1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1 Product identifiers

Commercial Product Name:	**PiaNOx® - A**
Substance name:	**Ammonia**
Chemical Formula:	NH3
CAS-No.:	7664-41-7
Index-No.:	007-001-00-5
EC-No.:	231-635-3
REACH Registration Number:	01-2119488876-14-0029

1.2 Identified uses

For nitrogen and Sulphur removal from combustion exhaust gases.

ERC1 (PROC 1, 2, 8b, 15); ERC2 (PROC 1, 2, 3, 8b, 9, 15); ERC 7 (PROC 1, 3, 8b,9); ERC6b (PROC 1, 2, 8a, 8b); ERC7 (PROC 1, 3, 8b, 9); ERC6a (PROC 1, 2, 3, 4, 8b, 9, 15)

1.3 Details of the supplier of the safety data sheet

SKW Stickstoffwerke Piesteritz GmbH
Möllensdorfer Str. 13
06886 Lutherstadt Wittenberg, Deutschland

Telephone: +49 3491 68 0
Telefax: +49 3491 68 4300

E-mail address: SDB@skwp.de

1.4 Emergency telephone number

SKW: +49 3491 68 2202
24-hour emergency number of the GGIZ: +49 361 730 730
National emergency number EU: https://echa.europa.eu/de/support/helpdesks/

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No 1272/2008 [CLP]:

Hazard class / Hazard category	Hazard statements	Classification procedure
Flam. Gas 2	H221	according to the Globally Harmonized System
Press. Gas	H281	according to the Globally Harmonized System
Acute Tox. 3	H331	according to the Globally Harmonized System
Skin Corr. 1B	H314	according to the Globally Harmonized System
Aquatic Acute 1	H400	according to the Globally Harmonized System

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008 [CLP]:

Product identifier: PiaNO® - A
Index-No.: 007-001-00-5
EINECS-No.: 231-635-3

Hazardous components which must be listed on the label:

- Ammonia, anhydrous

Hazard pictograms:

GHS04 GHS05 GHS06 GHS09

Signal word: Danger

Hazard statements:

H221	Flammable gas.
H281	Contains refrigerated gas; may cause cryogenic burns or injury.
H314	Causes severe skin burns and eye damage.
H331	Toxic if inhaled.
H400	Very toxic to aquatic life.

Precautionary statements:

P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P273	Avoid release to the environment.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P303 + P361 + P353	IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P311	Call a POISON CENTER/ doctor.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.

2.3 Other hazards

Adverse human health effects and symptoms:
Eye Dam. 1; H318 - Causes serious eye damage. EUH071 - Corrosive to the respiratory tract.

Potential environmental effects:
Aquatic Chronic 2; H411 - Toxic to aquatic life with long lasting effects.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substance related information

Chemical identity:	Ammonia
Index-No.:	007-001-00-5
EC-No.:	231-635-3
REACH Registration Number:	01-2119488876-14-0029
CAS-No.:	7664-41-7
Purity:	> 99,7 %
Molecular formula:	NH3

Additional advice:

Thise substance does not meet the PBT-/vPvB criteria of REACH, annex XIII.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General Information:	First aider needs to protect himself. Take off all contaminated clothing immediately. Call a physician immediately. Victim to lie down in the recovery position, cover and keep him warm. In case of shortness of breath, give oxygen. Move victims to fresh air and do not leave them without supervision.
If inhaled:	Call a physician immediately. No artificial respiration, mouth-to-mouth or mouth to nose. Use suitable instruments/apparatus. In case of accident by inhalation: remove casualty to fresh air and keep at rest. Ensure the presence of fresh air.
In case of skin contact:	Wash off immediately with plenty of water. Wash frost-bitten areas with plenty of water. Do not remove clothing. Call a physician immediately.
In case of eye contact:	Immediately flush eye(s) with plenty of water. Call a physician immediately.
If swallowed:	Call a physician immediately.

4.2 Most important symptoms and effects, both acute and delayed

Symptoms of poisoning may not appear for several hours. Keep under medical supervision for at least 48 hours.

4.3 Indication of any immediate medical attention and special treatment needed

Symptoms:
Shortness of breath. Cough. Unconsciousness. Aspiration may cause pulmonary oedema and pneumonitis. Risk of frostbite.

Hazards:
Later control for pneumonia and lung oedema.

Treatment:
Control of circulatory system, shock therapy if needed. Oxygen, if needed. Treat frost-bitten areas as needed. Early administration of cortisone spray.

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media:	Foam. Water. Water mist. Water spray jet.
Unsuitable extinguishing media:	High volume water jet. Do not let water come into contact with liquid ammonia.

5.2. Special hazards arising from the substance or mixture

Vapours may form explosive mixtures with air. Changes quickly into gaseous form. In presence of air, forms cold mists which have poisonous and corrosive effects and which are heavier than air.

5.3 Advice for firefighters

Self-contained breathing apparatus (EN 133). Complete suit protecting against chemicals.

Additional advice:

Collect contaminated fire extinguishing water separately. This must not be discharged into drains. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Cool containers/tanks with water spray.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Provide sufficient air exchange and/or exhaust in work rooms. Keep people away from and upwind of spill/leak. Remove all sources of ignition. Move unprotected people to a safe area. Equip personnel with a complete gasproof suit protecting against chemicals and a self contained breathing apparatus. When using liquid ammonia protect personnel from freezing injuries. Use of woollen gloves and warm underwear is necessary.

6.2 Environmental precautions

Suppress (knock down) gases/vapours/mists with a water spray jet. Do not let enter drains/ surface water/ ground water.

6.3 Methods and materials for containment and cleaning up

Do not direct water spray onto the leak. Put into suitable containers and take for recycling or disposal. Use respiratory protection during cleaning up.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Handle substance within a closed system. Provide sufficient air exchange and/or exhaust in work rooms.

Fire prevention measures: Keep away from heat and sources of ignition. Handle exclusively in the open or in explosion proof areas. Provide emergency cooling in case of a fire in the vicinity.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage areas and containers: Keep containers tightly closed in a cool, well-ventilated place. Keep away from heat. Avoid subsoil penetration. Handle exclusively in the open or in explosion proof areas. Keep and store locked up, with access only for competent personnel. Provide (catchment area) containment bund without drain. Provide alkali-resistant floor. Only use containers specifically approved for this substance.

German storage class: **2A** - Compressed, liquefied or pressurised gas

7.3 Specific end use(s)

none

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Exposure limit(s):

Components	CAS-No.	Control parameters	Ceiling Limit Value		Update	Basis
Ammonia, anhydrous	7664-41-7	20 ml/m³ 14 mg/m³	I (2)	AGW	12/2007	TRGS 900

Biological occupational exposure limits: none

DNEL - Workers:	
dermal, Acute systemic effects, Long-term systemic effects	6.8 mg/kg - relative to NH_3
inhalative, Acute systemic effects, Long-term systemic effects	47.6 mg/kg - relative to NH_3

DNEL - Consumers:	
dermal, Acute systemic effects, Long-term systemic effects	6.8 mg/kg - relative to NH_3
inhalative, Acute systemic effects, Long-term systemic effects	23.8 mg/kg - relative to NH_3
oral, Acute systemic effects, Long-term systemic effects	6.8 mg/kg - relative to NH_3

PNEC - aquatic:	
Marine water	0.0011 mg/l - free ammonia
aquatic, freshwater	0.0011 mg/l - free ammonia

8.2 Exposure controls

Personal protective equipment:

Eye/face protection: Tightly fitting safety goggles. Ensure that the type of material and the quality of the body protective equipment correspond with the recommendations of the producer for your particular type of work.

Hand protection: Protective gloves for chemicals Ensure that the type of material and the quality of the body protective equipment correspond with the recommendations of the producer for your particular type of work. Follow EN 374.

Skin and body protection: Complete suit protecting against chemicals. Ensure that the type of material and the quality of the body protective equipment correspond with the recommendations of the producer for your particular type of work.

Hygiene measures: When using do not eat, drink or smoke.

Respiratory protection: In case of insufficient ventilation, wear suitable respiratory equipment. Self-contained breathing apparatus (EN 133). For a short time, respirator with filter, filter type K.

General protective measures:

Avoid contact with skin. Do not breathe vapours or spray mist. Avoid contact with eyes.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

Physical state	Liquefied gas	
Colour	colourless	
Odour	ammoniacal, stinging	
pH	ca. 11	Concentration: 0.35 %
Melting point/range	-77.7 °C	Pressure: 1013 hPa
Initial boiling point	-33.4 °C	Pressure: 1013 hPa
Flash point		Not applicable
Ignition temperature	651 °C	
Vapour pressure (20 °C)	8611 hPa	

Vapour pressure (50 °C)	20340 hPa	
Vapour density (Air = 1.0)	0.596	Temperature: 20 °C relative to air
Relative density (-33,4 °C)	0.682 g/cm3	Pressure: 1013 hPa liquid
Relative density (0 °C)	0.771 g/l	Pressure: 1013 hPa gas
Water solubility (20 °C)	482 - 531 g/l	
Partition coefficient: n-octanol/water		inorganic substance, Not applicable
Viscosity, dynamic		Not applicable
Auto-flammability	not auto-flammable	
Upper explosion limit	28 %(V)	
Lower explosion limit	15 %(V)	

9.2 Other data

none

10. STABILITY AND REACTIVITY

10.1 Reactivity

Vapours may form explosive mixture with air. With acids and strong oxidising agents.

10.2. Chemical stability

No decomposition if stored and applied as directed.

10.3 Possibility of hazardous reactions

With acids and strong oxidising agents. Vapours may form explosive mixture with air. Because of the high vapour pressure the containers can burst with increased temperature.

10.4. Conditions to avoid

Keep away from heat and sources of ignition.

10.5. Incompatible materials to avoid

Strong acids and oxidizing agents, Corrodes copper and brass.

10.6 Hazardous decomposition products

Hazardous decomposition products: Hydrogen. In case of fire, nitrous gases are possible.

