

AMMONIA

E.U. Classification:

T: toxic

N: dangerous for
the environment



UN N°: 1005

MARPOL classification: N/A

SEBC Classification: GD (gas, dissolver)



GRANDE PAROISSE



Cedre

AMMONIA

PRATICAL GUIDE

INFORMATION

DECISION-MAKING

RESPONSE

This document was drafted by *Cedre* (the Centre of Documentation, Research and Experimentation on Accidental Water Pollution) with financial support and technical guidance from Grande Paroisse.

The information contained within this guide is a result of *Cedre's* research and experience. *Cedre* cannot be held responsible for the consequences resulting from the use of this information.

Translated by Sally Ferguson
Published: December 2006

Purpose of this guide

As part of the research funded, Grande Paroisse and *Cedre* (the Centre of Documentation, Research and Experimentation on Accidental Water Pollution) have produced a series of response guides for chemical hazards. They can be used to assist in emergency response in the event of an incident involving a vessel carrying hazardous substances which may cause water pollution.

These guides are updates of the 61 "mini response guides" published by *Cedre* in the early 1990s.

These guides are designed to allow rapid access to the necessary initial information (see chapter entitled "First line emergency data"), in addition to providing relevant bibliographical sources to obtain further information.

They also contain the results of scenarios relating to incidents which have occurred in the Channel, the Mediterranean and in ports and rivers. These scenarios are only intended to provide response authorities with indications of what to do in an emergency. Each real incident should be analysed individually and the response authorities should not underestimate the importance of taking in-situ measurements (air, water, sediment and marine fauna) in order to determine exclusion areas. These guides are intended primarily for specialists who know about the techniques to use in the event of an emergency in addition to the relevant operational response measures.

The main concern is to mitigate the consequences of a spill, however we cannot afford to overlook responder safety and human toxicology.

To contact the duty engineer at *Cedre* (24/7)
Please call: + 33 (0)2 98 33 10 10

National toxicology surveillance system in the event of a major toxicological threat.

In France, a hotline is manned around the clock by Division 7 of the General Department of Health (SD7/DGS).

During opening hours please call:
Tel.: + 33 (0)1 40 56 47 95
Fax: + 33 (0)1 40 56 50 56

Outside normal working hours please call the relevant authority.

Poison Control Centres in France

Angers (Centre Hospitalier d'Angers) Tel.: + 33 (0)2 41 48 21 21
Bordeaux (Hôpital Pellegrin-Tripode) Tel.: + 33 (0)5 56 96 40 80
Grenoble (Hôpital Albert Michallon) Tel.: + 33 (0)4 76 76 56 46
Lille (Centre Hospitalier Universitaire) Tel.: + 33 (0)8 25 81 28 22
Lyon (Hôpital Edouard Herriot) Tel.: + 33 (0)4 72 11 69 11
Marseille (Hôpital Salvator) Tel.: + 33 (0)4 91 75 25 25
Nancy (Hôpital Central) Tel.: + 33 (0)3 83 32 36 36
Paris (Hôpital Fernand Widal) Tel.: + 33 (0)1 40 05 48 48
Reims (Hôpital Maison Blanche) Tel.: + 33 (0)3 26 78 48 21
Rennes (Hôpital de Pontchaillou) Tel.: + 33 (0)2 99 59 22 22
Rouen (Hôpital Charles Nicolle) Tel.: + 33 (0)2 35 88 44 00
Strasbourg (Hôpitaux Universitaires) Tel.: + 33 (0)3 88 37 37 37
Toulouse (Hôpital de Purpan) Tel.: + 33 (0)5 61 77 74 47

Contents

Purpose of this guide	4
A WHAT YOU NEED TO KNOW ABOUT AMMONIA	6
B FIRST LINE EMERGENCY DATA	7
B.1 - First aid information	8
B.2 - ID card	9
B.3 - Physical data	10
B.4 - Flammability data	11
B.5 - Toxicological data	12
B.6 - Ecotoxicological data	15
B.7 - Persistence in the environment	16
B.8 - Classification	17
B.9 - Particular risks	20
B.10 - Transportation, handling, storage	22
C RESULTS OF ACCIDENT SCENARIOS	23
C.1 - Reminder of chemical properties	24
C.2 - Accident scenarios	25
C.3 - Consumption scenarios	40
D RESPONSE	41
D.1 - Examples of ammonia spills	42
D.2 - Response recommendations	44
D.3 - Response techniques	45
D.4 - Choosing personal protective equipment (PPE)	47
D.5 - Measuring devices and waste treatment	49
E FURTHER INFORMATION	50
E.1 - Glossary	51
E.2 - Acronyms	55
E.3 - Useful websites	57
E.4 - Bibliography	58
E.5 - Photo sources	60
Annexes	61
Annex 1: summary and additional physical and toxicological data	62
Annex 2: fax format data card	66

What you need to know about ammonia

A

Definition

Ammonia is a colourless gas with a characteristic irritating and pungent odour. This gas is toxic for humans and the environment.

In certain conditions, it can form an explosive mixture with air. Burning of ammonia requires both high temperatures and a high energy input from the source of ignition.

At normal temperatures and pressures, ammonia is in the form of a gas, but it is generally stored and transported as a liquefied gas under its own saturation vapour pressure.

Use

The main uses of ammonia gas are in the refrigeration industry and in fertilisers, either by direct application or as a primary material in the production of fertilisers containing nitrogen such as urea, ammonium nitrate, ammonium sulphate or ammonium phosphate.

Its other less widespread uses are: the treatment of metals, leather production, the paste and paper industry, food and drinks, production of pharmaceutical products and fume treatment techniques (reduction of nitrogen oxides NO_x).

Risks

- Toxicity: ammonia vapours are highly toxic through inhalation or corrosive upon contact, and lead to irritation of the skin, eyes and respiratory tract. Direct contact with liquefied ammonia can cause frostbite, burns by corrosion and ocular lesions, in the worst case sce-

nario leading to blindness.

- Fire and explosion: when mixed with air, ammonia presents a risk of explosion in certain cases (in particular confinement).

This risk can generally be considered as low. It is difficult to ignite and a violent explosion is only possible in the case of confinement or if there is a high energy input. This explains why violent explosions which have been known to occur mainly concern refrigeration installations.

Ammonia breaks down from 450°C to form hydrogen, which is flammable, and nitrogen. This breakdown can occur at a lower temperature in the presence of metals such as iron.

Excessive pressure in the presence of high temperatures can lead to toxic, flammable gases being released.

Behaviour in the environment

When spilt in water, ammonia boils violently and partially evaporates; it dissolves rapidly in water to form a corrosive, alkaline, aqueous solution, ammonia water or ammonium hydroxide, with a pH greater than 11.

Ammonia is highly volatile (vapour pressure: 890 kPa at 20°C) and therefore gives off vapours as it is spilled. Its vapours are less dense than air ($d = 0.6$) and should therefore tend to rise. However, when ammonia is spilt in large quantities it can produce a cloud of whitish vapour, which behaves like a heavy gas and moves around just above the water surface or the ground.

First line emergency data

- First aid information _____ **B1**
- ID card _____ **B2**
- Physical data _____ **B3**
- Flammability data _____ **B4**
- Toxicological data _____ **B5**
- Ecotoxicological data _____ **B6**
- Persistence in the environment _____ **B7**
- Classification _____ **B8**
- Particular risks _____ **B9**
- Transportation, handling, storage _____ **B10**

B

First aid information

(CCHST, 1998; G.P. MSDS, 2005)

Use breathing apparatus when rescuing someone in danger.

Remove the source of contamination or move the subject away from the polluted area. Cover the victim. Clouds of ammonia vapours can impede visibility.

Intoxication by inhalation

- Move the victim into the open air and lie them down.
- Give the victim air or oxygen intermittently if they have difficulty breathing.
- Prop the person up to a half-sitting position.
- Apply artificial respiration if the victim has stopped breathing.
- Transfer to hospital immediately.

B1

Skin contact

- Remove clothing carefully, do not remove any clothing which is stuck to the skin.
- In the case of frostbite causing material to stick to the skin, defrost with lukewarm water.
- Rinse the affected parts immediately at length (at least 15 minutes) with a light flow of lukewarm water.
- Do not rub damaged skin.
- Consult a doctor.

Eye contact

- Immediately wash the eyes with plenty of water for at least 15 minutes, keeping the eyelids open.
- Rinse with a buffer solution containing phosphate.
- Consult an ophthalmologist.

Intoxication by ingestion

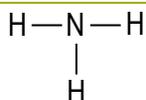
For gases, this type of intoxication is considered as an unlikely way of exposure.

ID card¹

Ammonia

Gross formula: NH_3

Developed formula:



Synonyms

Anhydrous ammonia

E.U. Classification

T: toxic

N: dangerous for the environment

R10: Flammable

R23: Toxic by inhalation

R34: Causes burns

R50: Very toxic to aquatic organisms

S1/2: Keep locked up and out of the reach of children

S9: Keep container in a well ventilated place

S16: Keep away from sources of ignition - no smoking

S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice

S36/37/39: Wear suitable protective clothing, gloves and eye/face protection

S45: In case of accident or if you feel unwell, seek medical advice immediately (show label where possible)

S61: Avoid release to the environment. Refer to special instructions/safety data sheet

CAS n°: 7664-41-7

EC N° (EINECS): 231-635-3

Index n°: 007-001-00-5

Classification for transportation

UN N°: 1005

Class: 2

¹ Additional data and sources in annex 1

Physical data

Conversion factor (air: 20° C): 1 ppm = 0.7 mg/m³
 1 mg/m³ = 1.14 ppm
 1 atm = 1.013×10⁵ Pa

B3

Molar mass	17.03 g/mol <small>INRS, 1997</small>					
Volumic mass at 0°C and at 101.3 kPa (1 atm)	0.77 g/L <small>G.P. MSDS, 2005</small>					
Melting point	-77.7°C <small>G.P. MSDS, 2005</small>					
Boiling point at atmospheric pressure	-33.3°C <small>INRS, 1997</small>					
Critical point at 11,480 kPa (0.11 atm)	132.4°C <small>INRS, 1997</small>					
pH of a 1% aqueous solution	11.7 <small>G.P. MSDS, 2005</small>					
Viscosity	10.225 mPa.s at -33°C <small>INERIS, 1999</small> 0.0092 mPa.s at 0°C <small>ENVIRONMENT CANADA,1985</small> 0.0098 mPa.s at 20°C <small>ENVIRONMENT CANADA,1985</small>					
Relative density (water = 1)	0.7 at -33°C <small>ENVIRONMENT CANADA, 1985</small>					
Vapour density (air = 1)	0.6 <small>G.P. MSDS, 2005</small>					
Solubility in fresh water	895 g/L at 0°C <small>INERIS, 1999</small> 529 g/L at 20°C <small>G.P. MSDS, 2005; INERIS, 1999</small>					
Olfactory threshold	5 to 25 ppm, very variable according to people <small>G.P. MSDS, 2005</small>					
Diffusion coefficient in water	1.10×10 ⁻⁹ m ² /s <small>CALTOX, 1997</small>					
Diffusion coefficient in air	2.16×10 ⁻⁵ m ² /s <small>CALTOX, 1997</small>					
Henry's law constant	1.61 Pa.m ³ /mol <small>CALTOX, 1997</small>					
Vapour pressure/tension	<small>G.P. MSDS, 2005</small>					
°C	- 18	0	4,7	25	50.1	78.9
kPa	200	430	500	1013	2000	4000

Flammability data

Ammonia does not readily burn in air without the addition of a hydrocarbon or a catalyst. In certain conditions, there is a danger of explosion in the case of containment or energy input.

Flash point G.P. MSDS,2005
N/A

Self-ignition point G.P. MSDS, 2005; ICSC,1998
651°C (DIN 51794)

Combustion rate RONNEY, 1988
0.07 m/s

Explosive limit, % by volume in air at 0°C G.P. MSDS,2005
LEL 15 % or 150,000 ppm
UEL 28 % or 280,000 ppm

Dangerous products of decomposition

G.P. MSDS, 2005; INRS, 1997; ENVIRONMENT CANADA, 1985

The normal products of the combustion of ammonia are nitrogen and water. As of 450/500°C, ammonia breaks down into nitrogen and hydrogen. Hydrogen forms explosive mixtures with air; in the presence of a source of ignition, the air-hydrogen mixture burns to produce a very hot dim flame (that is difficult to see) which spreads horizontally. Nitrogen is not toxic and only acts by asphyxiation.

In the presence of certain metals, such as iron, osmium, zinc and uranium, this decomposition begins at 300°C and is nearly complete at 500-600°C. Ammonia in the form of liquefied gas also acts on gold, silver and mercury by forming explosive compounds.

B4

Toxicological data

Ammonia is mainly absorbed by the respiratory tract.

Acute human toxicity

(ICSC, 1998; CSST, 2000; INERIS, 2003)

Ammonia in the form of a gas is irritating and corrosive for:

- the skin: irritation,
- the eyes: watering, burning sensation in eye, damage to corneas,
- the upper respiratory tract (nose and throat): drying out of the nose, coughing, pains in chest, shortness of breath, suffocation.

In serious cases, laryngeal oedema can be observed, evolving towards pulmonary oedema and death by asphyxiation. The appearance of symptoms may take up to 48 hours after exposure.

Exposure to high concentrations causes bronchial irritation, but may also lead to corrosion of the skin, eyes and upper respiratory tract.

Direct contact with the liquefied gas causes corrosion of the eyes and skin.

Probable acute effects due to accidental exposure depend on the concentration of gas: (INERIS, 2003)

Ammonia concentration (ppm in air)	Probable effects due to acute exposure
5	Odour may be detected by certain individuals.
20	Odour detected by most individuals (MEV).
50 - 80	Irritation of eyes felt by most individuals.
100 - 110	Irritation of eyes, nasal passages and mucus. Irritation of the throat and respiratory tract.
160	Nausea and headaches.
320 - 560	Immediate irritation of eyes, nose, throat and upper respiratory tract.
800 - 1 600	Significant coughing. Serious irritation of eyes, nose and throat, bronchial spasms.
2 400 - 3 200	Significant coughing. Serious irritation of eyes, nose and throat. Can be fatal after 30 minutes.
4 000 - 9 600	Breathing spasms. Rapid asphyxiation, serious oedema, strangulation. Fatal in a few minutes.

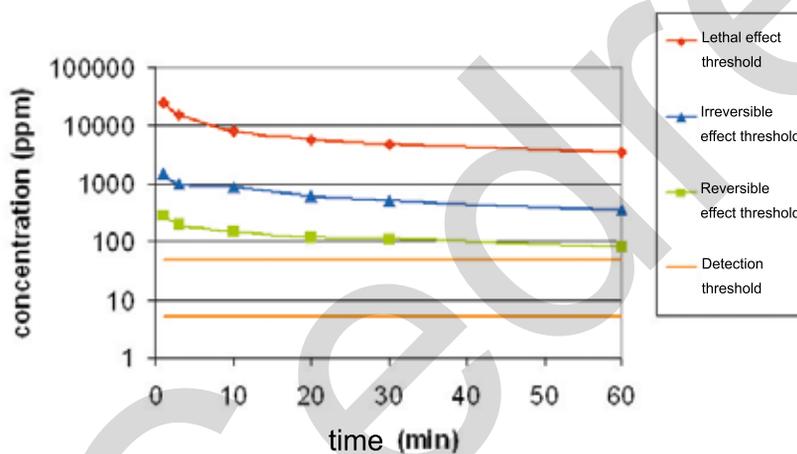
Toxicity indices

- Acute exposure guideline levels

AEGLs (INERIS, 2003)

Duration (minutes)	5	10	30	60
AEGL-1 (ppm)	25	25	25	25
AEGL-2 (ppm)	380	270	160	110
AEGL-3 (ppm)	3,800	2,700	1,600	1,100

- Acute toxicity levels in the case of accidental emission of ammonia (INERIS, 2003)



B5

Chronic human toxicity (INRS, 1997; ICSC, 1998; CHRIS, 1999; G.P. MSDS, 2005)

Repeated or prolonged exposure can create a certain tolerance, i.e. the irritating effects are detected at higher levels.

