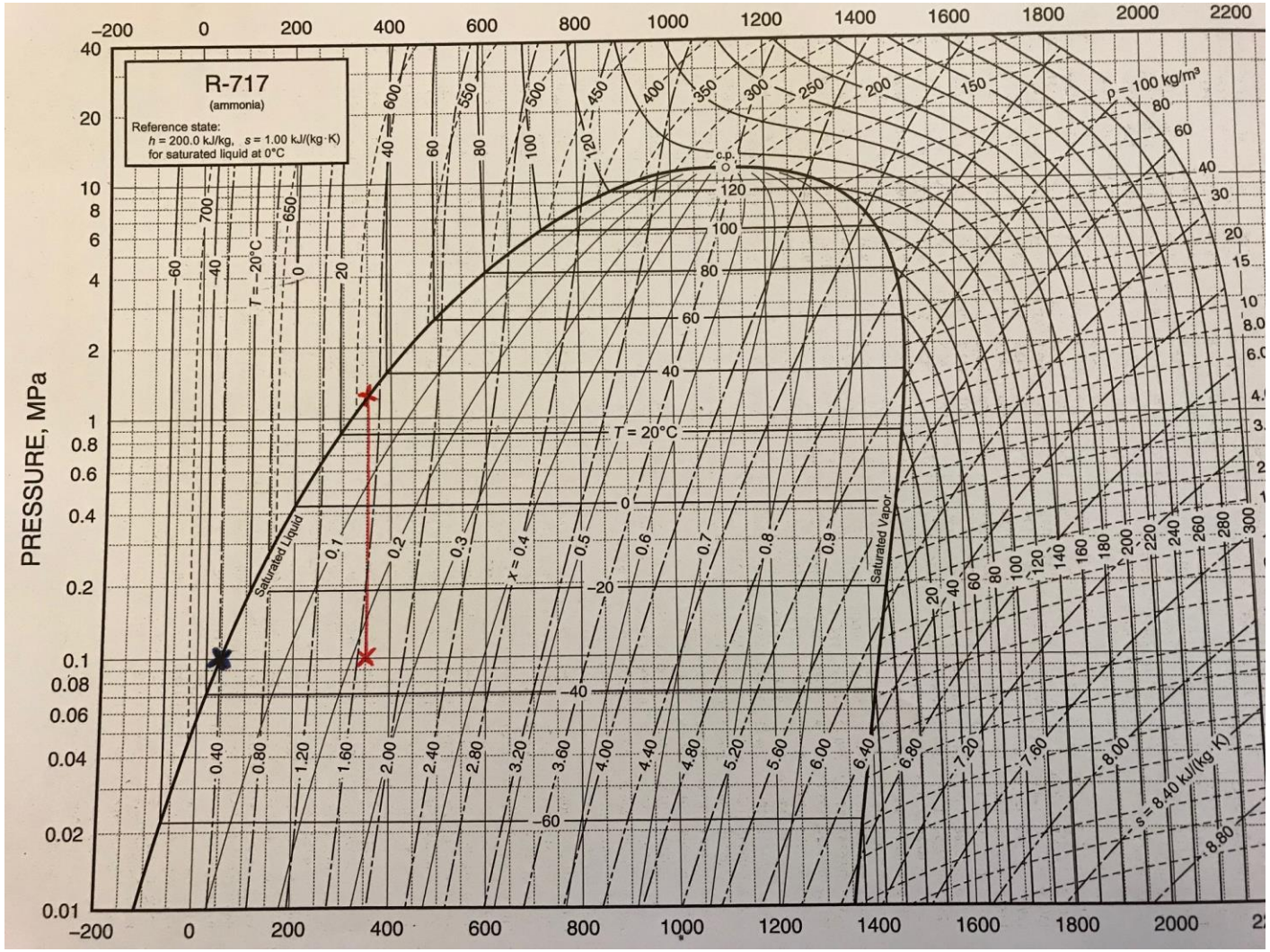
Therefore 1 litre/sec of liquid releasing will generate 168 litre/sec of flash gas which will violently propel an aerosol and then becomes a dense gas cloud which will be heavier than air.



Release from storage at atmospheric pressure usually results in a clear pure gas, which is lighter than air and quickly disappears into the sky.



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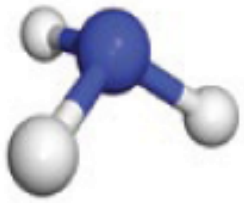


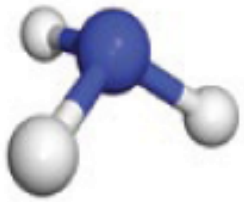
Release of saturated liquid at atmospheric pressure

It will run out a bit like water

A little bit of vapour may be visible whisping from the surface of the pool

The amount of gas evaporating from the surface will be a function of the quantity of heat entering the pool from the surface below and the air above. Ammonia has a very high latent heat of evaporation , so the rate at which the ammonia evaporates will be very low.

Spraying water onto the pool will increase the evaporation rate and even cause a gas cloud which may be heavier than air so this should not be done.

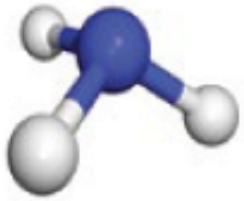


The majority of the gas evaporating from the pool will be invisible pure gas which is about 60% of the density of air and will quickly rise into the atmosphere. There will be no aerosol or dense gas cloud.

Conclusions :

The highest risk and hazard profile will be from a pressurized saturated ammonia liquid release in an enclosed space

The lowest risk and hazard profile will be from an atmospheric pressure storage of saturated liquid ammonia in an outdoor area



ASTI Vision for the Future

Continue to build contribution to the Refrigeration Industry

Ramp up involvement with the Fertilizer and Storage Terminal sectors

Engage with the ammonia maritime sector in research and review of safety systems

Assist in the promotion of ammonia as a safe fuel and energy carrier in many sectors including use as a Maritime Bunker Fuel.