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute oral toxicity:
Dose LD50: 350 mg/kg
Species: Rat
Method: OECD Test Guideline 401

Acute inhalation toxicity:
Dose LC50: 9850 ppm
Exposure time: 1 h
Species: Rat

Dose LC50: 13770 ppm
Exposure time: 1 h
Species: Rat

Acute dermal toxicity: Study not provided with scientific basis. Corrosive.

Skin irritation: Study not provided with scientific basis. Corrosive.

Eye irritation: Study not provided with scientific basis. Corrosive.

Sensitisation: **Result:** Not sensitizing.

Ames test: **Result:** Non mutagenic

Mutagenicity (micronucleus test): **Result:** Non mutagenic

Carcinogenicity:	**Application Route:**	oral
	Species:	Rat
	Result:	Animal testing did not show any carcinogenic effects.
Subacute toxicity:	**Application Route:**	oral
	NOAEL:	68 mg/kg
	Exposure time:	35 Days
	Application Route:	Inhalation
	NOAEL:	63 mg/kg
	Exposure time:	50 Days
	Result:	The substance or mixture is not classified as specific target organ toxicant, repeated exposure.
Reproductive toxicity:	**Application Route:**	oral
	Species:	Rat
	NOAEL F2	408 mg/kg
	Result:	none
Teratogenicity:	**Application Route:**	oral
	NOAEL:	100 mg/kg
	Species:	Rabbit
	Result:	none
Other data:	Toxic by inhalation. The product causes burns of eyes, skin and mucous membranes. Symptoms may be delayed. Risk of frostbite.	

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish:	**Dose LC50:**	0.89 mg/l
	Species:	Oncorhynchus mykiss (rainbow trout)
	Exposure time:	96 h
	Dose EC50:	101 mg/l
	Species:	Daphnia (water flea)
	Exposure time:	48 h
Toxicity to algae:	**Dose EC50:**	2700 mg/l
	Species:	Scenedesmus capricornutum (fresh water algae)
	Exposure time:	18 Days
Chronic toxicity to aquatic organisms:	**Dose LOEC:**	0.022 mg/l
	Species:	Oncorhynchus mykiss (rainbow trout)
	Exposure time:	73 Days
	Dose NOEC:	79 mg/l
	Species:	Daphnia magna (Water flea)
	Exposure time:	96 h

12.2 Elimination information (persistence and degradability)

Biological degradability: Readily biodegradable.

12.3 Bioaccumulative potential

Result: Does not bioaccumulate.

Partition coefficient: n-octanol/water inorganic substance
Not applicable

12.4 Mobility in soil

After release, adsorbs onto soil.

12.5 Results of PBT and vPvB assessment

Result: The substance does not meet the criteria for PBT or vPvB according to Regulation (EC) No 1907/2006. Annex XIII.

12.6 Endocrine disrupting properties

No data available.

12.7 Other adverse effects

Additional ecological information: Very toxic to aquatic organisms. Depending on local conditions and actual concentrations, addition into adapted biological water treatment plants can damage the degradation activity of activated sludge.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Waste key for the unused product:

16 05 04 gases in pressure containers (including halons) containing hazardous substances

Waste from residues:

Contact manufacturer. Can be used after re-conditioning.

Contaminated packaging:

Empty pressurised containers must be returned to the supplier with a residual pressure.

14. TRANSPORT INFORMATION

Land transport (ADR/RID/GGVSEB):

UN number:	**1005**
Proper technical name:	AMMONIA, ANHYDROUS
Class:	2
Hazard Identification Number:	268
Classification Code:	2TC
Packing group	
Labels:	2.3 + 8
Tunnel restriction code:	(C/D)
Labelling:	Dangerous for the environment

Sea transport (IMDG-Code/GGVSee):

UN number:	**1005**
Proper technical name:	AMMONIA, ANHYDROUS
Class:	2.3
Packing group	
Labels:	2.3 + 8
Marine pollutant:	no
EmS:	F-C, S-U

15. REGULATORY INFORMATION

National legislation (Germany):

Major Accident Hazard Legislation: 12. BImSchV app. I

Water contaminating class (Germany): WGK 2, obviously hazardous to water

TA Luft List (Germany): Paragraph 5.2.4 class III NH3

Other regulations:

TRG 280 "General requirements for pressurised gas containers, Working with pressurised gas containers"
TRG 101 "Pressurised gases, Gases"
BGV B6 "Gases"
Work restrictions for young people.
Occupational restrictions for pregnant and breast feeding women

15.2 Chemical safety assessment:

A Chemical Safety Assessment has been carried out for this substance.

16. OTHER INFORMATION

Relevant R-, H- and EUH-phrases (Number and full text):

H221:	Flammable gas.
H281:	Contains refrigerated gas; may cause cryogenic burns or injury.
H314:	Causes severe skin burns and eye damage.
H331:	Toxic if inhaled.
H400:	Very toxic to aquatic life.

Further information:

The data corresponds to our current knowledge and describes our product with regard to safety requirements. Therefore the data is not meant to warranty certain properties of the product. It is the responsibility of the receiver of our product to comply with current legislation and regulations.

17. ANNEX : EXPOSURE SCENARIO (Annex to extended Safety Data Sheet (eSDS))

Downstream user Exposure Scenario for Ammonia

Exposure Scenario 1: Manufacture of Ammonia

1	Exposure Scenario 1

Manufacture of anhydrous ammonia

Processes Covered:
Environmental Releases
ERC1: Manufacture of substances
Worker Processes

PROC01: Use in closed process, no likelihood of exposure.
PROC02: Use in closed, continuous process with occasional controlled exposure.
PROC08a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities.
PROC08b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities.
Anhydrous ammonia (>99.5 % wt) is manufactured by high temperature and pressure synthesis in large facilities. A typical ammonia-producing industrial plant first coverts natural gas (e.g. methane), liquefied petroleum gas (e.g. propane and butane) or petroleum naphtha into gaseous hydrogen. The method for producing hydrogen from hydrocarbons is referred to as “steam reforming”. Several processes are involved in producing hydrogen from a natural gas feedstock including sulphur and carbon dioxide removal and methanation to remove any small residual amounts of carbon dioxide or carbon monoxide. Catalytic shift conversion is used to convert CO to CO_2 and hydrogen. Hydrogen is then catalytically reacted with nitrogen (derived from air) in the ratio 3:1 by volume and compressed to around 200 times atmospheric pressure (up to 1000 atm or 100 megapascals) at high temperatures of around 700°C to form anhydrous liquid ammonia. This step is known as the ammonia synthesis loop (e.g. the Haber-Bosch process).

Contributing Environmental Scenario: Environmental exposure arising from the manufacture of anhydrous ammonia.

Contributing Worker Scenarios: Worker exposure arising due to day to day use in closed processes with no likelihood of exposure, day to day use in closed continuous processes with occasional exposure (such as sampling) and Transfer of substance to and from vessels and containers**.**

2.1	Contributing scenario 1 controlling environmental exposure for ES 1

Environmental exposure arising due manufacture of anhydrous ammonia.

Section 2.1 describes the environmental releases that may occur during the manufacture of Ammonia. These releases may occur due to emission to wastewater or through emission to the atmosphere. If emission to wastewater occurs on-site treatment in an industrial waste water treatment plant will be required in order to remove downstream emissions to the environment.
In reality removal of ammonia in sewage treatment plants is highly efficient being removed first by nitrification to nitrate followed by denitrification resulting in the release of nitrogen gas. It is considered that if these processes are employed complete removal from the wastewater stream will occur. Emissions to the atmosphere should not exceed concentrations of 40 mg/m^3.

Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 48200-53100 mg/L. Anhydrous ammonia is considered to be flammable.
Amounts used
Production sites may manufacture up to a largest individual site value of 950,000 tonnes per annum, with approximately 6.5 million tonnes produced per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use
Frequency of use is estimated to be 220 days per year, with a standard 8 hour working day.
Environmental factors not influenced by risk management
Flow rate of receiving water at least 18,000 m^3 per day. Dilution of STP emissions at least 10 fold.
Other operational conditions affecting environmental exposure
Production takes place in a highly specialized indoor facility with emissions to air being controlled. Reactions are performed under closed conditions, with transfer pipelines are either fully or partially closed systems. Emission via wastewater is prevented by on-site WWTP processes. Manufacturing processes may be indoor or outdoor.
Technical conditions and measures at process level (source) to prevent release
Manufacture is carried out indoors or outdoors in dedicated facilities. Losses to surface water or the municipal STP should be prevented by nitrification to nitrate followed by denitrification resulting in the release of nitrogen gas. With regards to environmental emissions the loss of aqueous ammonia is most relevant as once the anhydrous ammonia reacts with wastewater or atmospheric moisture aqueous ammonia will be formed.
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil
Waste water should be emitted to the on-site WWTP for specialized removal. Emissions to air from manufacturing or from the onsite WWTP should not exceed a concentration of 40 mg/m^3 of air. This is approximately equivalent to a total loss to air of 140,000 kg/day. Sludge from the on-site WWTP should not be spread to soil. Any solid waste will be sent as waste for landfill, incineration or recycling.
Organizational measures to prevent/limit releases from site
Workers are fully trained in order to prevent accidental release and exposures may be monitored to ensure airborne concentrations are within acceptable levels.
Conditions and measures related to municipal STP
Direct emissions to the municipal STP should not be made.
Conditions and measures related to external treatment of waste for disposal
Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the manufacturing process. Sludge from the onsite WWTP should be recycled, incinerated or sent to landfill.
Conditions and measures related to external recovery of waste
There is no envisaged external recovery of waste. Waste sludge is reduced and then incinerated and emissions to air are not collected.

2.2	**Contributing scenario 2 controlling worker exposure for day to day use in closed processes with no likelihood of exposure.**

Worker exposure arising due to day to day use in closed processes with no likelihood of exposure during the manufacturing process.

Section 2.2 describes the potential exposure to workers during the manufacture of anhydrous ammonia from operation of closed systems with occasional potential for exposure during tasks such as sampling, maintenance and cleaning. The potential exposure arises from the operation of the reactor and its associated machinery.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Manufactured anhydrous liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia). During tasks such as cleaning and sampling, suitable protective clothing and equipment is available.