B5

Threshold toxicological values

Occupational exposure values

MEV (France): $7 \text{ mg/m}^3 = 10 \text{ ppm}$

ELV (France): $14 \text{ mg/m}^3 = 20 \text{ ppm}$

TLV-TWA (ACGIH): $17 \text{ mg/m}^3 = 25 \text{ ppm}$

Risk management values for the population

IDLH (NIOSH): $210 \text{ mg/m}^3 = 300 \text{ ppm}$

TLV-STEL (ACGIH): $24 \text{ mg/m}^3 = 35 \text{ ppm}$

TEEL 0: $17.5 \text{ mg/m}^3 = 25 \text{ ppm}$

ERPG 1: $17.5 \text{ mg/m}^3 = 25 \text{ ppm}$

ERPG 2: $105 \text{ mg/m}^3 = 150 \text{ ppm}$

ERPG 3: $525 \text{ mg/m}^3 = 750 \text{ ppm}$

Specific effects (G.P. MSDS, 2005)

Effects on reproduction: no data available.

Carcinogenic effects: no carcinogenic effects according to the IARC.

Mutagenic effects: not mutagenic (Ames test with and without metabolic activation).

Ecotoxicological data

Acute ecotoxicity (ECB, 2000)

Crustacean (*Daphnia magna*) LC₅₀ (48h) = 25.4 mg/L (fresh water)

Crustacean (*Ceriodaphnia reticulata*) LC₅₀ (48h) = 131 mg/L (fresh water)

Fish (*Sciaenops ocellata*) CL₅₀ (24h) = 0.9 mg/L (seawater)

Fish (*Carassius auratus*) CL₅₀ (24h) = 7,2 mg/L (fresh water)

Fish (*Cyprinus carpio*) CL₅₀ (96h) = 1.1 mg/L (fresh water)

Chronic ecotoxicity

Fish (*Ictalurus punctatus*) NOEC (27 d) = 0.06 mg/L (fresh water) (ROBINETTE, 1976)

Crustacean (*Ceriodaphnia dubia*) NOEC reproduction (3 generations) = 2 mg/L (fresh water)

NOEC survival (3 generations) = 6.8 mg/L (fresh water)
(COWGILL & MILAZZO, 1991)

PNEC (Predicted No-Effect Concentration): No PNEC can be established from the data obtained on only two trophic levels (invertebrates and fish). No valid data on algae is available in the literature.

Persistence in the environment

(ENVIRONMENT CANADA, 1985)

Ammonia is present in its natural state in the environment. It is a product of the biological breakdown of nitrogen-containing matter, such as amino acids. Ammonia is also a natural compound, required by most organisms for protein synthesis; it is a waste product of metabolism in animals, fish and microbes.

Risk for the environment

Ammonia is toxic for aquatic species. Its toxicity heavily depends on the pH of the water and the total ammonia concentration, i.e. that of the non-ionised ammonia: NH_3 and the ammonium ion: NH_4^+ .

The ionised form NH_4^+ predominates in most natural waters and is not very toxic. However, in alkaline waters, non-ionised ammonia NH_3 can reach toxic levels.

This toxicity increases with the salinity and temperature.

Breakdown

In the ground: ammonia exists in the form of NH_4^+ ammonium ions. These ions can be immobilised in the ground and undergo nitrification, i.e. a transformation into NO_2^- then NO_3^- nitrites, more mobile than NH_4^+ ions. They can be carried into underground water reservoirs by washing, or react with organic matter.

In water: ammonia is eliminated from the water system by evaporation, transformation into NH_4^+ which undergoes nitrification into NO_2^- then NO_3^- or by adsorption onto particles in suspension.

In air: part of the ammonia is oxidised to form nitrogen oxides and nitrates.

The rest combines with sulphates present in the atmosphere. The ammonia remains in the atmosphere for 5 to 10 days.

Bioaccumulation

Ammonia is continually produced in the environment either directly by organisms which give it off (some fish for instance) or indirectly through the breakdown of proteins excreted by these organisms.

The environment is used to managing this molecule, which many bacteria are specialised in eliminating (for example *Nitrosomas*). Consequently, this inorganic molecule is not found in the environment and is neither persistent nor bioaccumulable.

B7

Partition coefficient for organic carbon and water (K_{oc}): N/A

Partition coefficient for octanol and water (K_{ow}): -1.14 at 25°C

Bioconcentration factor (BCF): N/A

Classification

IGC Code (IMO, 1993):

- Ship type: 3.
- **2G**: gas carrier which requires significant preventive measures to preclude the escape of such cargo.
- **2PG**: a gas carrier of 150 m in length or less which requires significant preventive measures to preclude escape of such cargo, and where the products are carried in independent type C tanks designed for a MARVS of at least 7 bar gauge and a cargo containment system design temperature of -55°C or above. Note that a ship of this description but over 150 m in length is to be considered a type 2G ship.
- Type C independent tanks required: no.
- Controlled tank environment: no.
- Vapour detection: T (Toxic vapour detection).
- Gauging: C.

Level indicators for cargo tanks:

Indirect devices: which determine the

amount of cargo by means such as weighing or pipe flow meters

Closed devices: which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices.

Closed devices: which penetrate the cargo tank, but which form part of a closed system and keep the cargo from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If a closed gauging device is not mounted directly on the tank it should be provided with a shutoff valve located as close as possible to the tank.

- MFAG table number: 725.
- Particular provisions:
 - Respiratory and eye protection suitable for emergency escape purposes.
 - Suitably marked decontamination showers and an eyewash should be available on deck.
- Materials of construction not to be used: mercury, copper and copper-bearing alloys, and zinc.

SEBC Classification: GD (gas, dissolver)



Example of a tanker: the *Kemira gas*

² Definition in acronyms

E.U. Classification:



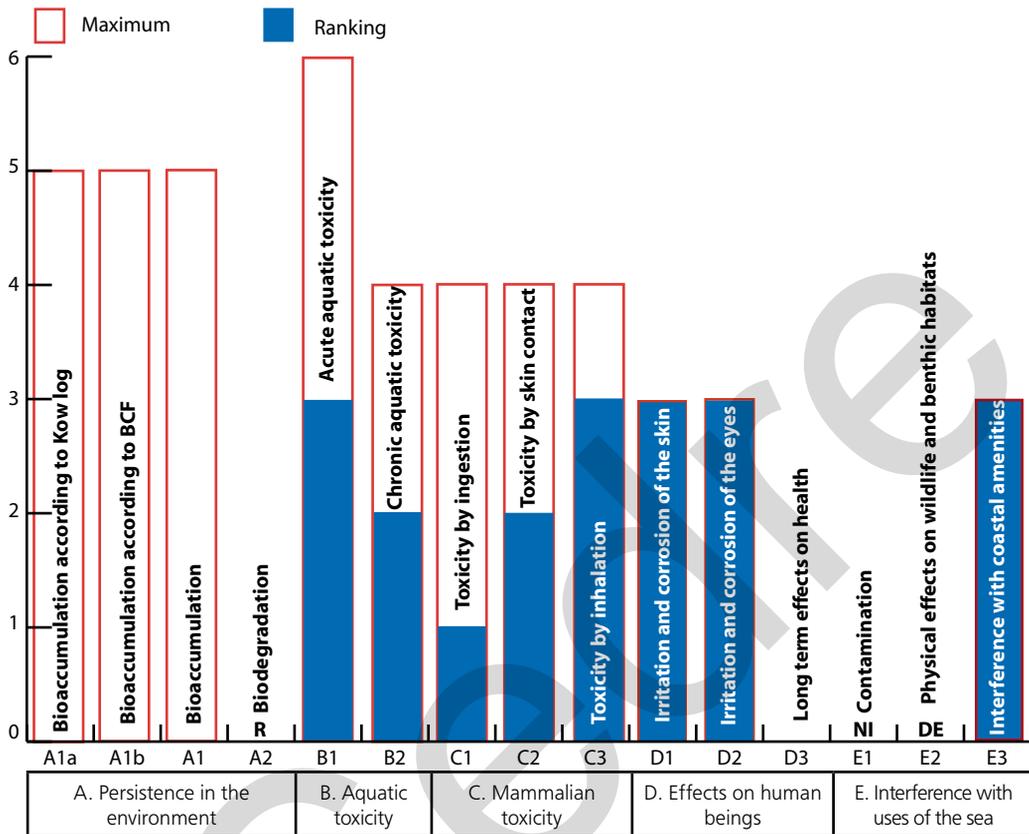
T: toxic



N: dangerous for
the environment

R10	Flammable
R23	Toxic by inhalation
R34	Causes burns.
R50	Very toxic to aquatic organisms.
S1/2	Keep locked up and out of the reach of children.
S9	Keep container in a well ventilated place.
S16	Keep away from sources of ignition. No smoking.
S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39	Wear suitable protective clothing, gloves and eye/face protection.
S45	In case of accident or if you feel unwell, seek medical advice immediately (show label where possible).
S61	Avoid release to the environment. Refer to special instructions/safety data sheet.
231-635-3	E.C. N° (EINECS)

GESAMP Classification of ammonia: (GESAMP, 2002)



B8

A1a, A1b: ammonia is an inorganic substance
A1: non bioaccumulable substance
A2: readily biodegradable substance

B1: moderate acute aquatic toxicity
B2: moderate chronic aquatic toxicity

C1: slightly toxic when ingested by mammals
C2: slightly toxic by skin contact with mammals
C3: relatively high toxicity through inhalation by mammals

D1: severely irritating or corrosive substance
D2: severely irritating for eyes leading to irreversible corneal lesions

E1: No Information
E2: product which dissolves and evaporates
E3: highly objectionable, closure of amenities

MARPOL classification: ammonia is a gas transported in the form of a liquefied gas: there is therefore no MARPOL classification.

Particular risks

Polymerisation

N/A

Danger (G.P., 2005; CEFIC ERICARDS, 2005; ICSC, 1998; INRS, 1997; CANUTEC, 1996).

- Releases of ammonia present different characteristics according to the physical storage conditions and the type of spill:

• **Sudden release of ammonia gas from a pressurised container (discharge of the gaseous part):** due to its high volatility (Henry's law constant: 1.6×10^{-5} atm.m³/mole), ammonia gas will spread over the water surface or the ground and will initially form a cloud of vapours. In air, the gas will behave like a heavy gas, despite its relative density of 0.6.

This can be explained by the formation of an aerosol at low temperatures, made up of liquid or droplets in suspension in a gaseous environment. The gas mixture, under the influence of environmental conditions, will rise and move downwind.

• **Sudden release of ammonia in biphasic form (gas and liquid) from a pressurised container (discharge of the liquid part):** production of a gas and an aerosol, in the form of a cold, white plume, heavier than air.

It behaves like a heavy gas and can travel several hundred metres just above the ground surface. If the source of leakage is stopped, the aerosol will completely dissipate after a few minutes. The cloud of ammonia is relatively cold and causes the water vapour it meets on its journey to condense until the plume is warmed by dilution with the air. The cloud moves at wind speed and after complete vaporisation the gas becomes lighter than air and disperses.

• **Evaporation of a pool of liquid ammonia (according to conditions of release):** ammonia is depressurised at atmospheric pressure and at temperatures lower than or equal to -33°C, and chills surrounding materials (for instance the ground).

Evaporation is initially high and gradually decreases. Dry, porous ground will absorb liquid ammonia without releasing gases. Water should not be poured over a pool of ammonia, as the heat of the water and the dissolving action will trigger a high level of evaporation.

• **Leak of liquid ammonia from a cold storage facility:** the behaviour of the product is identical to that of the previous case; the leaked ammonia will be subject to little depressurisation and most often only a negligible proportion of the ammonia which escapes will be transformed into vapours.

- When ammonia gas dissolves in water, heat is released.

- When a receptacle containing ammonia is heated, there is an increase in pressure leading to a risk of the container bursting and immediately releasing a cloud of toxic vapours.

- Rapid depressurisation of a container can present a danger by producing a shock wave.

- When burnt, ammonia can give off toxic or irritating fumes.

- Direct contact with liquefied ammonia can cause frostbite and serious ocular lesions.

- Pierced gas canisters can propel themselves violently.

- Ammonia in the form of liquefied gas rapidly attacks copper, zinc, silver and tin, as well as many alloys, particularly those containing copper. It also acts on gold, silver and mercury to produce explosive compounds.

Stability and reactivity (INRS, 1997; ENVIRONMENT CANADA, 1985; G.P. MSDS 2005)

At ordinary temperatures, ammonia gas is a stable compound.

Conditions to be avoided: breaks down at over 450°C to produce nitrogen and hydrogen.

Substances to be avoided: mineral or organic acids, reactive metals and metalloids (calcium, sodium, zinc, mercury...), oxidants and peroxides due to the violent and/or explosive reactions caused.

B9

Behaviour when in contact with other products INERIS, 1999; ENVIRONMENT CANADA, 1985

Ammonia reacts with a wide variety of substances. The main incompatibilities which may provoke a violent or explosive reaction are as follows:

halogens (chlorine, bromine pentafluoride...)	explosive reaction
heavy metals (gold chloride, silver oxides...)	reaction producing explosive materials
oxidants and peroxides (hydrogen peroxide, nitryl chloride, oxygen...)	explosion
acids (hypochlorous acid, nitric acid...)	violent reaction: explosion, ignition, release of dangerous compounds...
boron, chromic anhydride	incandescent reaction
nitric acid, chromyl chloride	self-igniting mixtures

Transportation, handling, storage

Transportation (G.P. MSDS, 2005)

Identification n° (UN): 1005

Land transportation:

RID (rail)/ADR (road)

Hazard classification: 268

Class: 2

Packaging group: -

Classification code: 2TC

Labels: 2.3 + 8

Transportation via inland waterways:

ADN/ADNR

Class: 2

Packaging group: -

Classification code: 2TC

Labels: 2.3 + 8

Maritime transport: IMDG

Class: 2

Subsidiary risk: 8

Packaging group: -

Marine pollutant (MP): No

Labels: 2.3 + 8

Air freight: IATA

Class: 2

Subsidiary risk: 8

Packaging group: -

Labels: Toxic gas & Corrosive

Air freight only

Handling (G.P. MSDS, 2005; ENVIRONMENT CANADA, 1985; INRS, 1997)

- Refer to supplier's instructions for information on handling container.
- Only use specialised equipment suitable for this product and its pressure and temperature. Contact the ammonia supplier if there is any doubt.
- Prevent the product from rising up in the

container.

- Prevent suction of water into the container.
- Keep away from all sources of ignition (including static charges).
- Purge the air in the installation before introducing the gas.
- Always handle pressurised canisters with care, do not drag or slide them across the ground and prevent blows.

Storage (G.P. MSDS, 2005; ENVIRONMENT CANADA, 1985; INRS, 1997)

Technical precautions

- Store containers in a well ventilated place, at a temperature lower than 50°C.
- Keep away from oxidising gases and other oxidising agents.
- Store the containers vertically, out of direct sunlight and away from heat and products liable to react violently with the ammonia. The containers should be tightly closed and clearly labelled.
- Store on impermeable ground with a retention tank so that in the event of a spill the solutions do not spread outside the storage facility.
- Ground the tanks and ensure that the electric wiring is watertight.
- Do not smoke.

Incompatible products:

Non ferrous metals (copper, zinc, tin, silver) and their alloys.

Recommended packaging materials

Bulk transportation: carbon steel/stainless steel.

