Safe handling of Ammonia as Refrigerant

Anders Lindborg
Ammonia Partnership AB
Sweden
AMMONIA - AS NATURAL AS WATER
The Education is "For Your Own Safety"

Do You want to know more? Ask questions
Physical Properties of Ammonia-I
(at 1.103 bar)

Melting temperature: -77.7°C
Boiling temperature: -33.4°C
Latent heat: 1.370 kJ/kg
Density liquid at -33.4°C: 0.682 kg/dm³
Density gas at 0°C: 0.771 kg/m³
Relative gas-density to dry air: 0.6
Physical Properties of Ammonia-II

- Ignition temperature: 651°C
- Thermal disintegration: over 450°C
- Dangerous disintegration: Hydrogen
- Flammable concentration in air, only confined space: 15%-28% by volume
Physical Properties of Ammonia-III

<table>
<thead>
<tr>
<th>Dangerous reaction</th>
<th>Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous reaction</td>
<td>Water to ammonia liquid</td>
</tr>
<tr>
<td>Other dangers</td>
<td>Attacks copper and zinc as well as their alloys</td>
</tr>
<tr>
<td>Solubility in mineral oils</td>
<td>None</td>
</tr>
</tbody>
</table>
Material state and related risk

- Great risk
- Boiling point
- Moderate risk
- Melting point
- Small risk
Dr Mark Mc Linden
Study for NASA 1988

860 chemicals were studied
• Application
• Liquid/gas physical properties
• Thermophysical properties
• Stability
• Toxicity
• Flammability
• Compatibility to materials, gaskets, oils....
• Price
Ammonia

— was considered the best and most appropriate followed by:

— Propane R 290, methylamine R 630, isobutane, R 152 a, R 22, Halon 1301 or R 13 B1, R 12 and R 11.

— The investigation shows that the better chemicals are simple molecules.

— It is not likely that there are other chemicals with
  • better refrigeration performance.
  • lower manufacturing costs.
  • better toxicity and flammability properties.
  • lower or no global environmental influence, ODP and GWP.
Solutions

- **Simple / natural**
  Basic elements such as water, air, ammonia, carbon dioxide and hydro carbons

- **Complicated / synthetic**
  Chemistry
“The Natural fives”

O$_2$, N$_2$, ... Air
H$_2$O Water
NH$_3$ Ammonia
CO$_2$ Carbon Dioxide
C$_3$H$_8$ Propane
and other HCs
REFRIGERATION PLANTS ARE NOT:

- Large scale storage: 5-50,000 tons
- Transport:
  - Road truckers: 1-25 ton
  - Railway cars: 60 ton
  - Ships: 5,000-50,000 ton

Process Industry
REFRIGERATION PLANTS ARE NOT
FARMING AND FERTILIZERS WHERE MOST NATURAL AND MANMADE AMMONIA IS USED
Ammonia Liquid Release

- Liquid Tank
- Jet
- Aerosol
- Heavy gas
- Gaussian dispersion, Light gas
- Transition
THE MAIN CONCERN ABOUT AMMONIA

1. General fear for environmental damage
2. Fear that vapours will harm people
3. Commercial interest from the chemical industri
4. Ignorance among own supporters
5. .... toxicity and risk of fire
Per Year in the World

- All ammonia in nature: 1-3 Billion tons
- Produced by Man: 140 Million tons
- Ammonia used as refrigerant: ca 0.5 Million tons
The smell alarms

Not dangerous even in unbearable concentration
High tolerance for the experienced
Create worries for the inexperienced
Putrefaction, stench, manure
Olfactory sense

- To find food
- To find a partner
- To define the belonging of a group
- Related to the memory of satisfaction
- Warning of danger
Ammonia gas exposure

4 — 20 ppm  Threshold, not dangerous
30 — 50 ppm  Characteristic, not dangerous
300 — 400 ppm Unpleasant, not dangerous
700 — 1000 ppm Damage after 30 min

Higher Concentration
Immediate injury
Latent Heat

Atmospheric Pressure

KL/Kg

100°C Water
-33°C Ammonia
-34°C Propane
-78°C Carbon Dioxide
-34°C Chlorine
23°C to -128°C "Freons"
Ammonia vapour leak