Product characteristics
The produced substance is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000mg/L. Anhydrous ammonia is considered to be flammable.
Amounts used
Production sites may produce up to 950,000 tonnes per annum, with approximately 6.5 million tonnes produced per year in the European Union.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential for exposure during manufacture is generally considered to be of short duration, with limited potential for exposure. Tasks such as maintenance are carried out only rarely. Exposure to workers was assessed taking into account different operational conditions that may be associated with the manufacturing of anhydrous ammonia and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90 % protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposure concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.
Human factors not influenced by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
During the manufacture of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not required.
Technical conditions and measures at process level (source) to prevent release
If being carried out indoors the transfer of the substance from the reactor vessel and the operation of the reactor vessel itself takes place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the reactor and associated machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia when operating equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal

loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.3	**Contributing scenario 3 controlling worker exposure due to day to day use in closed continuous processes with occasional exposure (such as sampling)**

Worker exposure arising due to day to day use in closed continuous processes with occasional exposure (such as sampling).

Section 2.3 describes the potential exposure to workers during the manufacture of anhydrous ammonia from operation of closed systems with occasional potential for exposure during tasks such as sampling, maintenance and cleaning. The potential exposure arises from the operation of the reactor and its associated machinery. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Manufactured anhydrous liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia). During tasks such as cleaning and sampling suitable protective clothing and equipment is available.

Product characteristics

The produced substance is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 48200-53100 mg/L. Anhydrous ammonia is considered to be flammable.

Amounts used

Production sites may manufacture up to 950,000 tonnes per annum, with approximately 6.5 million tonnes produced per year in the European Union.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential for exposure during manufacture is generally considered to be of short duration, with limited potential for exposure. Tasks such as maintenance are carried out only rarely.
Exposure to workers was assessed taking into account different operational conditions that may be associated with the manufacturing of anhydrous ammonia and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90 % protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposure concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the manufacture of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not required.

Technical conditions and measures at process level (source) to prevent release

If being carried out indoors the transfer of the substance from the reactor vessel and the operation of the reactor vessel itself takes place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the reactor and associated machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.

Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills, normal loading and unloading operations, cleaning and maintenance. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.4	**Contributing scenario 4 controlling worker exposure for transfer of produced ammonia to and from vessels and containers**

Worker exposure arising due to transfer of produced ammonia to and from vessels and containers.

Section 2.4 describes the potential exposure to workers during the transfer of manufactured of anhydrous ammonia. The potential exposure arises from the transfer of the substance from the reactor to storage areas or vessels. Workers involved in this transfer of the substance will be exposed in the manual handling of the substance to storage vessels and potentially during the loading of road and rail tankers.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Manufactured anhydrous liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

The transferred substance is a colourless gas (or a liquid at high pressure) at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.

Amounts used

Production sites may manufacture up to 950,000 tonnes per annum, with approximately 6.5 million tonnes produced per year in the European Union. It is expected that all produced amounts will be transferred to vessels or tanks at some point.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Transfer of ammonia may be carried out for periods from 1 to 4 hours or greater than 4 hours with limited potential for exposure due to the nature of the associated systems.

Human factors not influenced by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

When the transfer of ammonia from the reactor vessel is carried out indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the transfer processes are carried out outdoors LEV is not required.
Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and

insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur.
Anhydrous ammonia is stored in closed containers and tanks and is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions and measures at process level (source) to prevent release

If being carried out indoors the transfer of the substance from the reactor vessel to storage tanks or areas takes place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not always required.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations. All transfer pipelines should be sealed to prevent leaks.

Organizational measures to prevent/limit release

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

During transfer of produced ammonia workers may potentially be exposed to ammonia when operating equipment (e.g. valves, pumps or filling tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

3 Exposure estimation and reference to its source

The assessment of worker exposure to anhydrous ammonia during manufacturing (ES 1) was carried out for processes relevant to this scenario as identified by PROC codes reflecting: use and storage of ammonia in closed systems with no likelihood of exposure (PROC 1), use in closed, continuous processes with occasional controlled exposure (PROC 2), maintenance and clean-down (PROC 8a) and transfer (PROC 8b). A screening-level (Tier 1) assessment of worker exposure was carried out using the ECETOC Targeted Risk Assessment (TRA) model. The ECETOC TRA was used to predict dermal exposures (expressed as a daily systemic dose in mg/kg bw) and inhalation exposure concentrations (expressed as an airborne concentration in mg/m^3) associated with each process defined by PROC codes.

Exposure to workers was assessed taking into account different operational conditions that may be associated with the manufacturing of anhydrous ammonia and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90 % protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposure concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.
For environmental emissions complete removal in the on-site WWTP was considered during derivation of the values below.

Information for contributing scenario 1 (environmental exposure):

The following PEC values were calculated using EUSES 2.1

PEC	Values
PEC in sewage effluent	0 (due to complete removal)
PEC in aquatic compartment (mg/L): Freshwater Marine Water	 3.48×10^{-3} 7.61×10^{-4}
PEC in sediments (mg/kg): Freshwater sediments Marine water sediments	 3.76×10^{-3} 8.24×10^{-4}
PEC in soil and groundwater:	Upon contact with soil, ammonia will be rapidly converted by a variety of bacteria, actinomycetes and fungi to ammonium (NH_4^+) by the process of ammonification or mineralization. Ammonium is then rapidly converted to nitrate. Nitrate is subsequently taken up and utilised by plants or returned to the atmosphere following denitrification; the metabolic reduction of nitrate into nitrogen or nitrous oxide (N2O) gas. The most likely fate of ammonium ions in soils is conversion to nitrates by nitrification. Therefore accumulation of concentrations of ammonia in soil and groundwater will not be expected.
PEC in air: annual average (mg/m^3)	36.1

The following RCR values were obtained:

Compartments	PEC	PNEC	PEC/PNEC	Discussion
Freshwater (Tier 2)	3.48×10^{-3} mg/L (Total Ammonia) 1.33×10^{-4} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.121	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25°C. (Ref data tabulated in EPA document EPA-600/3-79-091)
Marine water (Tier 2)	8.24×10^{-4} mg/L (Total Ammonia) 3.15×10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.029	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

The following values were obtained using ECETOC TRA for worker exposure

Dermal exposures to anhydrous ammonia predicted using the ECETOC TRA model for industrial workers during manufacturing

Description of activity	PROC	Exposure assumptions		Estimated Exposure mg/kg bw/d	
		Duration	Use of ventilation	No gloves worn	Gloves worn (90% reduction)
Use in a closed process, no likelihood of exposure: storage (closed or bulk container)	PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at dedicated facilities	PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
			Indoors with LEV	0.69	0.07

Inhalation exposure concentrations for anhydrous ammonia predicted using the ECETOC TRA model for industrial workers during manufacturing

Description of activity	PROC	Exposure assumptions		Estimated Inhalation Exposure Concentration mg/m3	
		Duration	Use of ventilation	No RPE	RPE (95% reduction)
Use in a closed process, no likelihood of exposure: Storage (closed bulk or container)	PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA
			Indoors without LEV	0.01	NA
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	>4hrs	Outdoors	24.79	1.24
			Indoors without LEV	35.42	1.77
			Indoors with LEV	3.54	0.18
		1-4 hrs	Outdoors	14.88	0.74
			Indoors without LEV	22.25	1.06
			Indoors with LEV	2.13	0.11
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	>4hrs	Outdoors	123.96	6.20
			Indoors without LEV	177.08	8.85
			Indoors with LEV	17.71	0.89
		1-4 hrs	Outdoors	74.38	3.72
			Indoors without LEV	106.25	5.31
			Indoors with LEV	10.63	0.53
Transfer (charging/discharging)	PROC 8b	>4hrs	Outdoors	74.38	3.72

from/to vessels or large containers at dedicated facilities			Indoors without LEV	106.25	5.31
			Indoors with LEV	3.19	0.16
		1-4 hrs	Outdoors	44.63	2.23
			Indoors without LEV	63.75	3.19
			Indoors with LEV	1.91	0.10

The following RCR values were obtained using ECETOC TRA and the relevant DNELs

Quantitative risk characterisation of dermal exposures to anhydrous ammonia for industrial workers

PROC code	Exposure assumptions		ES 1- exposure concentrations (EC) mg/kg bw/d		Acute / long term systemic effects DNEL = 6.8 mg/kg bw/d	
					Risk characterisation ratio	
	Duration	Use of ventilation	No gloves worn	Gloves worn (90% reduction)	No gloves worn	Gloves worn (90% reduction)
PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14	0.20	0.02
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01

Quantitative risk characterisation of inhalation exposure concentrations of anhydrous ammonia for workers

PROC code	Exposure assumptions		ES 1- exposure concentrations (EC) mg/m³		Acute / long-term systemic effects DNEL = 47.6 mg/m3		Acute-local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE -95% reduction	No RPE	RPE – 95%	No RPE	RPE 95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.001	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.001	NA	<0.01	NA	<0.01	NA
	>4hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09

PROC 2		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05
		Indoors without LEV	22.25	1.06	0.47	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 8a	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8b	>4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	3.19	0.16	0.07	0.00	0.09	<0.01	0.23	0.01
	1-4 hrs	Outdoors	44.63	2.23	0.94	0.05	1.24	0.06	3.19	0.16
		Indoors without LEV	63.75	3.19	1.34	0.07	1.77	0.09	4.55	0.23
		Indoors with LEV	1.91	0.10	0.04	0.00	0.05	<0.01	0.14	0.01

4 Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environmental releases:

In order to work within the boundaries of the ES the following conditions should be met:

- Local emission to air less than 40 mg/m^3
- When the on-site WWTP is used the WWTP sludge should not be spread to soil
- Emissions from the waste-water stream should be completely removed
- Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the manufacturing process.
- Measured emissions should be ensured to lead to concentrations in the environment which are less than the relevant PNEC

Worker exposure:

In order to work within the boundaries of the ES the following conditions should be met:

- LEV should be in place in indoor facilities at times when natural ventilation is not sufficient.
- Where the potential for dermal exposure exists, gloves with a minimum efficiency of 90% and RPE with 95% efficiency should be worn.
- Health monitoring should be conducted regularly to ascertain the potential levels of exposure.
- Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) should be worn when any potential contact may arise.