Gas canisters: stainless steel except type T1.

Results of accident scenarios

- Reminder of properties ————— C1
- Accident scenarios ————— C2
- Consumption scenarios ————— C3



Reminder of properties

Vapour density and tension

- Relative density: 0.7 at -33°C
- Vapour density: 0.6
- Vapour tension: 1,013 kPa at 25°C

Solubility

Ammonia is highly soluble in water. When it dissolves it produces a corrosive, alkaline solution.

The solubility of ammonia in fresh water is 529 g/L at 20°C.

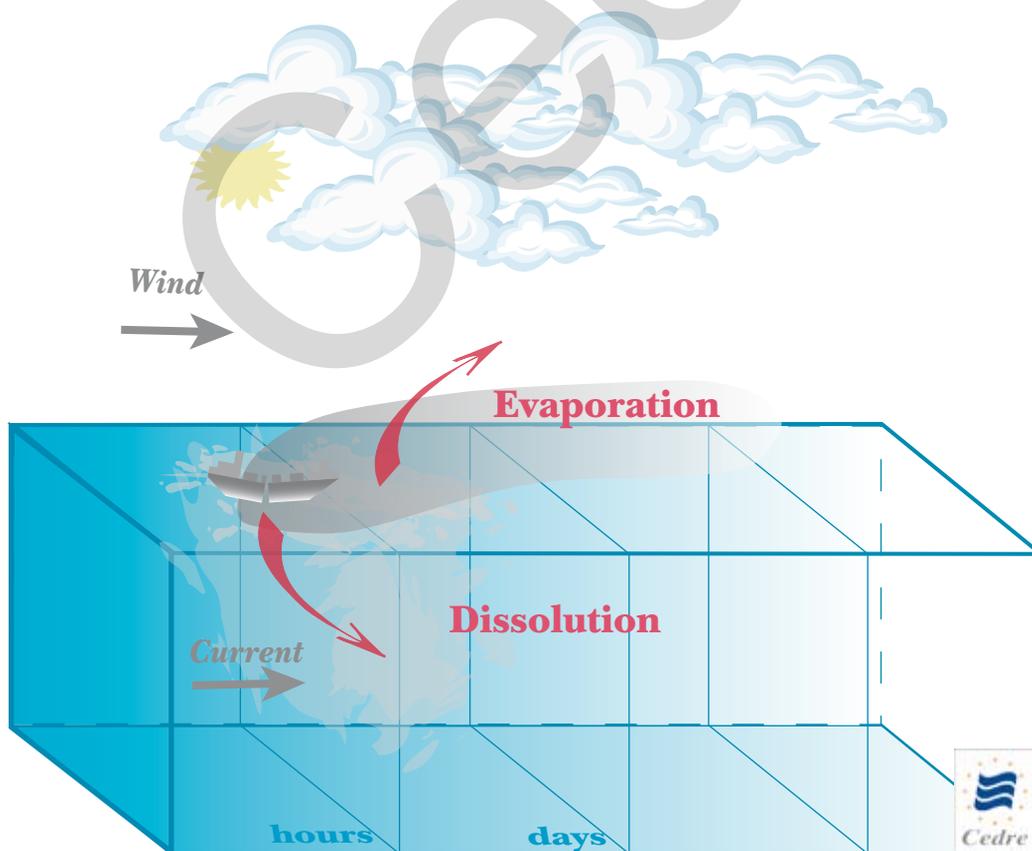
Transportation

Ammonia is transported in the form of liquefied gas in bulk by tanker vessels, rail tankers and road tankers made of steel, or in pressurised steel canisters.

Behaviour in the environment

When a spill occurs above the water surface, part of the liquid anhydrous ammonia which comes into contact with the water dissolves, the rest evaporates very rapidly.

Due to the high volatility of the product, the dissolved part will also form a plume of vapours less dense than air ($d = 0.6$) which will tend to rise. If a large quantity of ammonia is spilt, it will form a cloud of vapours which will act like a heavy gas and move around just above the water surface.



Behaviour of ammonia spilt at sea

Accident scenarios

The scenarios defined here are simply designed to give an indication of the possible behaviour of sodium hydroxide. In the event of a real spill, the results of simulations will naturally be different from those given here. The CHEMMAP behaviour model, the emergency response model employed by *Cedre*, was used for these simulations. Other more sophisticated models exist, but require response times which are incompatible with an emergency situation.

Four ammonia spill scenarios are given here with different spill rates:

- A - an open sea scenario (Channel) with four different spill rates: 10 kg/h, 1,000 kg/h, 100 t/h and 500 t (instantaneous spill)
- B - a port scenario (Cherbourg) with two different spill rates: 200 kg/h and 200 kg (instantaneous spill)
- C - a wreck scenario (Channel): 200 t/h over 5 hours
- D - a river scenario: 4 t/h over 5 hours.

The scenarios

A] Channel scenario

- Location 50°N, 3°W
- Air and water temperature: 10°C
- Two wind speeds: 3 and 10 m/s (NW)
- Channel currents
- Spill depth: 1 m
- Duration of spill:
 - 5 hours (A1)
 - instantaneous (A2)

B] Port scenario

- Location: port of Cherbourg
49°39N; 1°36W
- Air and water temperature: 10°C
- Two wind speeds: 3 and 10 m/s (NW)
- Slow current
- Spill depth: 1 m
- Duration of spill:
 - 1 hour (B1)
 - instantaneous (B2)

C] Wreck scenario

- Location: 49°27N; 3°15W
- Air and water temperature: 10°C
- Two wind speeds: 3 and 10 m/s (NW)
- Channel currents
- Spill depth: between 80 and 90 m
- Duration of spill: 5 hours

D] River scenario

- Depth: 4 to 5 m; width: 150 m
- Air and water temperature: 15°C
- Two current speeds: fast and slow
- Two wind speeds: 3 and 10 m/s (NW)
- Current speed: 0.72 m/s
- Spill depth: 1 m
- Duration of spill: 5 hours

Modelling

CHEMMAP software was used to model hypothetical spillages of ammonia in the aquatic environment.

This is a chemical spill model designed by ASA (Applied Science Associates, Inc - USA) which predicts the movement and fate of the spilt product in fresh and sea water.

This model indicates both the movement of the product on the water surface and its distribution in the environment (evaporation, dissolution in the water column...).

The time step used for the calculations is 15 minutes.

Results obtained after a spill of 1000 kg/h of ammonia over 5 hours in the Channel, with a NW wind of 3 m/s (Case A):



Figure 1

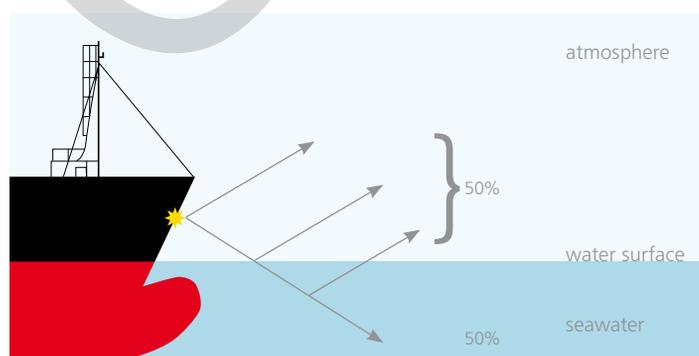
Location of the hypothetical spill in the Channel



Figure 2

View of the dissolved part.

When the ammonia is spilled above the water surface, part of the ammonia in the form of a gas is instantly released. When the liquid ammonia comes into contact with the water, part of it evaporates and another part dissolves, also leading to partial evaporation.



According to data from the US Coast Guard trials (FULLERINGER, 2000), the dissolved part represents between 50 and 72%.

The scenarios presented in this guide involve ammonia being released **below the water surface**.

Key used in this guide:

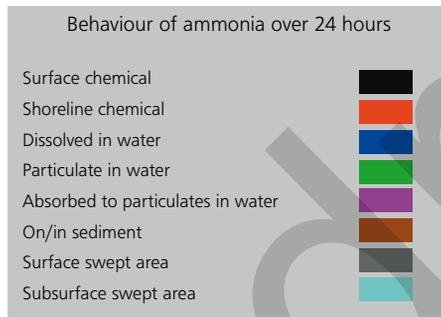
- for the graphs



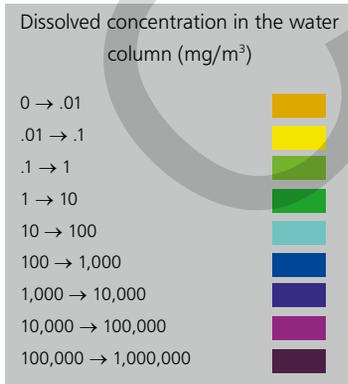
Spill location

Section line

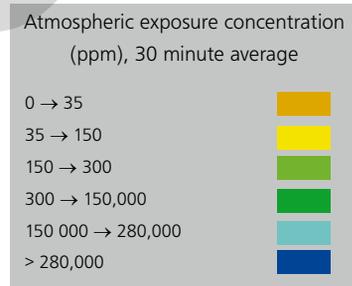
- for the behaviour of ammonia



- for concentrations in the water column



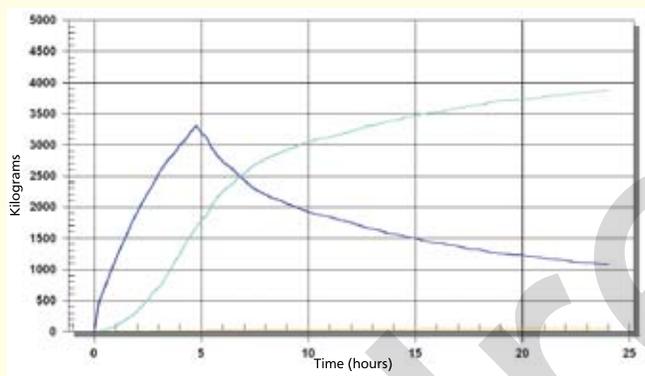
- for atmospheric concentrations



← LEL

Results of the Channel scenario: Case A1

Spill of 5,000 kg of ammonia over 5 hours (1,000 kg/h) with a NW wind of 3 m/s.



Graph 1

Quantity evaporated Quantity in water column Quantity decayed

Whatever the quantity spilt (50 kg, 5,000 kg or 500 tonnes over 5 hours), the results show that at the end of the spill 60% of the ammonia spilt is in the water column and 40% has evaporated into the atmosphere.

With a wind speed of 10 m/s, 55% of the ammonia spilt is in the water column, whereas 45% will have evaporated into the atmosphere.

Behaviour of ammonia spilt in the Channel, only considering the part in the water, after 24 hours, with a 3 m/s NW wind.

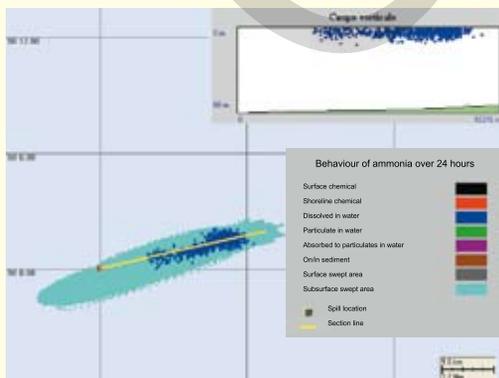


Figure 3

The spilt ammonia spreads over 23 km, with little influence from the north-westerly wind.

Behaviour of ammonia spilt in the Channel, only considering the part in the water, after 24 hours, with a 10 m/s NW wind.

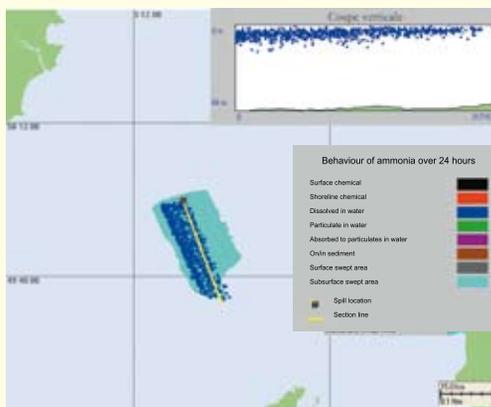


Figure 4

The ammonia spilt in the Channel is influenced by the north-westerly wind, and spreads over an area of 30 km by 18 km. It dissolves in the water column to a depth of approximately 9 m.

3 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

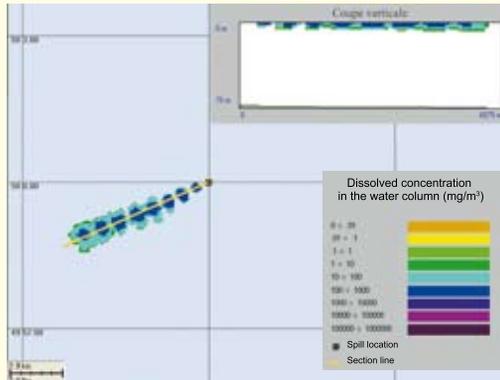


Figure 5

The ammonia dissolves and, under the influence of currents, travels 6.5 km. The product is found in the 9 m under the water surface. The maximum concentrations reached are from 100 to 1,000 mg/m³.

10 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

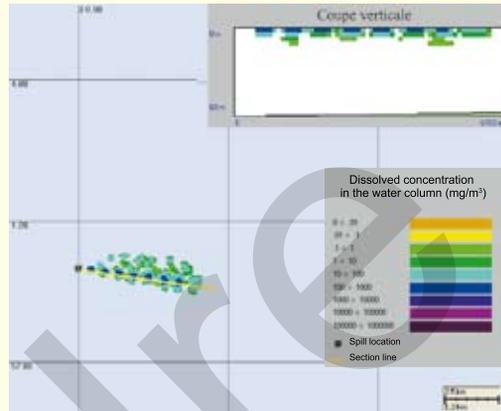


Figure 6

The ammonia dissolves and, under the influence of currents, travels 6 km. The product is found in the 13 m under the water surface. The maximum concentrations reached are from 100 to 1,000 mg/m³.

Study of atmospheric ammonia concentrations, 30 minutes after the spill.

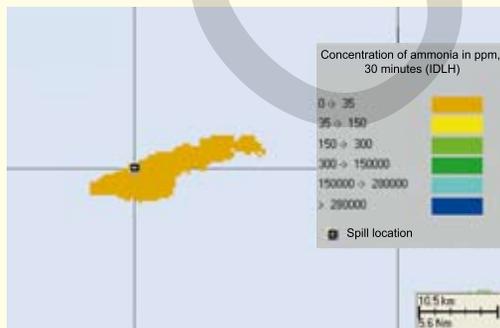


Figure 7

Figure 7 shows the atmospheric ammonia concentration after 30 minutes, which remains less than 300 ppm, which is the IDLH value. The area affected spreads over 120 km² (around 24 km EW and 5 km NS).

Study of atmospheric ammonia concentrations, 30 minutes after the spill.

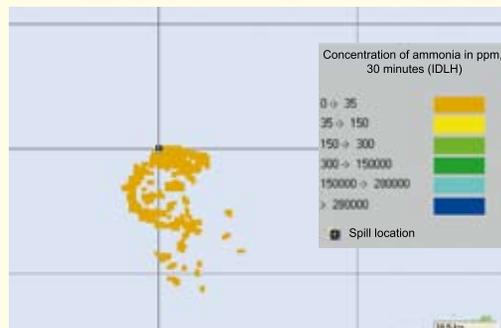


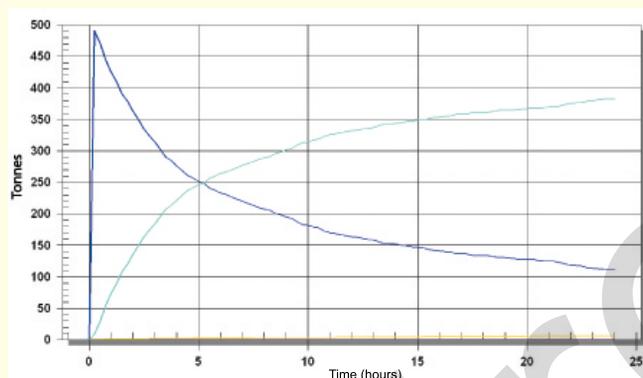
Figure 8

Figure 8 shows the atmospheric ammonia concentration after 30 minutes, which remains less than 300 ppm, which is the IDLH value. The area affected spreads over 525 km² (around 21 km EW and 25 km NS).