10-15% of content will go out - leak stops
Ammonia liquid leak

Content goes out to level of leak + 10% of the rest
# THE GASES LIGHTER THAN AIR

<table>
<thead>
<tr>
<th>Gas</th>
<th>Formula</th>
<th>Density Relative to Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>0.07</td>
</tr>
<tr>
<td>Helium</td>
<td>He</td>
<td>0.14</td>
</tr>
<tr>
<td>Methane</td>
<td>CH(_4)</td>
<td>0.55</td>
</tr>
<tr>
<td>Ammonia</td>
<td>NH(_3)</td>
<td>0.59</td>
</tr>
<tr>
<td>Hydrofluoric acid</td>
<td>HF</td>
<td>0.59</td>
</tr>
<tr>
<td>Neon</td>
<td>Ne</td>
<td>0.70</td>
</tr>
<tr>
<td>Acetylene</td>
<td>C(_2)H(_2)</td>
<td>0.91</td>
</tr>
<tr>
<td>Hydrocyanic acid</td>
<td>HCN</td>
<td>0.93</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N(_2)</td>
<td>0.97</td>
</tr>
<tr>
<td>Ethylene</td>
<td>C(_2)H(_4)</td>
<td>0.98</td>
</tr>
</tbody>
</table>
Emission

Ammonia evaporates and is dispersed upwards
Building with Ventilation

Fan

Air- Intake
Daily Ammonia Exposure

- Total Production by the Body: 17,000 mg
- Continuously Breathing 25 ppm: 379 mg
- Eating a 200g Steak: 13,000 mg
- Food Additives: 18 mg
- Drinking Water
  - City: 1.0 mg
  - Rural: 0.4 mg
- Normal Breathing
  - City: 0.4 mg
  - Rural: 0.1 mg
- Pack-a-Day Cigarette Smoking: 0.8 mg/dag
Gases dangerous to the health may enter the human body through

- the lungs, surface... 75 m²
- the skin, surface... 1.8 m²
# Ammonia Medical Aspects

<table>
<thead>
<tr>
<th>Respiration</th>
<th>Eyes</th>
<th>Skin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irritation</td>
<td>Tears</td>
<td>Irritation</td>
</tr>
<tr>
<td>Coughing</td>
<td>Lens</td>
<td>Burns</td>
</tr>
<tr>
<td>Lung tissues</td>
<td></td>
<td>Frostbite</td>
</tr>
<tr>
<td>Spasm of vocal cord</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

© 243
WATER WILL SAVE LIFE!
AMMONIA CONTAMINATED CLOTHES
NH$_3$ in atmospheric air

![Graph showing partial pressure vs. temperature for NH$_3$ in atmospheric air]
Medical aspects

1. Exposure – just smell, memory
2. Exposure – medical observation or treatment, no further damage.
5. Death.
Influence of ammonia on humans at different distances from a release.
Levels of Protection

- Escape hood
- Gas-mask, K-filter, Gloves, Overall
- Breathing apparatus, complete protective clothing, chemical suit, fire-mans suit
ANVÄNDNINGSOMRÅDE:

- I all verksamhet där gaser, ångor eller partiklar förekommer t.ex. i byggnadsindustri, verkstadsindustri eller kemisk industri.
- Vid utrymning av lokaler vid brand, mm.

Filtrerande halvmask

Halvmask
Leak detection, general purpose

Ammonia, “come here I am leaking, do something.

Carbon dioxide, “go away, I am dangerous.”

HFC, “go away, I am dangerous, come back with protection, come back and leak test.”
Ammonia Detection-I

1. As high alarm level as possible.
2. Hygienic exposure levels.
3. Protection of stored goods.
4. Protection against fire.
Ammonia Detection-II

1. Not below 50 ppm.
2. 25 - 50 ppm.
3. 80 - 120 ppm.
4. As high as possible, highest 30 000 ppm or 3 vol%.
Ammonia Detection-III

- Positioning of detectors.
- Calibration of detectors.
- Where is the alarm going?
- When is the alarm sent forward?
Where is the detector placed?
What setting of level is suitable?
Remember!

Always check escape routes and assembly-place.

In a calm way, warn and escape.

To inform management.

To check that the evacuation is made.