- All technological devices should have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
- Workers should be fully trained.
- Any measured worker exposure levels should be confirmed to be below the relevant DNEL as presented in section 3 above.

Downstream user Exposure Scenario for Ammonia

Exposure Scenario 2: Distribution and Formulation of Ammonia

1	Exposure Scenario 2

Distribution and formulation of anhydrous ammonia

Processes Covered:
Environmental Releases

ERC2: Formulation of preparations
Worker Processes

PROC01: Use in closed process, no likelihood of exposure.
PROC02: Use in closed, continuous process with occasional controlled exposure.
PROC03: Use in closed batch processes
PROC04: Use in batch and other processes where the potential for exposure occurs
PROC05: Mixing and blending
PROC08a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities.
PROC08b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities.
PROC09: Transfer of formulations to small containers.
PROC15: Laboratory use

Manufactured anhydrous liquid ammonia (>99.5 % wt) is distributed widely to many industrial and municipality users. Anhydrous liquid ammonia is transported to chemical formulation facilities which produce aqueous solutions of ammonia. Aqueous ammonia products are then distributed to a wide range of industrial end-users and is also used to produce products for professional and consumer users.

Manufactured anhydrous liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia). When transported in tanks, the pressure on the tank is the liquid pressure and remains the same whether the tank is 10% or 80% full. The maximum filling level of an anhydrous ammonia tank is 85%. Anhydrous liquid ammonia may also be distributed to end-user industries via pipeline systems.

Anhydrous liquid ammonia is used to produce aqueous ammonia solutions (5-25% w/w). The anhydrous liquid ammonia product is transported to chemical manufacturing facilities by rail or road where it is blended with deionised water to produce solutions of aqueous ammonia that are used for a broad range of applications. Aqueous ammonia solution products are distributed to a wide range of industrial users by road or rail in various quantities (e.g. tanks or 1, 5, 15 and 50 liter containers). Distributors of anhydrous and aqueous ammonia can operate on a regional or national level.

Contributing Environmental Scenario: Environmental exposure arising due to distribution and formulation of anhydrous ammonia.

Contributing Worker Scenarios: Worker exposure arising due to day to day use in closed processes with no likelihood of exposure, day to day use in closed continuous processes with occasional exposure (such as sampling), day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance), mixing and blending, transfer to small containers, transfer of substance to and from large vessels and containers and laboratory use.

2.1	Contributing scenario 1 controlling environmental exposure for ES 2

Environmental exposure arising from the distribution and formulation of anhydrous ammonia.

Section 2.1 describes the environmental releases that may occur during the distribution and formulation of anhydrous ammonia. These releases may occur due to emission to wastewater or through emission to the atmosphere. If emission to wastewater occurs on-site treatment in an industrial waste water treatment plant will be required in order to remove downstream emissions to the environment.
In reality removal of ammonia in sewage treatment plants is highly efficient being removed first by nitrification to nitrate followed by denitrification resulting in the release of nitrogen gas. It is considered that if there processes are employed complete removal from the wastewater stream will occur. Emissions to the atmosphere should not exceed concentrations of 21.1 mg/m^3.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected.
Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Formulation of ammonia is generally a short duration task, with limited potential for exposure.

Environmental factors influenced by risk management

Flow rate of receiving water at least 18,000 m^3 per day. Dilution of STP emissions at least 10 fold.

Other operational conditions affecting environmental exposure

Workers are fully trained in safe use and the use of appropriate systems in order to prevent accidental release. Closed systems are employed in order to prevent un-intended emissions.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. On site WWTPs should be available at industrial sites in order to eliminate emissions to the environment via contaminated wastewater.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Waste water should be emitted to the on-site WWTP for specialized removal. Emissions to air from formulation and distribution or from the onsite WWTP should not exceed a concentration of 21.1 mg/m^3 of air. This is approximately equivalent to a total loss to air of 74,000 kg/day. Sludge from the on-site WWTP should not be spread to soil. Any solid waste will be sent as waste for landfill, incineration or recycling.

Organizational measures to prevent/limit releases from site

Workers are fully trained in order to prevent accidental release and exposures may be monitored to ensure airborne concentrations are within acceptable levels.

Conditions and measures related to municipal STP

Direct emissions to the municipal STP should not be made.

Conditions and measures related to external treatment of waste for disposal

Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the formulation process. Sludge from the onsite WWTP should be recycled, incinerated or sent to landfill.

Conditions and measures related to external recovery of waste

There is no envisaged external recovery of waste. Waste sludge is reduced and then incinerated and emissions to air are not collected. .

2.2	**Contributing scenario 2 controlling worker exposure day to day use in closed processes with no likelihood of exposure.**

Worker exposure arising due to day to day use in closed processes with no likelihood of exposure during the distribution and formulation processes.

Section 2.2 describes the potential exposure to workers during the formulation of preparations of ammonia from operation of closed systems. The potential exposure arises from the operation of formulation equipment and its associated machinery.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated solutions are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected.

Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Formulation of ammonia is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the formulation and mixing of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required.

Technical conditions and measures at process level (source) to prevent release

If formulation is being carried out indoors the process should take place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required.
All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the transfer and formulation and machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating distribution and formulation equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.

Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.3	**Contributing scenario 3 controlling worker exposure due to day to day use in closed continuous processes with occasional exposure (such as sampling)**

Worker exposure arising due to day to day use in closed continuous processes with occasional exposure (such as sampling).

Section 2.3 describes the potential exposure to workers during the distribution and formulation of preparations of ammonia from operation of closed systems with the potential for occasional exposure during tasks such as sampling, cleaning and maintenance. The potential exposure arises from the operation of formulation equipment and its associated machinery and during routine sampling, cleaning and occasional maintenance.
Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in these tasks. Formulated solutions are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.
During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Tasks such as sampling, cleaning and routine maintenance of ammonia distribution and formulation machinery are generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the formulation and mixing of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release

If formulation is being carried out indoors the process should take place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release
Workers are fully trained in safe use of the transfer and formulation and machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia when operating distribution and formulation equipment (e.g. valves, pumps or tanks etc) or when carrying out specific tasks such as sampling, cleaning and maintenance. All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.4	**Contributing scenario 4 controlling worker exposure for day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance)**

Worker exposure arising due to day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance).
Section 2.4 describes the potential exposure to workers during day to day use of formulation and distribution machinery, pipelines and storage vessels. Potential exposure may occur during the day to day use however it is more likely to occur during tasks associated with the batch or other processes such as sampling of formulated solutions, cleaning and routine maintenance. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. formulated liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Tasks such as sampling, cleaning and routine maintenance of ammonia distribution and formulation machinery are generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
During the formulation and mixing of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release
If formulation is being carried out indoors the process should take place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the transfer and formulation and machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia when operating distribution and formulation equipment (e.g. valves, pumps or tanks etc) or when carrying out specific tasks such as sampling, cleaning and maintenance. All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.5	**Contributing scenario 5 controlling worker exposure for mixing and blending**

Worker exposure arising due to mixing and blending in batch processes during formulation of preparations
Section 2.5 describes the potential exposure to workers during mixing and blending of ammonia formulations Potential exposure may occur during the day to day use of machinery and technologies associated with the blending and mixing process. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. formulated liquid ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During mixing and blending of the formulations the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Tasks such as mixing and blending and use of formulation machinery generally have limited potential for exposure due to the specialized nature of the technologies involved.

Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
During the blending and mixing of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required. RPE is provided when required.
Technical conditions and measures at process level (source) to prevent release
If mixing and blending is being carried out indoors the process should take place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of mixing and blending machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia when operating mixing and blending equipment (e.g. valves, pumps or tanks etc). Operations are generally performed in a closed system. Pipelines and tanks are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.6	**Contributing scenario 6 controlling worker exposure for transfer to small containers**
Worker exposure arising due to transfer to small containers in a dedicated filling line.	
Section 2.6 describes the potential exposure to workers during the filling of small containers in dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers themselves. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the small sized containers.	
Product characteristics	
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.	

During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.

Amounts used

Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. Though it is unlikely that all this tonnage will be filled into small containers this amount has nonetheless been considered for the exposure assessment. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the filling of small containers indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release

If formulation is being carried out indoors the process should take place in a fully closed system, LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a closed system is still employed however specific LEV is not required.
All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Pipelines and container filling equipment should be closed and sealed systems where possible.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the transfer and container filling machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating filling lines and during the filling of the small containers.. Pipelines and vessels are sealed and insulated where possible. Extract ventilation is provided at openings and points were emissions may occur. The filled ammonia is stored in the closed small containers. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.7	**Contributing scenario 7 controlling worker exposure for transfer to and from large containers and vessels**

Worker exposure arising due transfer of ammonia to and from large containers and vessels

Section 2.7 describes the potential exposure to workers during the filling and loading to/from large containers and vessels in dedicated and non-dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers themselves.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the large sized containers.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.
During formulation the formation of solutions of aqueous ammonia in the 5 – 25% concentrations range is expected. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.

Amounts used

Formulation sites may use up to a largest individual site tonnage of 1,000,000 tonnes per annum, with approximately 3.8 million tonnes formulated per year in the European Union. Though it is unlikely that all this tonnage will be filled into large vessels and containers this amount has nonetheless been considered for the exposure assessment. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the filling and transfer of ammonia to/from large vessels and containers indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. When the processes are carried out outdoors LEV is not generally required. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release

If transfer to or from the large vessels or containers is being carried out indoors a LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). When carried out outdoors a specialized system is still employed however specific LEV is not required. The filling may be at dedicated or non-dedicated facilities however the transfer machinery will still be highly specialized and controlled.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Pipelines and container filling equipment should be closed and sealed systems where possible.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the transfer and container filling machinery and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating filling lines and during the filling of the large containers and vessels. Pipelines and vessels are generally sealed and insulated where possible. Extract ventilation is provided at openings and points were emissions may occur. The filled ammonia is stored in the closed small containers. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading

and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.8	Contributing scenario 7 controlling worker exposure for laboratory use

Worker exposure arising due to laboratory use of ammonia (small scale non-industrial laboratories).