*Definitions in glossary

Results of the Channel scenario: Case A2

Instantaneous spill of 500 tonnes of ammonia with a NW wind of 3 m/s.



Graph 2

— Quantity evaporated — Quantity in water column — Quantity decayed

When ammonia is spilled instantaneously 1 m under the water surface, all of the product is almost immediately found in the water column. 5 hours after the spill, 50% of the ammonia which was found in the water column has evaporated into the atmosphere.

With a stronger wind, 86% of the ammonia is found in the water column. 50% of the ammonia which was found in the water column has evaporated into the atmosphere only 1.5 hours after the spill.

Behaviour of ammonia spill instantaneously in the Channel, only considering the part in the water, after 24 hours, with a 3 m/s NW wind.

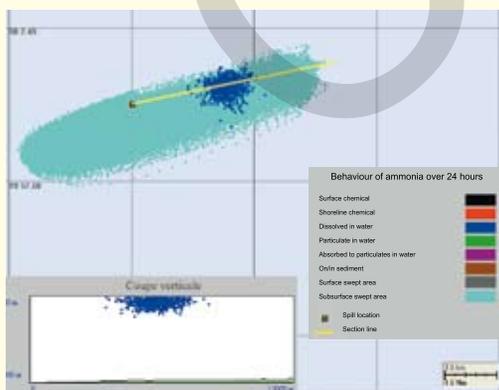


Figure 9

The ammonia spilled instantaneously dissolves and, under the influence of currents, covers an area of 20 km by 4 km.

Behaviour of ammonia spill instantaneously in the Channel, only considering the part in the water, after 24 hours, with a 10 m/s NW wind.

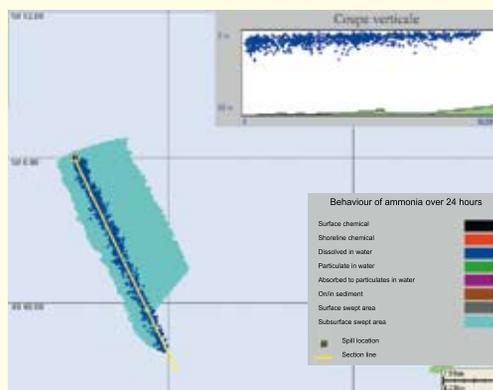


Figure 10

The ammonia spilled instantaneously dissolves and, under the influence of currents and more importantly of the NW wind blowing at 10 m/s, covers an area of 37 km by 12 km. It dissolves in the water column to a depth of approximately 20 m.

3 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

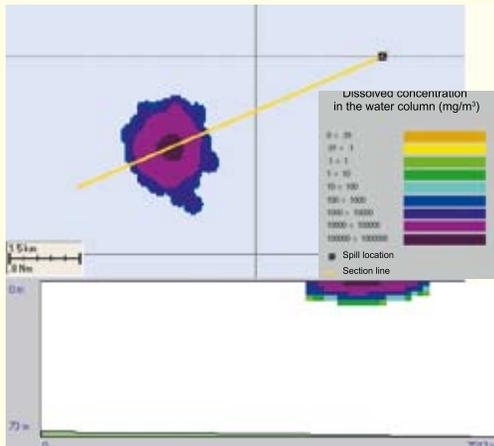


Figure 11

The ammonia moves according to the current and becomes concentrated over an area of 4.5 km², 5 km SE of the spill location. The concentrations are high, reaching 105 to 106 mg/m³.

10 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

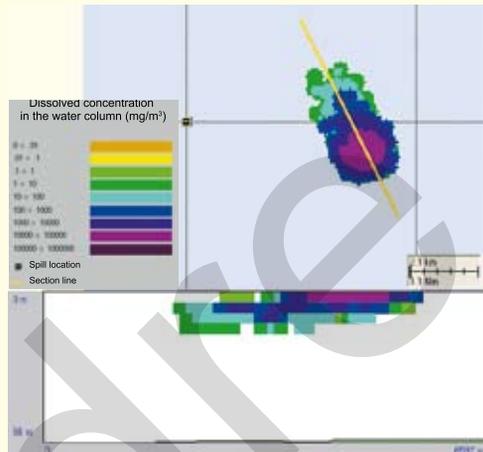


Figure 12

The dissolved ammonia, under the influence of the current and wind, becomes concentrated over an area of 12 km², 6.5 km east of the spill location. The concentrations are high, reaching 105 to 106 mg/m³.

Study of atmospheric ammonia concentrations, 30 minutes after the spill.

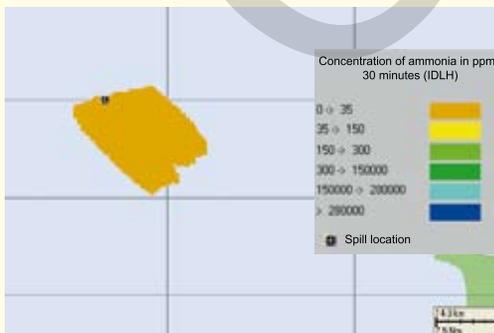


Figure 13

Figure 13 shows the atmospheric ammonia concentration after 30 minutes, which remains less than the IDLH value (300 ppm). The area affected spreads over 630 km² (around 30 km EW and 21 km NS).

Study of atmospheric ammonia concentrations, 30 minutes after the spill.



Figure 14

Figure 14 shows the atmospheric ammonia concentration after 30 minutes, which remains less than 300 ppm, which is the IDLH value. The area affected spreads over 900 km² (around 24 km EW and 38 km NS).

Safety distances for the toxic cloud of ammonia in the Channel: Case A

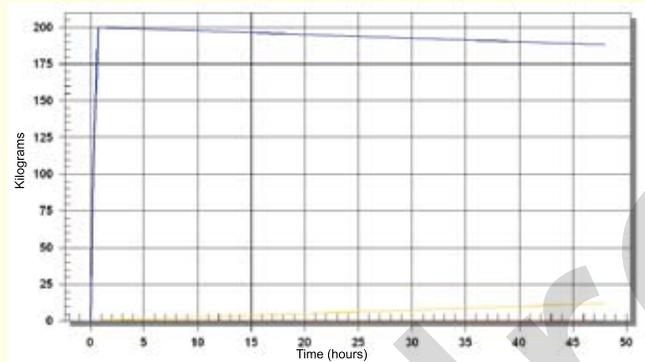
Quantity spilt	Wind	Concentration (ppm)	Maximum distance affected	Protection
10 kg/h over 5 hours	3 m/s	35 (TLV-STEL)	< 35 ppm: 1,500 m	A
		150 (ERPG 2)	*	B
		300 (IDLH)	800 m	C
		150 000 (LEL)	*	D
		280 000 (UEL)	*	D
	10 m/s	35 (TLV-STEL)	< 35 ppm: 1,840 m	A
		150 (ERPG 2)	*	B
		300 (IDLH)	740 m	C
		150 000 (LEL)	*	D
		280 000 (UEL)	*	D
1000 kg/h over 5 hours	3 m/s	35 (TLV-STEL)	1,650 m	A
		150 (ERPG 2)	1,120 m	B
		300 (IDLH)	800 m	C
		150 000 (LEL)	*	D
		280 000 (UEL)	*	D
	10 m/s	35 (TLV-STEL)	1,840 m	A
		150 (ERPG 2)	1,260 m	B
		300 (IDLH)	1,320 m	C
		150 000 (LEL)	*	D
		280 000 (UEL)	*	D
100 t/h over 5 hours	3 m/s	35 (TLV-STEL)	8,000 m	A
		150 (ERPG 2)	3,200 m	B
		300 (IDLH)	3,000 m	C
		150 000 (LEL)	*	D
		280 000 (UEL)	*	D
	10 m/s	35 (TLV-STEL)	9,510 m	A
		150 (ERPG 2)	6,310 m	B
		300 (IDLH)	5,100 m	C
		150 000 (LEL)	770 m	D
		280 000 (UEL)	*	D
500 t instantaneous spill	3 m/s	35 (TLV-STEL)	9,000 m	A
		150 (ERPG 2)	8,000 m	B
		300 (IDLH)	7,000 m	C
		150 000 (LEL)	840 m	D
		280 000 (UEL)	*	D
	10 m/s	35 (TLV-STEL)	15,600 m	A
		150 (ERPG 2)	11,300 m	B
		300 (IDLH)	8,930 m	C
		150 000 (LEL)	1,370 m	D
		280 000 (UEL)	900 m	D

*: distance too small to be calculated by the model

A	No danger.	C	Wear Personal Protective Equipment. Use self-contained breathing apparatus (SCBA).
B	Wear Personal Protective Equipment. Use a gas mask.	D	Area where the concentration reaches explosive limits. Use self-contained breathing apparatus (SCBA) and fire-proof material.

Results of the Port scenario: Cases B1 and B2

Spill of 200 kg of ammonia in 1 hour in a port with no wind.

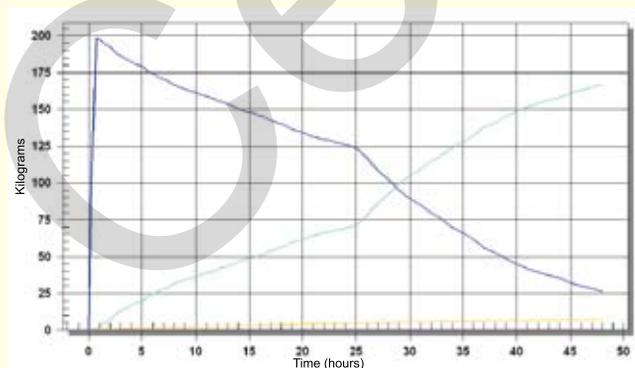


Graph 3

— Quantity evaporated — Quantity in water column — Quantity decayed

When there is no wind, the 200 kg of ammonia spilt dissolve in the water column without evaporating.

Spill of 200 kg of ammonia in 1 hour in a port with a NW wind.



Graph 4

— Quantity evaporated — Quantity in water column — Quantity decayed

With a NW wind speed of 3 or 10 m/s, the ammonia spilt initially dissolves in the water column, but gradually evaporates. 30 hours after the spill, around 50% of the total volume of ammonia has evaporated into the atmosphere.

Instantaneous spill of 200 kg of ammonia in a port.

In the case of an instantaneous spill of 200 kg of ammonia, the chemical behaves in the same way as above and in similar proportions, with or without wind.

**Spill of 200 kg of ammonia over 1 hour with a NW wind of 3 m/s.
Behaviour of ammonia 48 hours after the spill.**

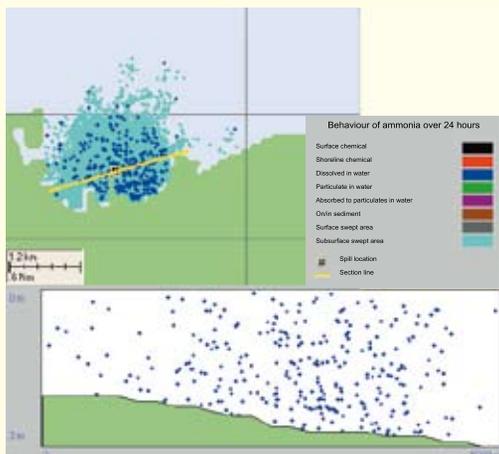


Figure 15

With a 3 m/s NW wind, the ammonia spill spread over an area of 9 km² around the spill location. Under the influence of the wind, the ammonia dissolved in the water tends to move SE of the spill location (figure 15).

With no wind and after 48 hours, the ammonia spill spreads over an area of 3.5 km by 2.7 km. The entire depth of the water column (3 m) is affected.

Study of the concentrations of ammonia dissolved in the water column, 2 hours after the spill.

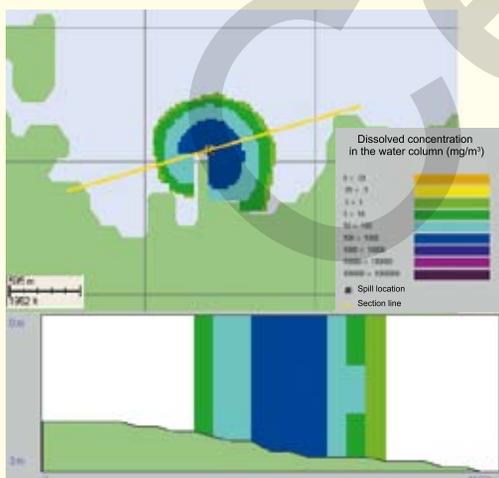
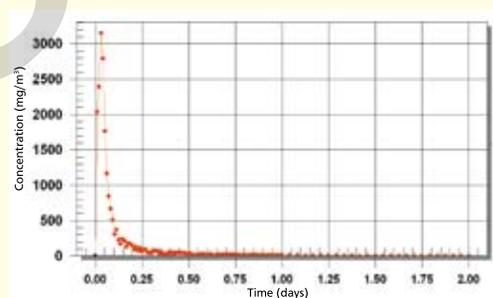


Figure 16



Graph 5

With a 3 m/s NW wind, the maximum concentrations of ammonia reach 100 to 1,000 mg/m³ and spread over an area 1 km in diameter around the spill location (figure 16). The evolution of the concentration at the spill location is shown in graph 5, reaching a maximum of 3,000 mg/m³. With no wind, the concentrations of dissolved ammonia are of the same order.

Study of atmospheric ammonia concentrations.

Spill of 200 kg of ammonia over 1 hour with a NW wind of 3 m/s.

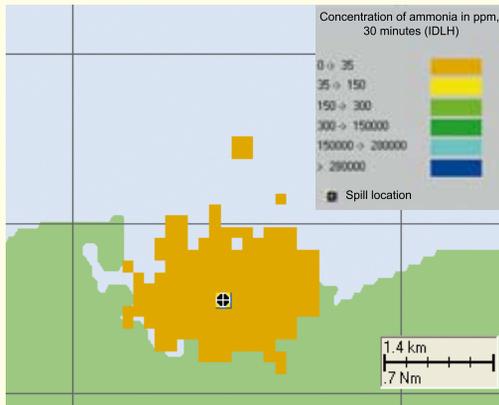


Figure 17

With a 3 m/s NW wind, the ammonia gradually evaporates and the atmospheric concentrations after 30 minutes remain lower than the IDLH value of 300 ppm (figure 17). With no wind, there is no ammonia present in the atmosphere.

Instantaneous spill of 200 kg of ammonia with a NW wind of 10 m/s.

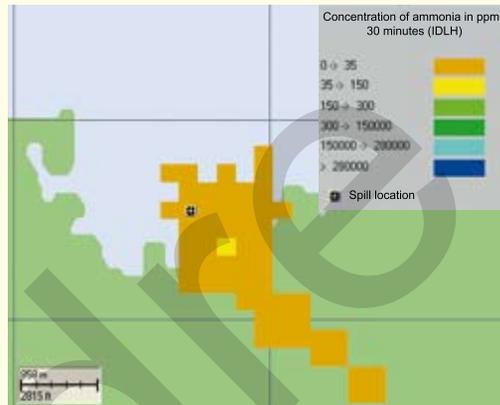


Figure 18

The ammonia spilled evaporates in the direction of the NW wind and the area affected extends over more than 700 m, while remaining lower than the IDLH value.