Section 2.8 describes the potential exposure to workers during laboratory use especially during the filling and loading of small flasks and vessels using non-dedicated filling lines or small scale transfer methods. Potential exposure is most likely to occur during tasks associated with the actual transfer or mixing of the ammonia solutions. For dedicated small scale laboratories appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.

During laboratory use of ammonia solutions of aqueous ammonia in the 5 – 25% concentrations range are most liklety to be encountered. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.

Amounts used

Amounts use in a non-industrial setting are likely to be small with less than 1 litre or 1 kilogram present on site. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330 however actual emission of ammonia is likely to be much less frequent in practice.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Again use of ammonia is not likely to be this frequent in practice.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the laboratory use of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release

During laboratory use LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases).
All technological devices should have a proper quality certification, and should be regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not considered sufficient or in enclosed areas.

Organizational measures to prevent/limit release

Laboratory workers are fully trained in safe use of chemicals in general and in the use of appropriate PPE in order to prevent accidental release or exposure.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia during laboratory use when filling containers and vessels or during transfer. Extract ventilation is provided at openings and points were emissions may occur.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.

Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

3	**Exposure estimation and reference to its source**

The assessment of worker exposure to aqueous ammonia during formulation or to anhydrous and aqueous forms of ammonia during distribution (ES 2) was carried out for processes relevant to this scenario as identified by PROC codes reflecting: use and storage of ammonia in closed systems with no likelihood of exposure (PROC 1), use in closed, continuous processes with occasional controlled exposure (PROC 2), formulation using closed batch processes (PROC 3), use in batch or other processes (PROC 4), mixing or blending in a batch process (PROC 5), maintenance and clean-down (PROC 8a), transfer (PROC 8b), transfer of ammonia into containers (PROC 9) and analysis of samples (PROC 15). A screening-level (Tier 1) assessment of worker exposure was carried out using the ECETOC Targeted Risk Assessment (TRA) model. The ECETOC TRA was used to predict dermal exposures (expressed as a daily systemic dose in mg/kg bw) and inhalation exposure concentrations (expressed as an airborne concentration in mg/m^3) associated with each process defined by PROC codes.

Exposure to workers was assessed taking into account different operational conditions that may be associated with the formulation of aqueous ammonia solutions and the distribution of anhydrous and aqueous ammonia products and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90% protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposure concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.
The ECETOC TRA model uses a simple algorithm to determine dermal exposures that does not take the physical-chemical properties of a substance into account. The same dermal exposures where therefore predicted for anhydrous and aqueous forms of ammonia. Parameters used in the ECETOC TRA model to assess inhalation exposures were: molecular weight (35 $g.mol^{-1}$ and 17 $g.mol^{-1}$ for aqueous and anhydrous forms respectively and vapour pressure (the vapour pressure of anhydrous forms of ammonia is 8.6×10^5 Pa at 20°C, whereas the vapour pressure of aqueous ammonia solution between 5 and 25% w/w ranges from 5×10^3 Pa to 4×10^4 Pa at 20°C. Systemic dermal exposures have been determined for a worker with bodyweight 70 kg.

For environmental emissions complete removal in the on-site WWTP was considered during derivation of the values below. Emission values and environmental concentrations were calculated using the EUSES 2.1 model.

Information for contributing scenario 1 (environmental exposure):
The following PEC values were calculated using EUSES 2.1

PEC	Values
PEC in sewage effluent	0 (due to complete removal)
PEC in aquatic compartment (mg/L): Freshwater Marine Water	 1.3×10^{-3} 3.14×10^{-4}

PEC in sediments (mg/kg): Freshwater sediments Marine water sediments	 1.41×10^{-3} 3.40×10^{-4}
PEC in soil and groundwater:	Upon contact with soil, ammonia will be rapidly converted by a variety of bacteria, actinomycetes and fungi to ammonium (NH_4^+) by the process of ammonification or mineralization. Ammonium is then rapidly converted to nitrate. Nitrate is subsequently taken up and utilised by plants or returned to the atmosphere following denitrification; the metabolic reduction of nitrate into nitrogen or nitrous oxide (N2O) gas. The most likely fate of ammonium ions in soils is conversion to nitrates by nitrification. Therefore accumulation of concentrations of ammonia in soil and groundwater will not be expected.
PEC in air: annual average (mg/M^3)	19

The following RCR values were obtained:

Compartments	**PEC**	**PNEC**	**PEC/PNEC**	**Discussion**
Freshwater (Tier 2)	1.30×10^{-3} mg/L (Total Ammonia) 4.97×10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.045	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
Marine water (Tier 2)	3.14×10^{-4} mg/L (Total Ammonia) 1.20×10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.011	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

The following values were obtained using ECETOC TRA for worker exposure

Dermal exposures predicted using the ECETOC TRA model

Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure mg/kg bw/d**	
		Duration	**Use of ventilation**	**No gloves worn**	**Gloves worn (90% reduction)**
Use in a closed process, no likelihood of exposure: storage (closed or bulk container)	PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03
Use in a closed, continuous process	PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14

with occasional controlled exposure (e.g. sampling)			Indoors with LEV	0.14	0.01
Use in closed batch process (synthesis or formulation)	PROC 3	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Mixing or blending in batch process	PROC 5	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.07	0.01
Transfer into small containers	PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at dedicated facilities	PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
			Indoors with LEV	0.69	0.07
Laboratory use : Quality control in a laboratory	PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01

Inhalation exposure concentrations predicted using the ECETOC TRA model

				Anhydrous ammonia		**Aqueous ammonia (5-25% w/w)**	
Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure Concentration mg/m3**			
		Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE (95% reduction)**
Used in a closed process, no likelihood of exposure: Storage (closed bulk or container)	PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	0.01	NA
		1-4 hrs or >4 hrs	Indoors without LEV	0.01	NA	0.01	NA
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	>4hrs	Outdoors	24.79	1.24	30.63	1.53
		>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.53	0.18	4.38	0.22
		1-4 hrs	Outdoors	14.88	0.74	18.38	0.92
		1-4 hrs	Indoors without LEV	22.25	1.06	26.25	1.31

		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Use in closed batch process (synthesis or formulation)	PROC 3	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.50	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.5	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Mixing or blending in batch process	PROC 5	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Maintenance, clean down	PROC 8a	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Transfer of ammonia (charging/discharging) from/to vessels or large containers at dedicated facilities	PROC 8b	>4hrs	Outdoors	74.38	3.72	91.88	4.59
		>4hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		>4hrs	Indoors with LEV	3.19	0.16	3.94	0.20
		1-4 hrs	Outdoors	44.63	2.23	55.13	2.76
		1-4 hrs	Indoors without LEV	63.75	3.19	78.75	3.94
		1-4 hrs	Indoors with LEV	1.91	0.1	2.36	0.12
Transfer into small containers	PROC 9	>4hrs	Outdoors	99.17	4.96	122.50	6.13
		>4hrs	Indoors without LEV	141.67	7.08	175.00	8.75

		>4hrs	Indoors with LEV	14.17	0.71	17.50	0.88
		1-4 hrs	Outdoors	59.50	2.98	73.50	3.68
		1-4 hrs	Indoors without LEV	85.00	4.25	105.00	5.25
		1-4 hrs	Indoors with LEV	8.5	0.43	10.50	0.53
Quality control in a laboratory	PROC 15	>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.54	0.18	4.38	0.22
		1-4 hrs	Indoors without LEV	21.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13

The following RCR values were obtained using ECETOC TRA and the relevant DNELs

Quantitative risk characterisation of dermal exposures to anhydrous or aqueous (in preparations of 5- 25 % w/w) ammonia for industrial workers (ES 2 – formulation and distribution)

PROC code	**Exposure assumptions**		**ES 2- exposure concentrations (EC) mg/kg bw/d**		**Acute / long term systemic effects DNEL = 6.8 mg/kg bw/d**	
					Risk characterisation ratio	
	Duration	**Use of ventilation**	**No gloves worn**	**Gloves worn (90% reduction)**	**No gloves worn**	**Gloves worn (90% reduction)**
PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14	0.20	0.02
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 3	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 4	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 5	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.07	0.01	0.01	<0.01
PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01

PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01

Quantitative risk characterisation of inhalation exposure concentrations of anhydrous ammonia for industrial workers (ES 3 – formulation and distribution)

PROC code	Exposure assumptions		ES 2- exposure concentrations (EC) mg/m³		Acute / long-term systemic effects DNEL = 47.6 mg/m3		Acute-local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE -95% reduction	No RPE	RPE – 95%	No RPE	RPE 95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09
		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05
		Indoors without LEV	22.25	1.06	0.47	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 3	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 4	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 5	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38

		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8a	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8b	>4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	3.19	0.16	0.07	0.00	0.09	<0.01	0.23	0.01
	1-4 hrs	Outdoors	44.63	2.23	0.94	0.05	1.24	0.06	3.19	0.16
		Indoors without LEV	63.75	3.19	1.34	0.07	1.77	0.09	4.55	0.23
		Indoors with LEV	1.91	0.10	0.04	0.00	0.05	<0.01	0.14	0.01
PROC 9	>4 hrs	Outdoors	99.17	4.96	2.08	0.10	2.75	0.14	7.08	0.35
		Indoors without LEV	141.67	7.08	2.98	0.15	3.94	0.20	10.12	0.51
		Indoors with LEV	14.17	0.71	0.30	0.01	0.39	0.02	1.01	0.05
	1-4 hrs	Outdoors	59.50	2.98	1.25	0.06	1.65	0.08	4.25	0.21
		Indoors without LEV	85.00	4.25	1.79	0.09	2.36	0.12	6.07	0.30
		Indoors with LEV	8.5	0.43	0.18	0.01	0.24	0.01	0.61	0.03
PROC 15	>4 hrs	Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Indoors without LEV	21.25	1.06	0.45	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01

Quantitative risk characterisation of inhalation exposure concentrations of aqueous ammonia (in preparations of 5-25 % w/w) in workers (ES 2 – formulation and distribution)

PROC code	**Exposure assumptions**		**ES 2-exposure concentrations (EC) mg/m³**		**Acute /long-term systemic effects DNEL = 47.6 mg/m3**		**Acute – local effects DNEL = 36 mg/m3**		**Long-term local effects DNEL = 14 mg/m3**	
					RCR		**RCR**		**RCR**	
	Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE - 95% reduction**	**No RPE**	**RPE -95% reduction**	**No RPE**	**RPE -95% reduction**
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.0001	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	30.63	1.53	0.64	0.03	0.85	0.04	2.19	0.11
		Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16

		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Outdoors	18.38	0.92	0.39	0.02	0.51	0.03	1.31	0.07
		Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 3	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.50	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 4	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.5	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 5	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8a	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8b	>4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	3.94	0.20	0.08	0.00	0.11	0.01	0.28	0.01
	1-4 hrs	Outdoors	55.13	2.76	1.16	0.06	1.53	0.08	3.94	0.20
		Indoors without LEV	78.75	3.94	1.65	0.08	2.19	0.11	5.63	0.28
		Indoors with LEV	2.36	0.12	0.05	0.00	0.07	<0.01	0.17	0.01
PROC 9	>4hrs	Outdoors	122.50	6.13	2.57	0.13	3.40	0.17	8.75	0.44
		Indoors without LEV	175.00	8.75	3.68	0.18	4.86	0.24	12.50	0.63

		Indoors with LEV	17.50	0.88	0.37	0.02	0.49	0.02	1.25	0.06
	1-4 hrs	Outdoors	73.50	3.68	1.54	0.08	2.04	0.10	5.25	0.26
		Indoors without LEV	105.00	5.25	2.21	0.11	2.92	0.15	7.50	0.38
		Indoors with LEV	10.50	0.53	0.22	0.01	0.29	0.01	0.75	0.04
PROC 15	>4 hrs	Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01

4	Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environmental releases:
In order to work within the boundaries of the ES the following conditions should be met:

- Local emission to air less than 21.1 mg/M^3
- When the on-site WWTP is used the WWTP sludge should not be spread to soil
- Emissions from the waste-water stream should be completely removed
- Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the formulation process.
- Measured emissions should be ensured to lead to concentrations in the environment which are less than the relevant PNEC
- Emissions to wastewater from laboratory use should not be discharged to the municipal STP

Worker exposure:
In order to work within the boundaries of the ES the following conditions should be met:

- LEV should be in place in indoor facilities at times when natural ventilation is not sufficient.
- Where the potential for dermal exposure exists, gloves with a minimum efficiency of 90% and RPE with 95% efficiency should be worn.
- Health monitoring should be conducted regularly to ascertain the potential levels of exposure.
- Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) should be worn when any potential contact may arise.
- All technological devices should have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
- Workers should be fully trained.
- Any measured worker exposure levels should be confirmed to be below the relevant DNEL as presented in section 3 above.

Downstream user exposure scenario for Ammonia

Exposure Scenario 3: Industrial use of Anhydrous Ammonia as an Intermediate

1	Exposure Scenario 3

Industrial uses of anhydrous ammonia as an intermediate

Processes Covered:
Environmental Releases

ERC6a: Industrial use of intermediates
Worker Processes

PROC01: Use in closed process, no likelihood of exposure.
PROC02: Use in closed, continuous process with occasional controlled exposure.
PROC03: Use in closed batch processes
PROC04: Use in batch and other processes where the potential for exposure occurs
PROC05: Mixing and blending
PROC08a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities.
PROC08b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities.
PROC09: Transfer of formulations to small containers.
PROC15: Laboratory use

Ammonia is used by the chemicals industry to manufacture a range other substances including: nitric acid, alkalis, dyes, pharmaceuticals, cosmetics, vitamins, synthetic textile fibres and plastics.
Ammonia is used as an intermediate in the synthesis of a number of chemicals. It is used in the manufacture of nitric acid (HNO_3) which is used in making explosives such as TNT (2,4,6-trinitrotoluene); nitro-glycerine (which is also used as a vasodilator) and PETN (pentaerythritol nitrate). Ammonia is also used in the synthesis of alkakis: sodium hydrogen carbonate (sodium bicarbonate; $NaHCO_3$), soda ash (sodium carbonate, Na_2CO_3), hydrogen cyanide (hydrocyanic acid; HCN) and hydrazine (N_2H_4) used in rocket propulsion systems.
Ammonia is used to manufacture explosives such as ammonium nitrate (NH_4NO_3). It is also used as an intermediate in the synthesis of dyes, and synthetic 'man-made' fibres such as nylon, rayon and acrylics. It is also used in the manufacture of plastics such as phenolics and polyurethanes.
Ammonia is used in the manufacture of drugs such as sulphonamide which inhibit the growth and multiplication of bacteria that require *p*-aminobenzoic acid (PABA) and for the biosynthesis of folic acids, antimalarials and vitamins (e.g. B vitamins: nicotinamide and thiamine).
Ammonia is also used in the production of ammonium and nitrate salts used in fertilisers.

Contributing Environmental Scenario: Environmental exposure arising due to Industrial uses of anhydrous ammonia as an intermediate.

Contributing Worker Scenarios: Worker exposure arising due to day to day use in closed processes with no likelihood of exposure, day to day use in closed continuous processes with occasional exposure (such as sampling), day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance), mixing and blending, transfer to small containers, transfer of substance to and from large vessels and containers and laboratory use.

2.1	Contributing scenario 1 controlling environmental exposure for ES 3

Environmental exposure arising due to industrial uses of anhydrous ammonia as an intermediate.

Section 2.1 describes the environmental releases that may occur during the industrial uses of anhydrous ammonia as an intermediate. These releases may occur due to emission to wastewater or through emission to the atmosphere. If emission to wastewater occurs on-site treatment in an industrial waste water treatment plant will be required in order to remove downstream emissions to the environment.
In reality removal of ammonia in sewage treatment plants is highly efficient being removed first by nitrification to nitrate followed by denitrification resulting in the release of nitrogen gas. It is considered that if these processes are employed complete removal from the wastewater stream will occur. Emissions to the atmosphere should not exceed concentrations of 30.5 mg/m^3.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Environmental factors influenced by risk management

Flow rate of receiving water at least 18,000 m^3 per day. Dilution of STP emissions at least 10 fold.

Other operational conditions affecting environmental exposure

Workers are fully trained in safe use and the use of appropriate systems in order to prevent accidental release. Closed systems are employed in order to prevent un-intended emissions.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed sealed. On site WWTPs should be available at industrial sites in order to eliminate emissions to the environment via contaminated wastewater.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

Waste water should be emitted to the on-site WWTP for specialized removal. Emissions to air from the industrial processes or from the onsite WWTP should not exceed a concentration of 30.5 mg/m^3 of air. This is approximately equivalent to a total loss to air of 106,000 kg/day. Sludge from the on-site WWTP should not be spread to soil. Any solid waste will be sent as waste for landfill, incineration or recycling.

Organizational measures to prevent/limit releases from site

Workers are fully trained in order to prevent accidental release and exposures may be monitored to ensure airborne concentrations are within acceptable levels.

Conditions and measures related to municipal STP

Direct emissions to the municipal STP should not be made.

Conditions and measures related to external treatment of waste for disposal

Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the industrial process. Sludge from the onsite WWTP should be recycled, incinerated or sent to landfill.

Conditions and measures related to external recovery of waste

There is no envisaged external recovery of waste. Waste sludge is reduced and then incinerated and emissions to air are not collected.

2.2	

	Contributing scenario 2 controlling worker exposure day to day use in closed processes with no likelihood of exposure.

Worker exposure arising due to day to day use in closed processes with no likelihood of exposure during the industrial use processes.

Section 2.2 describes the potential exposure to workers during the industrial use of ammonia as an intermediate from operation of closed systems. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.3	**Contributing scenario 3 controlling worker exposure due to day to day use in closed continuous processes with occasional exposure (such as sampling)**

Worker exposure arising due to day to day use in closed continuous processes with occasional exposure (such as sampling).

Section 2.3 describes the potential exposure to workers during the industrial use of preparations of ammonia from the operation of closed systems with the potential for occasional exposure during tasks such as sampling, cleaning and maintenance. The potential exposure arises from the operation of industrial intermediate use equipment and its associated machinery and during routine sampling, cleaning and occasional maintenance.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in these tasks. Formulated solutions are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.4	**Contributing scenario 4 controlling worker exposure for day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance)**

Worker exposure arising due to day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance).

Section 2.4 describes the potential exposure to workers during day to day use of industrial machinery, pipelines and storage vessels. Potential exposure may occur during the day to day use however it is more likely to occur during tasks associated with the batch or other processes themselves such as sampling of produced intermediates, cleaning and routine maintenance.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Solutions of ammonia are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

This contributing considers the potential exposures from batch and other processes (such as one off exposures) and though there is some potential for exposure generally systems are in place to control losses or unintended emissions of ammonia at the industrial facility.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use during batch and other processes is generally a short duration task, with limited potential for exposure occurring in reality.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.

Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.

Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.5	**Contributing scenario 5 controlling worker exposure for mixing and blending**

Worker exposure arising due to mixing and blending in batch processes during use as an intermediate

Section 2.5 describes the potential exposure to workers during mixing and blending of ammonia formulations. Potential exposure may occur during the day to day use of machinery and technologies associated with the blending and mixing process as part of the overall industrial use of ammonia as an intermediate.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Stock ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or blending tanks etc). All operations are performed in a closed system. Pipelines, blending apparatuses and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.6	**Contributing scenario 6 controlling worker exposure for transfer to small containers**

Worker exposure arising due to transfer to small containers in a dedicated filling line.