Results of the Wreck scenario: Case C

A wreck is lying on the seabed 87 m below the surface not far from an inhabited coastline and begins to leak.

The leak leads to the **continuous release of 1,000 tonnes of ammonia over 5 hours from the tanks of the wreck.**



Figure 19

Location of the wreck.

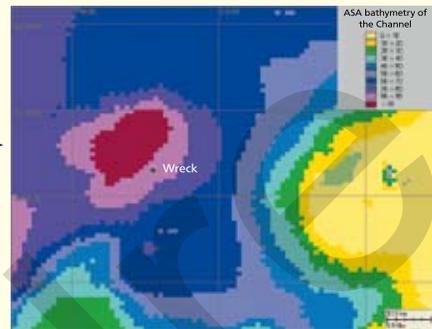
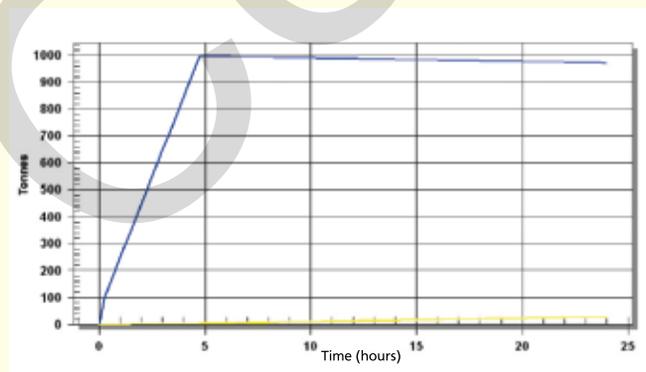


Figure 20

Bathymetry of the Channel.

Spill of 1,000 tonnes of ammonia over 5 hours (200 t/h) from the seabed of the Channel (87 m deep).

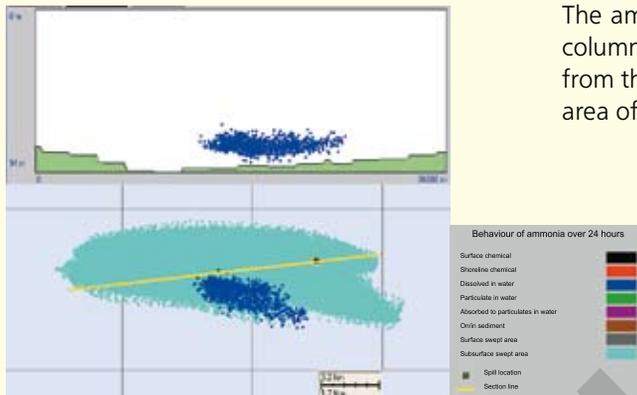


Graph 6

— Quantity evaporated — Quantity in water column — Quantity decayed

The ammonia spilled in the depths of the sea has totally dissolved by the end of the spill. There is no evaporation from the surface.

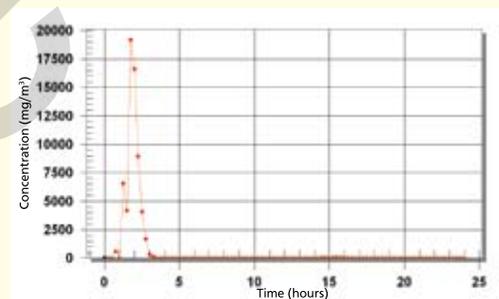
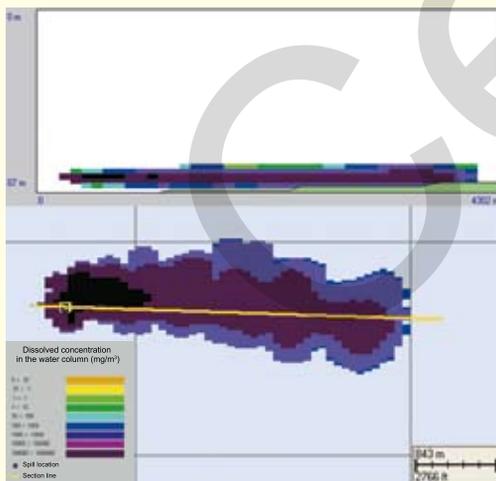
Behaviour of the 1,000 tonnes of ammonia released from the seabed after 24 hours.



The ammonia released dissolves in the water column to a height of approximately 27 m from the seabed; the product spreads over an area of 120 km² (20 km EW by 6 km NS).

Figure 21

Ammonia concentrations in the water column obtained 2 hours after the release of ammonia.



Graph 7

Figure 22

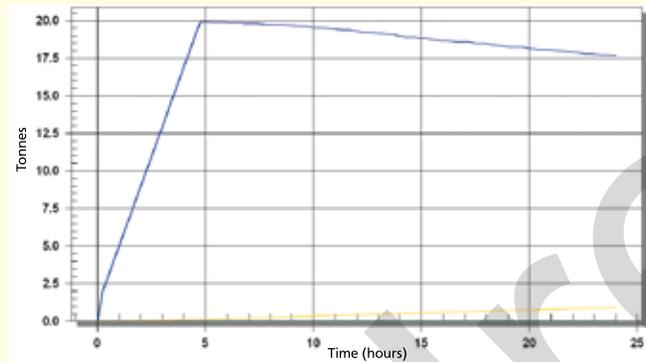
Two hours after the chemical is released, the concentrations of dissolved ammonia reach 105 to 106 mg/m³ and spread over an area 4 km by 1.3 km (figure 22).

The concentrations of dissolved ammonia at the spill location can reach a maximum of 190,000 mg/m³ over a period of 24 hours (graph 7).

The product, released at the seabed, is not found in the atmosphere.

Results of the river scenario: Case D

Spill of 20 tonnes of ammonia over 5 hours, with a 3 m/s NW wind and a 0.72 m/s current.



Graph 8

— Quantity evaporated — Quantity in water column — Quantity decayed

At the end of the spill (5 hours), the ammonia has completely dissolved in the water column.

Behaviour over 24 hours of ammonia spilt in the river with a 0.72 m/s current and a 3 m/s NW wind.

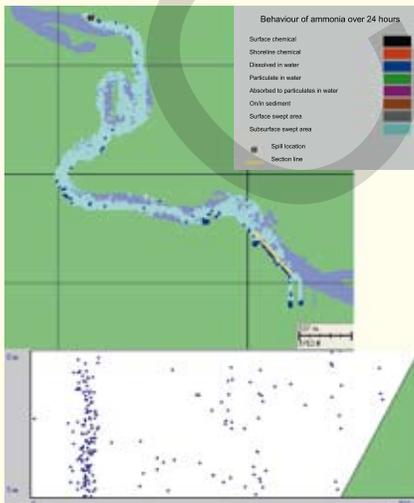


Figure 24

The ammonia spilt dissolves in the water column up to 3.6 km downstream of the spill location. The product spreads through the entire depth of the river (5 m).

Behaviour over 24 hours of ammonia spilt in the river with a 0.72 m/s current and a 10 m/s NW wind.

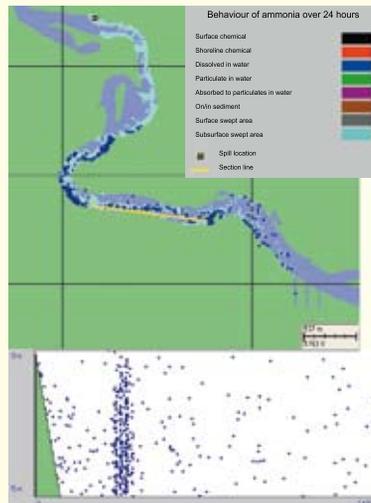


Figure 25

In the case of stronger winds, the ammonia in the water column dissolves over an area of 3.4 km downstream and remains by the edges of the river due to the NW wind direction. The product spreads through the entire depth of the river (5 m).

3 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

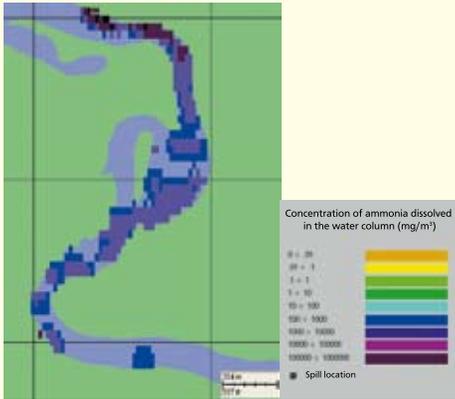


Figure 26

Concentrations of dissolved ammonia are found up to 2 km downstream and reach 10^3 to 10^6 mg/m³.

10 m/s wind

Study of ammonia concentrations in the water column, 2 hours after the spill.

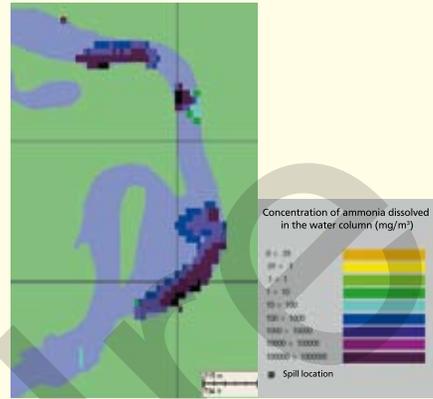


Figure 27

The area affected by the spill extends up to 1.4 km downstream, and the presence of ammonia leads to concentrations of between 10 and 10^6 mg/m³.

Study of ammonia concentrations in the water column, 24 hours after the spill.

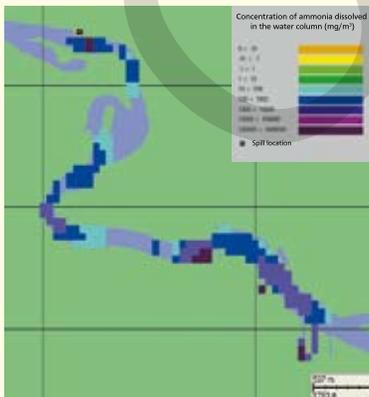


Figure 28

24 hours after the spill, the maximum concentration of dissolved ammonia is between 100 and 10^5 mg/m³ and affects an area of up to 3.5 km downstream.

Study of ammonia concentrations in the water column, 24 hours after the spill.

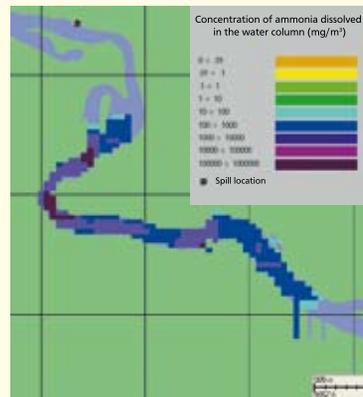


Figure 29

The concentrations of dissolved ammonia become concentrated 24 hours after the spill 3.5 km downstream of the spill location (at between 10 and 10^5 mg/m³).

Consumption scenarios

As ammonia does not bioaccumulate along the food chain, it will therefore not be found in aquatic organisms in high enough concentrations to have an impact on consumers of exposed sea produce.

Response

- Examples of ammonia spills _____ **D1**
- Response recommendations _____ **D2**
- Response techniques _____ **D3**
- Choosing personal protective equipment (PPE) _____ **D4**
- Measuring devices and waste treatment _____ **D5**

Cedre



Examples of ammonia spills

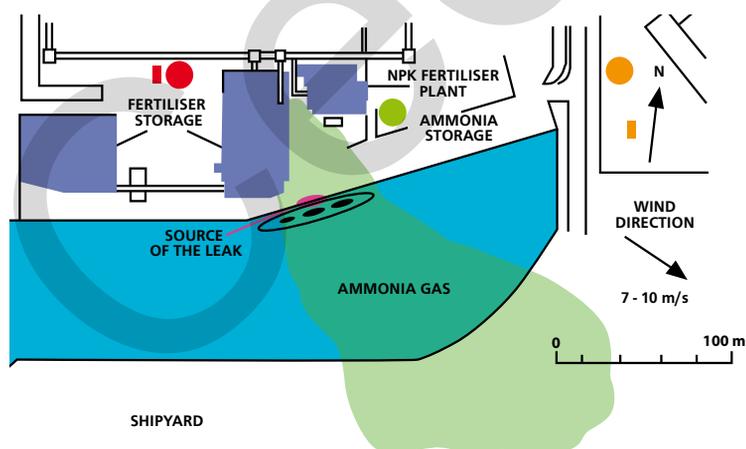
Ammonia spill in a port during unloading (Sweden, 1976)

TROCS-REMPEC, 2004; IMO, 1999 (MANUEL SUR LA POLLUTION CHIMIQUE ÉVALUATION ET INTERVENTION)

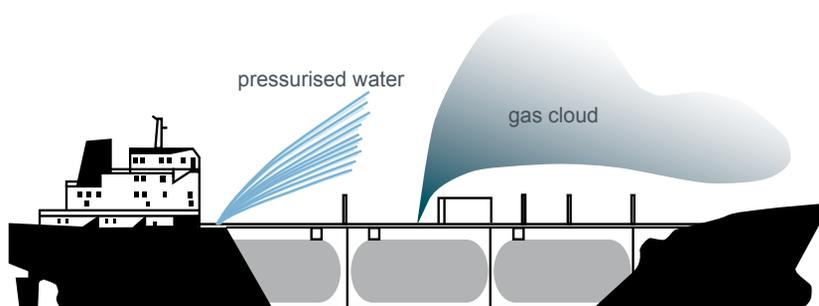
The Belgian gas carrier *René 16* entered the port of Landskrona (Sweden) to unload its cargo of 550 tonnes of anhydrous ammonia, intended for a fertiliser plant on the port complex.

During the unloading operation, a pipe burst due to the **incompatibility** of its construction material with ammonia. In total, **180 tonnes** leaked out in 50 minutes. A **vast cloud** enveloped the vessel, before moving in the direction of the wind towards a shipyard where 2 people were at work.

The fire service used **pressurised water** to spray the cloud so that a valve could be closed to stop the leak. The fire fighters, **wearing protective clothing and equipment**, boarded the vessel to close the valve of the discharge pipeline. After the cloud of ammonia had dispersed, 2 members of the crew were found dead on the quayside. The investigation showed that they had been **sprayed with ammonia**.



A section of the industrial port at Supra, Landskrona, Sweden.



Release of anhydrous ammonia onboard the *René 16* in the port of Landskrona, Sweden.

Rail accident (Canada, 2001)

RAILWAY INVESTIGATION REPORT, DERAILMENT OF TRAIN NO. CP 966-02 FROM THE CANADIAN PACIFIC RAILWAY AT MILE 95.6, RED DEER SUBDIVISION, RED DEER, ALBERTA ON 02 FEBRUARY 2001, REPORT NUMBER R01E0009

More than **71 tonnes of anhydrous ammonia** escaped from a rail tanker which was overturned as it ran off the rails on 2 February 2001 at Red Deer (Alberta, Canada). An emergency brake application occurred. While attempting to find the reason for the emergency braking, the locomotive engineer noticed a **"steam-like" cloud**, which was thought to be composed of anhydrous ammonia. The engineer disconnected the locomotive from the rail cars and departed from the scene.

Fire fighters who attempted to respond, before having the time to activate their breathing apparatus, suffered **minor inhalation and eye injuries**.

The ambulance attendants who transported the casualties to hospital were also exposed to the fumes from the anhydrous ammonia. In the course of establishing a safety perimeter, three constables were exposed to ammonia vapour. They did not have any emergency respiratory protection against toxic gases nor did they have the necessary training in how to effectively respond to this type of chemical spill.

Some 1,300 residents and employees had to be **evacuated**.

Thirty-four people were sent to hospital, resulting in one fatality, a person who had been **overcome by the anhydrous ammonia vapours** while crossing the railway right-of-way.



Derailment of the train, Canada 2001

Response recommendations

All response actions must be carried out by trained personnel with the necessary equipment, or else left to evaporate. Clouds of ammonia vapours can impede visibility.

Is response possible?

- Approach the accident area from upwind (wind behind you), equipped with breathing apparatus and chemical suits (see PPE).
- Beware of the possibility of large-scale release of gases when ammonia dissolves in water.

Emergency measures in the event of a leak or spill

- Create natural ventilation, put on personal protective equipment before entering the contaminated area and remain upwind.
- Avoid all contact with the product, do not inhale vapours.
- Evacuate the area downwind which may be affected or advise the nearby population to remain indoors in closed, unventilated buildings, according to the emergency services' recommendations.
- Remove all sources of ignition. Do not smoke.
- If possible, stop the leak and locate the substances released, if this is not dangerous. Keeping well away from the source, spray with water and protect response personnel (keep far behind the mist of water). Do not pour water over a pool of ammonia: the heat produced will trigger a high level of evaporation.
- Restrict the number of responders in the high risk area.
- Close off drains, prevent ammonia or ammonia solutions from being released into waterways and contain run-off where possible.

Emergency response in the event of fire

Ammonia does not readily burn in air without the addition of a hydrocarbon or a catalyst. In certain conditions, there is a danger of explosion in a confined space, or if there is a high energy input.

- Stop the leak of ammonia, if this operation is not dangerous, before attempting to put out the fire.
- Do not pour water on the source of ammonia. Do not use a solid water stream to extinguish the fire.

Minor fire:

- Use a dry chemical powder or carbon dioxide fire extinguisher.

Major fire:

- Away from the source of ammonia, use an air pressurised water, water mist or foam extinguisher (ensure compatibility of foam compounds).
- Remove containers from fire area if this can be done safely.
- Prevent suction of water into the container.
- Damaged gas canisters should only be handled by specialists.

Fire involving tanks (other than ammonia):

- Fight the fire at its source from as far away as possible or use remote controlled hoses or water cannons.
- Cool the containers with plenty of water for a long time after the fire has been extinguished.
- Do not apply water to the point of leakage or the safety equipment to prevent obstruction by ice.
- Immediately move away if the hissing of the safety mechanisms becomes louder or if the tank discolours, and in this case beware of the risk of the tank exploding.

Response techniques

Transshipment

- Simultaneous transportation of ammonia and other products is impossible, except if the tanks are entirely segregated. Lightering must therefore only be carried out by a vessel specifically used for ammonia and by specialised personnel.
- Ammonia solutions are unloaded by pumping or by pressurised transfer.
- Liquefied ammonia is unloaded by submersible pumps or using a compressor. Inert gas containing carbon dioxide must not be used as ammonia reacts with carbon dioxide to produce an ammonium carbonate (in the presence of traces of water), made up of crystals which may block the channels. If there is no nitrogen onboard, use air for degassing and cargo transfer operations.
- To prevent risks of static electricity during transfer in tanks containing air, all pipes and reception tanks should be connected to the hull. Use fireproof materials.
- Degassing of tanks should be carried out by deflation (purging with air). Completely eliminating all the ammonia during cargo transfer or degassing is very difficult, due to its high solubility in water. Any slight trace of dampness will retain ammonia by absorption.
- The equipment which should be used for lightering are as follows:
 - carbon steel or untinned steel pipes
 - flange joints or welded joints; use tongue and groove flanges, designed for ammonia pipes.
- The materials recommended for handling ammonia are steel or stainless steel and PTFE joints (polytetrafluoroethylene or Teflon).
- The materials which should not be used are copper and its alloys, due to the corrosion caused by contact with ammonia.

Response

FICHE RÉFLEXE D'INTERVENTION ANTIPOLLUTION « PRODUITS » GAZ ET LIQUIDES ÉVAPORANTS ET SOLUBLES, FICHE ANTIPOLLUTION STRATÉGIES ET MOYENS N°5 : « DÉTECTION, MODÉLISATION ET REPÉRAGE » ; N°12 : « CONFINEMENT ET LUTTE DANS L'ATMOSPHÈRE »

In the case of tanks of ammonia, according to the case in hand it may be possible to seal the breach or plug the leak using a bung or inflatable cushion.

At sea

It is probably difficult to respond before all the product has evaporated or dissolved. Most of the time, it will be impossible to respond and action will be restricted to assessing the extent and the evolution of the gas cloud using prediction models, and to measuring the increase in pH as the gas dissolves in the water.

In inland waters and ports

It is generally impossible to contain a slick of liquid ammonia due to its evaporation and dissolution. If possible, treat the contained water and run-off.

On land

Prevent all polluted water from reaching drains and waterways by containing it using dykes or small basins. The liquid can then be neutralised with monosodium phosphate.

In the case of very small spills, pour a large quantity of water over the area and neutralise it. The addition of pressurised water will cause violent boiling until the ammonia is sufficiently diluted to form an aqueous solution which will then infiltrate the soil. This action must not be carried out in the case of a large pool of liquid ammonia.

Finally, it is useful for responders to understand the behaviour of ammonia in the water column. This behaviour is modelled using the CHEMMAP model for the simulation of chemical spills (see the "Accident scenarios" chapter).

Choosing personal protective equipment (PPE)

Ensure maximum protection in the case of high concentrations of ammonia

Choosing breathing apparatus

(FINGAS, 2000)

According to maximum use concentrations (MUC)²:

- wear a gas mask for concentrations of up to 300 ppm for a short period of time.
- use self-contained breathing apparatus (SCBA) above 300 ppm without time restrictions.

A hazmat suit must be worn if the ammonia concentration is liable to be high.

Choosing protective clothing

(CEFIC; ERICARD, 2005)

In all cases, a protective suit adapted to gas must be worn.

Protect response personnel against the heat emitted using a curtain of pressurised water or some other thermal protection system.

Protection by insulated underwear and gloves made of thick fabric or leather is recommended.

Consider wearing classic fire clothing underneath the suit.

Recommendations for use in the event of a spill

- Self-contained breathing apparatus (SCBA) provides the best protection as it supplies air from an uncontaminated source. The user is

independent of the surrounding atmosphere.

Certain facial characteristics such as a facial hair (even two day stubble), side-burns, scars, skin eruptions or glasses may prevent the mask from being watertight. Special frames exist for ordinary corrective glasses. However contact lenses can now be used, as new contact lenses allow for gas exchange and thus do not dry out or stick to the eyeball. Mask adjustment tests are recommended for new users and regular tests for other users in order to ensure optimal protection.

- Hose masks are suitable for static operations with a localised pollution risk; air line respirators are more suitable for mobile operations with diffuse or scattered pollution.

- Pressure demand and positive pressure, compressed air, open circuit, self-contained breathing apparatus have a protection factor of around 10,000, i.e. they can ensure protection against up to 200,000 ppm of ammonia in the surrounding air (ELV = 20 ppm).

- Use SCBA to respond to an emergency situation:

- if the oxygen concentration is, or is liable to become, less than 17% in volume
- if the toxic concentration reaches or exceeds values greater than the limit values or if it is unknown
- in the event of a fire.

² Maximum use concentrations can vary according to the make and model. Contact the manufacturer for more information.

Measures to take after using PPE in a spill situation

- Decontaminate boots after response. A foot bath and mild detergent can be used. Do not forget to treat the contaminated water.
- Decontaminate gloves separately from boots in a bucket with a mild detergent.
- Also decontaminate protective suits.

Permeation times through different materials (FORSBERG ET KEITH, 1995)

BETEX (butyl/neoprene): > 360 minutes.
Butyl: > 480 minutes.
Natural rubber: 2 minutes (variable).
Neoprene > 180 minutes.
Nitrile: 250 minutes (variable).
Polyvinyl chloride: 15 minutes (variable).
Teflon: > 300 minutes.
Viton: no trials conducted.

Measuring devices and waste treatment

Measuring devices

Methods of detection and determination in air and water: (INRS,1997)

- Colorimetric method by dosage using Nessler's reagent
- Potentiometric method using a specific electrode
- Dräger detection system using ammonia indicator tubes 5/a, 25/a, 0,5%/a
- Sampling of impregnated material and dosage by ion chromatography.

Waste treatment

Aqueous solutions of ammonia or polluted waters should not be directly discharged into drains or surface waters; they should first be neutralised, either at the spill location or at a water treatment plant.

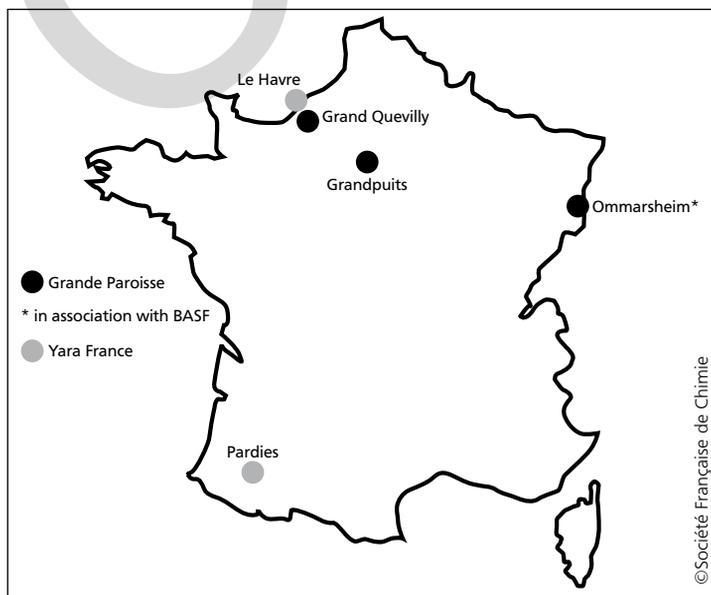
Addresses of special industrial waste treatment plants in France

The organisations able to treat this type of waste are listed at the following address:
<http://www.observatoire-dechets-bretagne.org> (French only).

European manufacturers of ammonia

Grande Paroisse, Yara, Kemira, Fertiberia, BASF, SKW, PCK Raffinerie, DSM, PFI, NRT, ACHEMA, ANWIL, Zakłady Azotow, ADP, AMI (Agrolinz).

Sites of ammonia production in France



Further information

- Glossary  E1
- Acronyms  E2
- Useful websites  E3
- Bibliography  E4
- Photo sources  E5

Centre

Glossary

Acceptable Daily Dose (ADD)

For humans this dose is the quantity of a substance that can be ingested by an organism per day for its entire lifetime without presenting a health hazard for the organism in question.

Acute Exposure Guideline Levels (AEGs)

Defined by the National Research Council's Committee on Toxicology (USA), AEGs are three levels above which the general population may experience certain effects. These three AEGs are given for five exposure times: 10, 30 min, 1, 4 and 8 hours.

AEGL 1: the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non sensory effects. However, the effects are transient and reversible when exposure ceases.

AEGL 2: the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL 3: the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Adsorption

Elevation of the concentration of a substance dissolved at the interface of a condensed phase and a liquid phase under the influence of surface forces. Adsorption can also occur at the interface of a condensed phase and a gas phase.

Aerosol

A mass of particles, solids or liquids in suspension in a gaseous environment.

Bioaccumulation

Continued retention of a substance in the tissue of an organism throughout the course of its existence (the bioaccumulation factor increases all the time).

Bioamplification

Retention of a substance in the tissue at increasingly higher concentrations the higher one goes in the food chain.

Bioconcentration

Retention of a substance in the tissue of an organism to the extent that the content of the substance in the tissue exceeds that found in nature at one point in the lifetime of the organism.

Bioconcentration factor (BCF)

Ratio of the chemical concentration in the exposed organism (minus the concentration in a control organism) to that in surrounding water.

Biotransformation

Biological transformation of substances in a living organism via enzymatic processes.

Boiling Liquid Expanding Vapour Explosion (BLEVE)

A violent vapour explosion of a liquid that is significantly above its usual boiling point at atmospheric pressure after a tank has burst.

Boiling point (measured at a pressure of 1 atmosphere)

Temperature at which a liquid begins to boil. More specifically, when the temperature at which saturating vapour pressure of a liquid is equal to standard atmospheric pressure (1,013.25 hPa). The boiling point measured depends on atmospheric pressure.

Buffering capacity

Capacity of a solution to absorb a certain quantity of acid or base without causing a significant variation in pH. In the marine environment, the buffering capacity is due to the dihydrogenocarbonate/carbonate balance.

Combustion rate

Rate at which an object subjected to fire will burn entirely.

Critical point

Point at which the temperature and pressure at which the intensive properties of a liquid and vapour (density, calorific value...) are equal. It represents the highest temperature (critical temperature) and pressure (critical pressure) at which a gas phase and a liquid phase of a given compound can coexist.

Critical pressure

Maximum pressure for which the distinction can be made between a gas and a liquid.

Critical temperature

Temperature at which, when boiling, there is no longer any clear cut transition between the liquid and the gas state.

Daily exposure dose

Dose (internal or external) of a substance in an organism compared to the weight of the individual and the number of days of exposure (in the case of a non carcinogenic substance) and the number of days lived by the organism (for a carcinogenic substance).

Decomposition products

Products stemming from chemical or thermal disintegration of a substance.

Diffusion coefficient in air (and in water)

A constant that describes the movement of a substance in the gas phase (or liquid phase) in response to a concentration differential in the gas phase (or liquid phase).

Effective concentration 50 (EC₅₀)

Concentration causing a given effect (mortality, growth inhibition...) for 50% of the population under consideration during a given period of time.

Emergency Response Planning Guidelines (ERPG)

The American International Health Alliance (AIHA) set three maximum concentrations in 1988 below which a category of effects is not expected for an exposure duration of one hour, in a bid to protect the general public.

ERPG1: is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly identifiable odour.

ERPG2: is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to protect themselves.

ERPG3: is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Exposure limit value (ELV)

Ceiling exposure value measured for a maximum duration of 15 minutes.

Flash point

The lowest temperature at which a substance generates vapours that ignite or burn immediately

when in contact with a flame.

Foam

The foam layer absorbs most of the vapours, physically eliminates vapours and isolates the chemical from sunlight and ambient air which reduces the amount of heat and subsequent vaporisation.

Henry's law constant

Value indicating a substance's volatility (see graph on p. 41)

Immediately Dangerous to Life or Health (IDLH)

Level below which a worker can escape to safety in thirty minutes in the event of sudden exposure to a dangerous atmosphere, without respiratory protection and without impairing his ability to escape.

Irreversible effect threshold (IET)

Concentration, for a stated exposure duration, above which irreversible effects can occur in the exposed population.

Lethal effect threshold (LET)

Concentration, for a stated exposure duration, above which mortality can be observed in the exposed population.

Lower Explosive Limit (LEL)

Minimum airborne concentration above which vapours ignite.

Lowest Observed Effect Concentration (LOEC)

Lowest concentration at which an effect is observed.

Marine pollutant

Substance, object or matter likely to cause serious damage to the marine environment when spilled.

Maximum Allowable Relief Valve Setting (MARVS)

Indicates the maximum admissible calibration of pressure relief valves of a cargo tank.

Mean exposure value (MEV)

Value that has been measured or estimated for a work station lasting 8 hours and is intended to protect workers from long term effects. MEV can be exceeded for very short periods providing the ELV value (should there be one) is not exceeded.

Median lethal concentration (LC₅₀)

Concentration of a substance deduced statistically that should, during or after exposure and for a given period of time, cause the death of 50% of the animals exposed during a given time period.

Melting point

Temperature at which solid and liquid state coexist. The melting point is a constant for a pure substance and is usually calculated at standard atmospheric pressure (one atmosphere).