Section 2.6 describes the potential exposure to workers during the filling of small containers in dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers themselves.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the small sized containers.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.7	**Contributing scenario 7 controlling worker exposure for transfer to and from large containers and vessels**

Worker exposure arising due transfer of ammonia to and from large containers and vessels

Section 2.7 describes the potential exposure to workers during the filling and loading to/from large vessels and containers in dedicated and non-dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers and vessels themselves.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the small sized containers.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 800,000 tonnes per annum, with up to 3.8 million tonnes consumed per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial use is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia when operating industrial use equipment (e.g. valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emissions may occur. Ammonia is stored in closed containers and tanks and transferred under containment. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.8	**Contributing scenario 8 controlling worker exposure for laboratory use**

Worker exposure arising due to laboratory use of ammonia (small scale non-industrial laboratories).
Section 2.8 describes the potential exposure to workers during laboratory use of ammonia as an intermediate especially during the filling and loading of small flasks and vessels using non-dedicated filling lines or small scale transfer methods. Potential exposure is most likely to occur during tasks associated with the actual transfer or mixing of the ammonia solutions. For dedicated small scale laboratories appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During laboratory use of ammonia solutions of aqueous ammonia in the 5 – 25% concentrations range are most liklety to be encountered. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.
Amounts used

Amounts use in a non-industrial setting are likely to be small with less than 1 litre or 1 kilogram present on site. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330 however actual emission of ammonia is likely to be much less frequent in practice.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Again use of ammonia is not likely to be this frequent in practice.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
During the laboratory use of ammonia as an intermediate indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. RPE is provided when required.
Technical conditions and measures at process level (source) to prevent release
During laboratory use LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). All technological devices should have a proper quality certification, and should be regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not considered sufficient or in enclosed areas.
Organizational measures to prevent/limit release
Laboratory workers are fully trained in safe use of chemicals in general and in the use of appropriate PPE in order to prevent accidental release or exposure.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia during laboratory use when filling containers and vessels or during transfer. Extract ventilation is provided at openings and points were emissions may occur. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in these procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

3	**Exposure estimation and reference to its source**

The assessment of worker exposure to anhydrous and aqueous forms of ammonia used as an intermediate in chemical synthesis (ES 3) was carried out for processes relevant to this scenario as identified by PROC codes reflecting: use and storage of ammonia in closed systems with no likelihood of exposure (PROC 1), use in closed, continuous processes with occasional controlled exposure (PROC 2), formulation using closed batch processes (PROC 3), use in batch or other processes (PROC 4), mixing or blending in a batch process (PROC 5), maintenance and clean-down (PROC 8a), transfer (PROC 8b), transfer of ammonia into containers (PROC 9) and analysis of samples (PROC 15). A screening-level (Tier 1) assessment of worker exposure was carried out using the ECETOC Targeted Risk Assessment (TRA) model. The ECETOC TRA was used to predict dermal exposures (expressed as a daily systemic dose in mg/kg bw) and inhalation exposure concentrations (expressed as an airborne concentration in mg/m^3) associated with each process defined by PROC codes.

Exposure to workers was assessed taking into account different operational conditions that may be associated with the use of ammonia as an intermediate in chemical synthesis and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves

affording 90% protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.

The ECETOC TRA model uses a simple algorithm to determine dermal exposures that does not take the physical-chemical properties of a substance into account. The same dermal exposure where therefore predicted for anhydrous and aqueous forms of ammonia. Parameters used in the ECETOC TRA model to assess inhalation exposures were: molecular weight (35 $g.mol^{-1}$ and 17 $g.mol^{-1}$ for aqueous and anhydrous forms respectively and vapour pressure (the vapour pressure of anhydrous forms of ammonia is 8.6 x 10^5 Pa at 20°C, whereas the vapour pressure of aqueous ammonia solution between 5 and 25% w/w ranges from 5 x 10^3 Pa to 4 x10^4 Pa at 20°C. Systemic dermal exposures have been determined for a worker with bodyweight 70 kg.

For environmental emissions complete removal in the on-site WWTP was considered during derivation of the values below. Emission values and environmental concentrations were calculated using the EUSES 2.1 model.

Information for contributing scenario 1 (environmental exposure):

The following PEC values were calculated using EUSES 2.1

PEC	**Values**
PEC in sewage effluent	0 (due to complete removal)
PEC in aquatic compartment (mg/L): Freshwater Marine Water	 2.19 x 10^{-3} 5.37 x 10^{-4}
PEC in sediments (mg/kg): Freshwater sediments Marine water sediments	 2.37 x 10^{-3} 5.82 x 10^{-4}
PEC in soil and groundwater:	Upon contact with soil, ammonia will be rapidly converted by a variety of bacteria, actinomycetes and fungi to ammonium (NH_4^+) by the process of ammonification or mineralization. Ammonium is then rapidly converted to nitrate. Nitrate is subsequently taken up and utilised by plants or returned to the atmosphere following denitrification; the metabolic reduction of nitrate into nitrogen or nitrous oxide (N2O) gas. The most likely fate of ammonium ions in soils is conversion to nitrates by nitrification. Therefore accumulation of concentrations of ammonia in soil and groundwater will not be expected.
PEC in air: annual average (mg/M^3)	30.5

The following RCR values were obtained:

Compartments	**PEC**	**PNEC**	**PEC/PNEC**	**Discussion**
ERC 6a Freshwater (Tier 2)	2.19 x 10^{-3} mg/L (Total Ammonia) 8.37 x 10^{-5}mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.076	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

ERC 6a Marine water (Tier 2)	5.37 x 10^{-4} mg/L (Total Ammonia) 2.05 x 10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.019	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

The following values were obtained using ECETOC TRA for worker exposure

Dermal exposures predicted using the ECETOC TRA model

Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure mg/kg bw/d**	
		Duration	**Use of ventilation**	**No gloves worn**	**Gloves worn (90% reduction)**
Use in a closed process, no likelihood of exposure: storage (closed or bulk container)	PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14
			Indoors with LEV	0.14	0.01
Use in closed batch process (synthesis or formulation)	PROC 3	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Mixing or blending in batch process	PROC 5	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.07	0.01
Transfer into small containers	PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at dedicated facilities	PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
			Indoors with LEV	0.69	0.07

Laboratory use : Quality control in a laboratory	PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01

Inhalation exposure concentrations predicted using the ECETOC TRA model

				Anhydrous ammonia		**Aqueous ammonia (5-25% w/w)**	
Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure Concentration mg/m3**			
		Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE (95% reduction)**
Used in a closed process, no likelihood of exposure: Storage (closed bulk or container)	PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	0.01	NA
		1-4 hrs or >4 hrs	Indoors without LEV	0.01	NA	0.01	NA
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	>4hrs	Outdoors	24.79	1.24	30.63	1.53
		>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.53	0.18	4.38	0.22
		1-4 hrs	Outdoors	14.88	0.74	18.38	0.92
		1-4 hrs	Indoors without LEV	22.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Use in closed batch process (synthesis or formulation)	PROC 3	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.50	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.5	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Mixing or blending in batch process	PROC 5	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09

		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Maintenance, clean down	PROC 8a	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Transfer of ammonia (charging/discharging) from/to vessels or large containers at dedicated facilities	PROC 8b	>4hrs	Outdoors	74.38	3.72	91.88	4.59
		>4hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		>4hrs	Indoors with LEV	3.19	0.16	3.94	0.20
		1-4 hrs	Outdoors	44.63	2.23	55.13	2.76
		1-4 hrs	Indoors without LEV	63.75	3.19	78.75	3.94
		1-4 hrs	Indoors with LEV	1.91	0.1	2.36	0.12
Transfer into small containers	PROC 9	>4hrs	Outdoors	99.17	4.96	122.50	6.13
		>4hrs	Indoors without LEV	141.67	7.08	175.00	8.75
		>4hrs	Indoors with LEV	14.17	0.71	17.50	0.88
		1-4 hrs	Outdoors	59.50	2.98	73.50	3.68
		1-4 hrs	Indoors without LEV	85.00	4.25	105.00	5.25
		1-4 hrs	Indoors with LEV	8.5	0.43	10.50	0.53
Quality control in a laboratory	PROC 15	>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.54	0.18	4.38	0.22
		1-4 hrs	Indoors without LEV	21.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13

The following RCR values were obtained using ECETOC TRA and the relevant DNELs

Quantitative risk characterisation of dermal exposures to anhydrous or aqueous (in preparations of 5- 25 % w/w) ammonia for industrial workers (ES 3 – Use as an intermediate)

PROC code	Exposure assumptions	ES 3- exposure concentrations (EC) mg/kg bw/d	Acute / long term systemic effects DNEL = 6.8 mg/kg bw/d
			Risk characterisation ratio

	Duration	Use of ventilation	No gloves worn	Gloves worn (90% reduction)	No gloves worn	Gloves worn (90% reduction)
PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14	0.20	0.02
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 3	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 4	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 5	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.07	0.01	0.01	<0.01
PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01

Quantitative risk characterisation of inhalation exposure concentrations of anhydrous ammonia for industrial workers (ES 3 – industrial use)

PROC code	Exposure assumptions		ES 3- exposure concentrations (EC) mg/m³		Acute / long-term systemic effects DNEL = 47.6 mg/m3		Acute-local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE -95% reduction	No RPE	RPE – 95%	No RPE	RPE 95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09
		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05

		Indoors without LEV	22.25	1.06	0.47	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 3	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 4	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 5	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8a	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8b	>4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	3.19	0.16	0.07	0.00	0.09	<0.01	0.23	0.01
	1-4 hrs	Outdoors	44.63	2.23	0.94	0.05	1.24	0.06	3.19	0.16
		Indoors without LEV	63.75	3.19	1.34	0.07	1.77	0.09	4.55	0.23
		Indoors with LEV	1.91	0.10	0.04	0.00	0.05	<0.01	0.14	0.01
PROC 9	>4 hrs	Outdoors	99.17	4.96	2.08	0.10	2.75	0.14	7.08	0.35
		Indoors without LEV	141.67	7.08	2.98	0.15	3.94	0.20	10.12	0.51
		Indoors with LEV	14.17	0.71	0.30	0.01	0.39	0.02	1.01	0.05
	1-4 hrs	Outdoors	59.50	2.98	1.25	0.06	1.65	0.08	4.25	0.21
		Indoors without LEV	85.00	4.25	1.79	0.09	2.36	0.12	6.07	0.30
		Indoors with LEV	8.5	0.43	0.18	0.01	0.24	0.01	0.61	0.03