Minimum Risk Level (MRL)

This level is an estimate of daily human exposure to a chemical which probably has no appreciable risk of non-carcinogenic noxious effect on health for a specific exposure duration.

Miscible

Matter that mixes readily with water

Nautical Mile

1 nautical mile is the equivalent of 1,852 metres and corresponds to one minute of latitude.

N-octanol/water partition coefficient (Kow)

Ratio of the equilibrium concentrations of a substance dissolved in a two phase system made up of two solvents that virtually do not mix.

No Observed Effect Concentration (NOEC)

Concentration of a substance measured during chronic toxicity tests for which no effect is observed, meaning that the substance presents no chronic toxicity below this concentration.

No Observed Effect Level (NOEL)

The highest dose of a substance that causes no distinct changes as compared with those observed in control animals.

Olfactory threshold

Minimum air or waterborne concentration to which the human nose is sensitive.

Partition coefficient for organic carbon and water (Koc) (for organic substances)

Ratio of the amount of compound absorbed per unit mass of organic carbon in the soil or in a sediment and the concentration of the same compound in a water solution in a state of equilibrium.

Photo-oxidation

Oxidation of a chemical compound caused by exposure to light energy.

Polymerisation

This term describes the chemical reaction generally associated with the production of plastics. Fundamentally, the individual molecules of a chemical (liquid or gas) react together to form a long chain. These chains can be used for many applications.

Protective equipment

This refers to the respiratory or physical protection of a human being. Protection levels have been defined, including both protective clothing and breathing apparatus as accepted by response authorities such as the USCG, NIOSH and the EPA (US).

Level A: an SCBA (self contained breathing apparatus/respirator) and fully air and chemical-tight suit (that resists permeation).

Level B: an SCBA and a suit that protects against liquid spray (splash proof).

Level C: a full face mask or goggles and a suit that protects responders against chemicals (splash proof).

Level D: overalls without a respirator.

Rate of evaporation or volatility (ether = 1)

The rate of evaporation expresses the number of times that a product takes to evaporate as compared with a control substance of an equal volume (ether for instance). This rate varies with the nature of the product and the temperature.

Regression speed

Speed at which a burning liquid slick reduces in thickness. For a given liquid, this speed is constant regardless of the slick surface (slick diameter greater than 2 metres). Regression speed allows the total duration of a fire to be estimated if no attempt is made to extinguish it.

e.g. a 1,000 mm thick slick, where the regression speed is 10 mm/minute
duration of fire = 1000/10 = 100 minutes.

Relative density

Ratio of the mass of a substance to that of water for a liquid or to that of air for a gas.

Relative vapour density

Weight of a volume of vapour or pure gas (without air) compared to that of an equal volume of dry air at the same temperature and pressure.

A vapour density lower than 1 indicates that the vapour is lighter than air and will have a tendency to rise. When the vapour density is higher than 1, vapour is heavier than air and will tend to stay near ground level and spread.

Self-ignition temperature

Minimal temperature at which vapours ignite spontaneously.

SCBA

Self-Contained Breathing Apparatus

Solubility

Quantity of a substance dissolved in water. It will depend on salinity and temperature.

Source of ignition

Examples of sources of ignition: heat, sparks, flame, static electricity and friction. Sources of ignition should always be eliminated when handling flammable products or responding to an emergency in risky areas (use explosion proof pumps and VHF walky-talkies).

Surface roughness

Length of a transfer area between the atmospheric layer and a contact surface. This will depend on the average size of the roughness of the contact and atmospheric parameters near the water surface. When the sea is calm it is of the order of 0.02 to 0.06 cm.

Surface tension

A constant that expresses the force owing to molecular interaction exerted at the surface of a liquid when it comes into contact with another surface (liquid or solid) and that affects surface dispersion.

Temporary Emergency Exposure Limits (TEEL)

Exposure times when there is no ERPG.

TEEL 0 is the threshold concentration below which a large part of the population will experience no effect on health. TEEL 1 is equivalent to ERPG1, TEEL 2 is equivalent to ERPG2 and TEEL 3 is equi-

valent to ERPG3.

Threshold Limit Value (TLV)

Average limit value (weighted as a function of time) that people can be exposed to regularly at work 8 hours a day, 5 days a week without experiencing noxious effects. This value was defined and determined by ACGIH.

TLV-STEL: Mean weighted 15 minutes concentration that must never be exceeded at any time during the day.

TLV-TWA: Mean weighted values for an 8 hour period per day and 40 hours a week.

TLV-ceiling Ceiling values never to be exceeded not even for an instant.

Unconfined Vapour Cloud Explosion (UVCE)

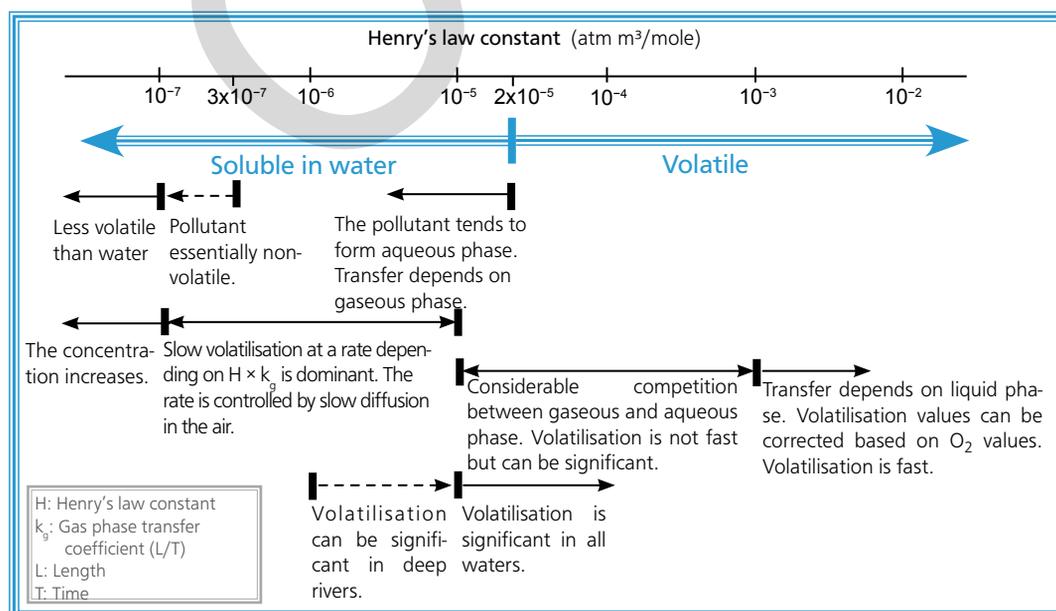
Explosion of a gas cloud or slick of combustible vapours in an unconfined environment.

Upper Explosive Limit (UEL)

Maximum airborne concentration of a compound above which vapours will not ignite for lack of oxygen.

Vapour pressure or tension

Partial pressure of gas molecules in a state of equilibrium with the liquid phase for a given temperature.



Characteristics of volatilisation associated with different Henry's law constant values (Lyman et al., 1990).

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
ADD	Acceptable Daily Dose
ADNR	European Agreement concerning International Carriage of Dangerous Goods on the Rhine river
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
AEGLs	Acute Exposure Guideline Levels
AFFF	Aqueous Film-Forming Foam
AFSSA	French National Agency for Food Safety
AIHA	American International Health Alliance
ALOHA	Areal Locations of Hazardous Atmospheres
ATSDR	Agency for Toxic Substances and Disease Registry
AUV	Autonomous Underwater Vehicle
BCF	Bio Concentration Factor
BLEVE	Boiling Liquid Expanding Vapour Explosion
CAS	Chemical Abstracts Service
CEA	French Atomic Energy Commission
CEDRE	Centre of Documentation, Research and Experimentation on Accidental Water Pollution
CEPIC	European Chemical Industry Council
CHRIS	Chemical Hazards Response Information System
CSST	French Occupational Health and Safety Commission
CSTEE	French Scientific Committee on Toxicity, Ecotoxicity and the Environment
DDASS	French Departmental Health and Social Action Directorate
DDE	French Departmental Equipment Directorate
DRASS	French Regional Department of Health and Social Affairs
DRIRE	French Regional Directorates for Industry, Research and Environment
EC	Effective Concentration
ECB	European Chemicals Bureau
EFMA	European Fertilizer Manufacturers Association
EINECS	European Inventory of Existing Chemical Substances
ELV	Exposure Limit Value
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guidelines
ETC	Environmental Technology Centre
GP	Grande Paroisse
HSDB	Hazardous Substances Data Bank
IARC	International Agency for Research on Cancer
IATA	International Air Transport Association
IBC	International Bulk chemical Code
ICSC	International Chemical Safety Cards
IDLH	Immediately Dangerous to Life or Health
IFREMER	French Research Institute for Exploitation of the Sea
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IMDG	International Maritime Dangerous Goods
IMO	International Maritime Organization
INCHEM	International Chemical industries, Inc.
INERIS	French National Institute for Industrial Environment and Risks
INRS	French National Research and Safety Institute for occupational risk prevention
IPCS	International Programme on Chemical Safety

IPSN	French Institute for Nuclear Safety and Protection
IUCLID	International Uniform Chemical Information Database
LC	Lethal Concentration
LEL	Lower Explosive Limit
LET	Lethal Effect Threshold
LLDPE	Linear Low Density PolyEthylene
LOEC	Lowest Observed Effect Concentration
MARPOL	Marine Pollution
MARVS	Maximum Allowable Relief Valve Setting
MCA	Maritime and Coastguard Agency
MEV	Mean Exposure Value
MFAG	Medical First Aid Guide
MP	Marine Pollutant
MRL	Minimum Risk Level
MSDS	Material Safety Data Sheet
MUC	Maximum Use Concentrations
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NOEC	No Observed Effect Concentration
OECD	Organisation for Economic Co-operation and Development
PEC	Predicted Effect Concentration
PID	Photo Ionisation Detector
PNEC	Predicted No-Effect Concentration
PPE	Personal Protective Equipment
ppm	Parts per million
PTBC	Para-tertiary-butylcatechol
PVC	Polyvinyl chloride
PVDC	Polyvinylidene chloride
PVDF	Polyvinylidene fluoride
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
ROV	Remote Operated Vehicle
SCBA	Self-Contained Breathing Apparatus
SEBC	Standard European Behaviour Classification system of chemicals spilled into the sea
SIDS	Screening Information Data Set
SIW	Special Industrial Waste
TEEL	Temporary Exposure Limits
TGD	Technical Guidance Document
TLV-ceiling	Threshold Limit Values – Ceiling
TLV-STEL	Threshold Limit Values - Short Term Exposure Limit
TLV-TWA	Threshold Limit Values - Time Weighted Average
TNO	Netherlands Organisation for Applied Scientific Research
TRANSAID	Agreement between UIC (French Chemical Industry Association) & the French Government
TROCS	Transport of Chemical Substances - database created by REMPEC
UEL	Upper Explosive Limit
UIISC	French Unit of Instruction and Intervention on Civil Security
US EPA	United States Environmental Protection Agency
UVCE	Unconfined Vapour Cloud Explosion
VCM	Vinyl chloride monomer
VHF	Very High Frequency
v/v	Volume to volume
WHO	World Health Organisation

Useful websites

AFSSA (French National Agency for Food Safety) (French only)

<http://www.afssa.fr>

ATSDR (Agency for Toxic Substances and Disease Registry)

<http://www.atsdr.cdc.gov>

Bonn Agreement

<http://www.bonnagreement.org>

CEFIC (European Chemical Industry Council)

<http://www.ericards.net>

Chemfinder. Chemical database.

<http://chemfinder.cambridgesoft.com>

CHRIS (Chemical Hazards Response Information System)

<http://www.chrismanual.com/findform.htm>

CSST (Occupational Health and Safety Commission)

<http://www.reptox.csst.qc.ca>

CTE (Environmental Technology Centre, Canada)

http://www.etc-cte.ec.gc.ca/etchome_e.html

ECB (European Chemicals Bureau)

<http://ecb.jrc.it>

GRANDE PAROISSE

<http://www.grande-paroisse.fr> (French only)

ICSC (International Chemical Safety Cards)

<http://www.cdc.gov/niosh/ipcs/ipcard.html>

INERIS (French National Institute for Industrial Environment and Risks)

<http://www.ineris.fr>

INRS (French National Research and Safety Institute for Occupational Risk Prevention)

<http://www.inrs.fr>

IPCS (International Program on Chemical Safety)

<http://www.inchem.org>

NIOSH (US National Institute for Occupational Safety and Health)

<http://www.cdc.gov/niosh/idlh/intridl4.html>

NOAA (National Oceanic and Atmospheric Administration)

<http://www.noaa.gov/ocean.html>

TROCS REMPEC database (Regional marine pollution emergency response centre for the Mediterranean Sea) on transportation of chemicals

<http://www.rempec.org/databases.asp?lang=en>

UIC (French Chemical Industry Association)

<http://www.uic.fr/index-us.htm>

US DEPARTMENT OF ENERGY, Chemical Safety Program: Revision 21 of ERPGs and TEELS for Chemicals of Concern

http://www.hss.energy.gov/healthsafety/wshp/chem_safety/

US EPA (US Environmental Protection Agency)

<http://www.epa.gov>

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Photo sources

p. 17: Tanker *Kemira gas*, © jtashipphoto.dk 2003 - 2006.

p. 43: *Derailed tank cars overturned and resting in ditch*.
Transportation Safety Board of Canada, 2001. Reproduced with the permission of the Minister of
Public Works and Government Services Canada, 2006.

p. 49: © Société Française de Chimie

ANNEXES

Annex 1: summary and additional physical and toxicological data

Annex 2: fax format data card

ANNEX 1: SUMMARY AND ADDITIONAL PHYSICAL AND TOXICOLOGICAL DATA

Classification

(CHRIS, 1999; INRS, 1997)

CAS n°: 7664-41-7
EC n° (EINECS): 231-635-3
UN n°: 1005
Index n°: 007-001-00-5
Class: 2

Physical data

Conversion factor in air:

1 ppm = 0.7 mg/m³

1 mg/m³ = 1.14 ppm

Molar mass: 17.03 g/mol

Volumic mass at 0°C and at 1 atm: 0.77 g/l

INRS, 1997

G.P. MSDS, 2005

Physical state

Appearance: gas

Colour: colourless

Odour: characteristic, irritating and pungent

Density

Density of liquid (water = 1): 0.7 at -33°C

Relative vapour density (air = 1): 0.6

ENVIRONMENT CANADA, 1985

G.P. MSDS, 2005

Solubility in fresh water

895 g/L at 0°C

529 g/L at 20°C

INERIS, 1999

G.P. MSDS, 2005; INERIS, 1999

pH of a 1% aqueous solution: 11.7

G.P. MSDS, 2005

Vapour pressure/tension

G.P. MSDS, 2005

°C	- 18	0	4.7	25	50.1	78.9
kPa	200	430	500	1013	2000	4000

Important temperatures

Melting point: - 77.7°C	G.P. MSDS, 2005
Boiling point at atmospheric pressure: -33.3°C	INERIS, 1997
Flash point: N/A	G.P. MSDS, 2005
Self-ignition point: 651°C (DIN 51794)	G.P. MSDS, 2005; ICSC, 1998
Critical point at 0.11 atm: 132.4°C	INRS, 1997

Other properties

Henry's law constant: 1.61 Pa.m ³ /mol	CALTOX, 1997
Diffusion coefficient:	
in air: 2.16×10 ⁻⁵ m ² /s	CALTOX, 1997
in water: 1.10×10 ⁻⁹ m ² /s	CALTOX, 1997
Viscosity:	
at - 33°C: 10.225 mPa.s	INERIS, 1997
at 0°C: 0.0092 mPa.s	ENVIRONMENT CANADA, 1985
at 20°C: 0.0098 mPa.s	ENVIRONMENT CANADA, 1985
Olfactory threshold: 5 to 25 ppm, very variable according to people	G.P. MSDS, 2005

Toxicological data

Threshold toxicological values

Occupational exposure values

MEV (France): 7 mg/m³ = 10 ppm

ELV (France): 14 mg/m³ = 20 ppm

TLV-TWA (ACGIH): 17 mg/m³ = 25 ppm

Risk management values for the population

IDLH (NIOSH): 210 mg/m³ = 300 ppm

TLV-STEL (ACGIH): 24 mg/m³ = 35 ppm

TEEL 0: 17.5 mg/m³ = 25 ppm

ERPG 1: 17.5 mg/m³ = 25 ppm

ERPG 2: 105 mg/m³ = 150 ppm

ERPG 3: 525 mg/m³ = 750 ppm

Specific effects

Effects on reproduction: no data available.

Carcinogenic effects: no carcinogenic effects according to the IARC.

Mutagenic effects: not mutagenic (Ames test with and without metabolic activation).

Chronic human toxicity

(INRS, 1997; ICSC, 1998; CHRIS, 1999; G.P. MSDS, 2005)

Repeated or prolonged exposure can create a certain tolerance, i.e. the irritating effects are detected at higher levels.

Acute human toxicity

(ICSC, 1998; CSST, 2000; INERIS, 2003)

Ammonia in the form of a gas is irritating and corrosive for:

- the skin: irritation
- the eyes: watering, burning sensation in eye, damage to corneas
- the upper respiratory tract (nose and throat): drying out of the nose, coughing, pains in chest, shortness of breath, suffocation.

In serious cases, laryngeal oedema can be observed, evolving towards pulmonary oedema and death by asphyxiation. The appearance of symptoms may take up to 48 hours after exposure.

Exposure to high concentrations causes bronchial irritation, but may also lead to corrosion of the skin, eyes and upper respiratory tract.

Direct contact with the liquefied gas causes corrosion of the eyes and skin.

Probable acute effects due to accidental exposure depend on the dose of gas.

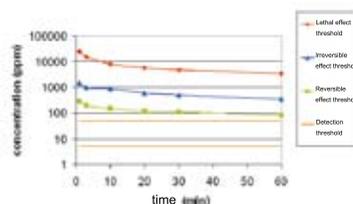
Toxicity indices

• Acute exposure guideline levels

AEGLs (INERIS, 2003)

Duration (minutes)	5	10	30	60
AEGL-1 (ppm)	25	25	25	25
AEGL-2 (ppm)	380	270	160	110
AEGL-3 (ppm)	3 800	2 700	1 600	1 100

• Acute toxicity levels in the case of accidental ammonia emission (INERIS, 2003)



• Thresholds established in France by the Ministry of Ecology and the Ministry of Health

Lethal effect threshold 1% (INERIS, 2003)

Time (minutes)	Concentration	
	mg/m ³	ppm
1	17 710	25 300
3	10 290	14 700
10	5 740	8 200
20	4 083	5 833
30	3 337	4 767
60	2 380	3 400

Lethal effect threshold 5% (INERIS, 2004)

Time (minutes)	Concentration	
	mg/m ³	ppm
1	19 623	28 033
10	6 183	8 833
20	4 387	6 267
30	3 593	5 133
60	2 543	3 633

Reversible effect threshold (INERIS, 2003)

Time (minutes)	Concentration	
	mg/m ³	ppm
1	196	280
3	140	200
10	105	150
20	84	120
30	77	110
60	56	80

Irreversible effect threshold (INERIS, 2003)

Time (minutes)	Concentration	
	mg/m ³	ppm
1	1 050	1 500
3	700	1 000
10	606	866
20	428	612
30	350	500
60	248	354

Detection thresholds (G.P. MSDS, 2005)

Olfactory threshold: 5 - 25 ppm
Irritation threshold: 50 - 100 ppm

Ecotoxicological data

Acute ecotoxicity (ECB, 2000)

Crustacean (<i>Daphnia magna</i>)	LC ₅₀ (48h) = 25.4 mg/L (fresh water)
Crustacean (<i>Ceriodaphnia reticulata</i>)	LC ₅₀ (48h) = 131 mg/L (fresh water)
Fish (<i>Sciaenops ocellata</i>)	LC ₅₀ (24h) = 0.9 mg/L (seawater)
Fish (<i>Carassius auratus</i>)	LC ₅₀ (24h) = 7.2 mg/L (fresh water)
Fish (<i>Cyprinus carpio</i>)	LC ₅₀ (96h) = 1.1 mg/L (fresh water)

Chronic ecotoxicity

Fish (<i>Ictalurus punctatus</i>)	NOEC (27 d) = 0.06 mg/L (fresh water) (ROBINETTE, 1976)
Crustacean (<i>Ceriodaphnia dubia</i>)	NOEC reproduction (3 generations) = 2 mg/L (fresh water) NOEC survival (3 generations) = 6.8 mg/L (fresh water) (COWGILL & MILAZZO, 1991)

PNEC (Predicted No-Effect Concentration): No PNEC can be established from the data obtained on only two trophic levels (invertebrates and fish). No valid data on algae is available in the literature.

ANNEX 2: FAX FORMAT DATA CARD

Ammonia Anhydrous ammonia	NH₃	CAS n°: 7664-41-7 EC N° (EINECS): 231-635-3 Index n°: 007-001-00-5 UN N°: 1005 Class: 2
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First aid information

Use breathing apparatus when rescuing someone in danger.

Remove the source of contamination or move the subject away from the polluted area.

Cover the victim.

Clouds of ammonia vapours can impede visibility.

Intoxication by inhalation

- Move the victim into the open air and lie them down.
- Give the victim air or oxygen intermittently if they have difficulty breathing.
- Prop the person up to a half-sitting position.
- Apply artificial respiration if the victim has stopped breathing.
- Transfer to hospital immediately.

Skin contact

- Remove clothing carefully, do not remove any clothing

which is stuck to the skin.

- In the case of frostbite causing material to stick to the skin, defrost with lukewarm water.
- Rinse the affected parts immediately at length (at least 15 minutes) with a light flow of lukewarm water.
- Do not rub the damaged skin.
- Consult a doctor.

Eye contact

- Immediately wash the eyes with plenty water for at least 15 minutes, keeping the eyelids open.
- Rinse with a buffer solution containing phosphate.
- Consult an ophthalmologist.

Intoxication by ingestion

For gases, this type of intoxication is considered as an unlikely way of exposure.

Physical data

Molar mass: 17.03 g/mol

Volumic mass at 0°C and at 101.3 kPa (1 atm): 0.77 g/L

Melting point: -77.7°C

Boiling point at atmospheric pressure: -33.3°C

Critical point at 11,480 kPa (0.11 atm): 132.4°C

pH of a 1% aqueous solution: 11.7

Viscosity: 10.225 mPa.s at -33°C
0.0092 mPa.s at 0°C
0.0098 mPa.s at 20°C

Relative density (water = 1): 0.7 at -33°C

Relative vapour density (air = 1): 0.6

Solubility: 895 g/L at 0°C
529 g/L at 20°C

Olfactory threshold: 5 to 25 ppm, very variable according to people

Diffusion coefficient in water: 1.10×10^{-9} m²/s

Diffusion coefficient in air: 2.16×10^{-5} m²/s

Henry's law constant: 1.61 Pa.m³/mol

Vapour pressure/tension

°C	-18	0	4,7	25	50,1	78,9
kPa	200	430	500	1013	2000	4000

E.U. Classification:



T: toxic



N: dangerous for the environment

R10: Flammable

R23: Toxic by inhalation

R34: Causes burns.

R50: Very toxic to aquatic organisms.

S1/2: Keep locked up and out of the reach of children.

S9: Keep container in a well ventilated place.

S16: Keep away from sources of ignition. No smoking.

S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

S36/37/39: Wear suitable protective clothing, gloves and eye/face protection.

S45: In case of accident or if you feel unwell, seek medical advice immediately (show label where possible).

S61: Avoid release to the environment. Refer to special instructions/safety data sheet.

Information on flammability

Ammonia does not readily burn in air without the addition of a hydrocarbon or a catalyst. In certain conditions, there is a danger of explosion in the case on containment of energy input.

Flash point: N/A

Self-ignition point: 651°C

Combustion rate: 0.07 m/s

Explosive limit, % by volume in air at 0°C:

LEL 15 % or 150,000 ppm

UEL 28 % or 280,000 ppm

Toxicological data

Acute human toxicity

Ammonia in the form of a gas is irritating and corrosive for:

- the skin: irritation
- the eyes: watering, burning sensation in eye, damage to corneas
- the upper respiratory tract (nose and throat): drying out of the nose, coughing, pains in chest, shortness of breath, suffocation.

In serious cases, laryngeal oedema can be observed, evolving towards pulmonary oedema and death by asphyxiation. The appearance of symptoms may take up to 48 hours after exposure. Exposure to high concentrations causes bronchial irritation, but may also lead to corrosion of the skin, eyes and upper respiratory tract. Direct contact with the liquefied gas causes corrosion of the eyes and skin.

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Repeated or prolonged exposure can create a certain tolerance, i.e. the irritating effects are detected at higher levels.

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NOEC reproduction (3 generations) = 2 mg/L (fresh water)
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PNEC (Predicted No-Effect Concentration): No PNEC can be established from the data obtained on only two trophic levels (invertebrates and fish). No valid data on algae is available in the literature.

Persistence in the environment

Ammonia is present in its natural state in the environment. It is a product of the biological breakdown of nitrogen-containing matter, such as amino acids. Ammonia is also a natural compound, required by most organisms for protein synthesis; it is a waste product of metabolism in animals, fish and microbes.

Risk for the environment

Ammonia is toxic for aquatic species. Its toxicity heavily depends on the PH of the water and the total ammonia concentration, i.e. that of the non-ionised ammonia: NH₃ and the ammonium ion: NH₄⁺. The ionised form NH₄⁺ predominates in most natural waters and is not very toxic. However, in alkaline waters, non-ionised ammonia NH₃ can reach toxic levels. This toxicity increases with the salinity and temperature.

Breakdown

In the ground: ammonia exists in the form of NH₄⁺ ammonium ions. These ions can be immobilised in the ground and undergo nitrification, i.e. a transformation into NO₂⁻ then NO₃⁻ nitrites, more mobile than NH₄⁺ ions. They can be carried into underground water reservoirs by washing, or react with organic matter.

In water: ammonia is eliminated from the water system by evaporation, transformation into NH₄⁺ which undergoes nitrification into NO₂⁻ then NO₃⁻ or by adsorption onto particles in suspension.

In air: part of the ammonia is oxidised to form nitrogen oxides and nitrates. The rest combines with sulphates present in the atmosphere. The ammonia remains in the atmosphere for 5 to 10 days.

Bioaccumulation

Ammonia is continually produced in the environment either directly by organisms which give it off (some fish for instance) or indirectly through the breakdown of proteins excreted by these organisms.

The environment is used to managing this molecule, which many bacteria are specialised in eliminating. Consequently, this inorganic molecule is not found in the environment and is neither persistent nor bioaccumulable.

Partition coefficient for organic carbon and water (K_{oc}):
N/A

Partition coefficient for octanol and water (K_{ow}):
-1.14 at 25°C

Bioconcentration factor (BCF): N/A

MARPOL classification: N/A
SEBC Classification: GD

Particular risks

Danger

- Releases of ammonia present different characteristics according to the physical storage conditions and the type of spill:

• **Sudden release of ammonia gas from a pressurised container (discharge of the gaseous part):** due to its high volatility (Henry's law constant: 1.6×10^{-5} atm.m³/mole), ammonia gas will spread over the water surface or the ground and will initially form a cloud of vapours. In air, the gas will behave like a heavy gas, despite its relative density of 0.6. This can be explained by the formation of an aerosol at low temperatures, made up of liquid or droplets in suspension in a gaseous environment. The gas mixture, under the influence of environmental conditions, will rise and be moved around by the wind.

• **Sudden release of ammonia in biphasic form (gas and liquid) from a pressurised container (discharge of the liquid part):** production of a gas and an aerosol, in the form of a cold, white plume, heavier than air. It behaves like a heavy gas and can travel several hundred metres just above the ground surface. If the source of leakage is stopped, the aerosol will completely dissipate after a few minutes. The cloud of ammonia is relatively cold and causes the water vapour it meets on its journey to condense until the plume is warmed by dilution with the air. The cloud moves at wind speed and after complete vaporisation the gas becomes lighter than air and disperses.

• **Evaporation of a pool of liquid ammonia (according to conditions of release):** ammonia is depressurised at atmospheric pressure and at temperatures lower than or equal to -33°C, and chills surrounding materials (for instance the ground). Evaporation is initially high and gradually decreases. Dry, porous ground will absorb liquid ammonia without releasing gases. Water should not be poured over a pool of ammonia, as the heat of the water and the dissolving action will trigger a high level of evaporation.

• **Leak of liquid ammonia from a cold storage facility:** the behaviour of the product is identical to that of the previous case; the leaked ammonia will be subject to little depressurisation and most often only a negligible proportion of the ammonia which escapes will be transformed into vapours.

- When ammonia gas dissolves in water, heat is released.
- When a receptacle containing ammonia is heated, there is an increase in pressure leading to a risk of the container bursting and immediately releasing a cloud of toxic vapours.
- Rapid depressurisation of a container can present a danger by producing a shock wave.
- When burnt, ammonia can give off toxic or irritating fumes.
- Direct contact with liquefied ammonia can cause frostbite and serious ocular lesions.
- Pierced gas canisters can propel themselves violently.
- Ammonia in the form of liquefied gas rapidly attacks copper, zinc, silver and tin, as well as many alloys, particularly those containing copper. It also acts on gold, silver and mercury to produce explosive compounds.

Stability and reactivity

At ordinary temperatures, ammonia gas is a stable compound. Conditions to be avoided: breaks down at over 450°C to produce nitrogen and hydrogen.

Substances to be avoided: mineral or organic acids, reactive metals and metalloids (calcium, sodium, zinc, mercury...), oxidants and peroxides due to the violent and/or explosive reactions caused.

Transportation	Handling	Storage
<p>General data: Class: 2 Toxic gas & Corrosive Labels: 2.3 + 8</p> <p>Land transportation: RID / ADR Hazard classification: 268 Classification code: 2TC</p> <p>Transportation via inland waterways: ADN/ADNR Classification code: 2TC</p> <p>Maritime and air transportation: IMDG/IATA Marine pollutant (MP): No Subsidiary risk: 8</p>	<ul style="list-style-type: none"> - Refer to supplier's instructions for information on handling container. - Only use specialised equipment suitable for this product and its pressure and temperature. Contact the ammonia supplier if there is any doubt. - Prevent the product from rising up in the container. - Prevent suction of water into the container. - Keep away from all sources of ignition (including static charges). - Purge the air in the installation before introducing the gas. - Always handle pressurised canisters with care, do not drag or slide them across the ground and prevent blows. 	<p>Technical precautions</p> <ul style="list-style-type: none"> - Store containers in a well ventilated place, at a temperature lower than 50°C. - Keep away from oxidising gases and other oxidising agents. - Store the containers vertically, out of direct sunlight and away from heat and products liable to react violently with the ammonia. The containers should be tightly closed and clearly labelled. - Store on impermeable ground with a retention tank so that in the event of a spill the solutions do not spread outside the storage facility. - Ground the tanks and ensure that the electric wiring is watertight. - Do not smoke. <p>Incompatible products Non ferrous metals (copper, zinc, tin, silver) and their alloys.</p> <p>Recommended packaging materials Bulk transportation: carbon steel/stainless steel. Gas canisters: stainless steel except type T1.</p>