PROC 15	>4 hrs	Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Indoors without LEV	21.25	1.06	0.45	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01

Quantitative risk characterisation of inhalation exposure concentrations of aqueous ammonia (in preparations of 5-25 % w/w) in workers (ES 3 – industrial use)

PROC code	**Exposure assumptions**		**ES 3-exposure concentrations (EC) mg/m³**		**Acute /long-term systemic effects DNEL = 47.6 mg/m3**		**Acute – local effects DNEL = 36 mg/m3**		**Long-term local effects DNEL = 14 mg/m3**	
					RCR		**RCR**		**RCR**	
	Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE - 95% reduction**	**No RPE**	**RPE -95% reduction**	**No RPE**	**RPE -95% reduction**
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.0001	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	30.63	1.53	0.64	0.03	0.85	0.04	2.19	0.11
		Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Outdoors	18.38	0.92	0.39	0.02	0.51	0.03	1.31	0.07
		Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 3	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.50	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 4	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.5	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 5	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55

		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8a	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8b	>4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	3.94	0.20	0.08	0.00	0.11	0.01	0.28	0.01
	1-4 hrs	Outdoors	55.13	2.76	1.16	0.06	1.53	0.08	3.94	0.20
		Indoors without LEV	78.75	3.94	1.65	0.08	2.19	0.11	5.63	0.28
		Indoors with LEV	2.36	0.12	0.05	0.00	0.07	<0.01	0.17	0.01
PROC 9	>4hrs	Outdoors	122.50	6.13	2.57	0.13	3.40	0.17	8.75	0.44
		Indoors without LEV	175.00	8.75	3.68	0.18	4.86	0.24	12.50	0.63
		Indoors with LEV	17.50	0.88	0.37	0.02	0.49	0.02	1.25	0.06
	1-4 hrs	Outdoors	73.50	3.68	1.54	0.08	2.04	0.10	5.25	0.26
		Indoors without LEV	105.00	5.25	2.21	0.11	2.92	0.15	7.50	0.38
		Indoors with LEV	10.50	0.53	0.22	0.01	0.29	0.01	0.75	0.04
PROC 15	>4 hrs	Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01

4 Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environmental releases:

In order to work within the boundaries of the ES the following conditions should be met:

- Local emission to air less than 30.5 mg/M^3
- When the on-site WWTP is used the WWTP sludge should not be spread to soil
- Emissions from the waste-water stream should be completely removed
- Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the industrial process.
- Measured emissions should be ensured to lead to concentrations in the environment which are less than the relevant PNEC

- Emissions to wastewater from laboratory use should not be to the municipal STP

Worker exposure:

In order to work within the boundaries of the ES the following conditions should be met:

- LEV should be in place in indoor facilities at times when natural ventilation is not sufficient.
- Where the potential for dermal exposure exists, gloves with a minimum efficiency of 90% and RPE with 95% efficiency should be worn.
- Health monitoring should be conducted regularly to ascertain the potential levels of exposure.
- Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) should be worn when any potential contact may arise.
- All technological devices should have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
- Workers should be fully trained.
- Any measured worker exposure levels should be confirmed to be below the relevant DNEL as presented in section 3 above.

Downstream User Exposure Scenario for Ammonia

Exposure Scenario 4: Industrial End-use of anhydrous and aqueous Ammonia as processing aids, non-processing aids and auxiliary agents

1	Exposure Scenario 4

Industrial end uses of anhydrous and aqueous Ammonia as processing aids, non –processing aids and auxiliary agents.

Processes Covered:
Environmental Releases

ERC4: Industrial uses of processing aids
ERC5: Industrial end use resulting in inclusion into or onto a matrix
ERC6b: Industrial end use of reactive processing aids
ERC 7: Industrial end use of substances in closed systems

Worker Processes
PROC01: Use in closed process, no likelihood of exposure.
PROC02: Use in closed, continuous process with occasional controlled exposure.
PROC03: Use in closed batch processes
PROC04: Use in batch and other processes where the potential for exposure occurs
PROC05: Mixing and blending
PROC07: Industrial spraying
PROC08a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities.
PROC08b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities.
PROC09: Transfer of formulations to small containers.
PROC10: Roller application or brushing of coatings
PROC13: Treatment of articles by dipping and pouring
PROC15: Laboratory use
PROC19: Low energy hand mixing
Anhydrous liquid and aqueous solutions of ammonia are used by a range of industry sectors in a broad number of applications. These include industrial end use as a reactive or non-reactive processing aid in continuous or batch processes, as an auxiliary agent or as substance in a closed system. Common industrial end-uses of ammonia are shown below.

Common industrial end-uses of ammonia

Industrial end-use	Type of use					Description of use
	Processing aid	Non-processing aid	Reactive processing aid	Auxiliary agent	Use in closed system	
Use as developing agent in photochemical processes	X					Ammonia is used as a developing agent in photochemical processes such as white printing, blue printing and in the diazo duplication press.
Use of refrigerant systems		X			X	Anhydrous liquid ammonia is used as a refrigerant in household, commercial and industrial systems due to its high heat of vaporisation and relative ease of liquefaction.
Insulation products		X				
Inks and toners	X	X				Ammonia vapours are used as a reagent in treating writing or ink marks
Coatings, thinners, paint removers	X	X				
Processing aid in chemicals industry			X			
Use as an extraction agent			X			Ammonia is used as an extraction agent in the mining industry to extract metals like copper, nickel and molybdenum from their ores.
Treatment of gas (NOx and SOx reduction)			X		X	Ammonia is used in stack emission control systems to neutralise sulphur oxides from combustion of sulphur-containing fuels, as a method of NOx control in both catalytic and non-catalytic applications and to enhance the efficiency of electrostatic precipitators for particulate control.
Processing aid in nutrition			X		X	The food and beverage industry use ammonia as a source of nitrogen required for yeast and micro-organism
Use as neutralising agent			X		X	Ammonia is used by the petrochemical industry in neutralizing the acid constituents of crude oil and in the protection of equipment from corrosion
Textile dyes			X			
Treatment of water	X		X			Aqueous ammonia is used in water and waste-water treatment areas to control pH, to regenerate weak anion exchange resins and as an oxygen scavenger in boiled water treatment. In water disinfection, aqueous ammonia is added to water containing free chlorine to produce a chloramines disinfectant.
Use as washing and cleaning products	X		X			Weak ammonia solutions are used extensively within industry, by professionals and consumers as commercial and household cleaners and detergents cleaning products. Commercial ammonia cleaning products contain up to 30% ammonia whereas household products contain 5-10% ammonia

Treatment of textiles		X	X			Liquid ammonia is used to increase the quality of textiles
Treatment of pulp and paper		X	X			Ammonia is used in the pulp and paper industry to pulp wood and as a casein dispersant to coat paper.
Treatment of leather		X	X			The leather industry utilises ammonia as a curing agent, as a slime and mould preservative in tanning liquors and as a protective agent for leather and furs in storage
Treatment of wood	X		X			Anhydrous ammonia fumes are used to darken wood in a process called “ammonia fuming”
Treatment of metal surfaces	X		X			Ammonia is used in metal treatment processes such as nitriding, carbonitriding, bright annealing, furnace brazing, sintering, sodium hydride descaling, atomic hydrogen welding and other application where protective atmospheres are required.
Treatment of rubber/latex		X	X			Concentrated aqueous ammonia is used in the rubber industry as a preservative for natural and synthetic latex due to its antibacterial and alkaline properties and as a stabiliser to prevent pre-mature coagulation (e.g. “ammoniation” of natural rubber latex.
Manufacture of semiconductors/electronics				X		Ammonia is used in the electronics industry in the manufacturing of semiconductor chips.
Adhesives, sealants	X			X		
Polymer preparations	X			X		
Aircare products					X	
Preservatives		X				Ammonia is uses as a preservative for the storage of high moisture corn

Contributing Environmental Scenario: Environmental exposure arising due to Industrial end uses of anhydrous and aqueous ammonia.

Contributing Worker Scenarios: Worker exposure arising due to day to day use in closed processes with no likelihood of exposure, day to day use in closed continuous processes with occasional exposure (such as sampling), day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance), mixing and blending, transfer to small containers, transfer of substance to and from large vessels and containers, roller and brushing application of coatings, treatment of articles by dipping and pouring, laboratory use, hand mixing and industrial spraying.

2.1	**Contributing scenario 1 controlling environmental exposure for ES 4**

Environmental exposure arising due to industrial end uses of anhydrous and aqueous ammonia.

Section 2.1 describes the environmental releases that may occur during the industrial end uses of anhydrous and aqueous ammonia. These releases may occur due to emission to wastewater or through emission to the atmosphere. If emission to wastewater occurs on-site treatment in an industrial waste water treatment plant will be required in order to remove downstream emissions to the environment.
In reality removal of ammonia in sewage treatment plants is highly efficient being removed first by nitrification to nitrate followed by denitrification resulting in the release of nitrogen gas. It is considered that if there processes are employed complete removal from the wastewater stream will occur. Emissions to the atmosphere should not exceed concentrations of 30.5 mg/m^3.

Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Possible exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.
Environmental factors influenced by risk management
Flow rate of receiving water at least 18,000 m^3 per day. Dilution of any STP emissions at least 10 fold.
Other operational conditions affecting environmental exposure
Workers are fully trained in safe use and the use of appropriate systems in order to prevent accidental release. Closed systems are employed in order to prevent un-intended emissions.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed sealed. On site WWTPs should be available at industrial sites in order to eliminate emissions to the environment via contaminated wastewater.
Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil
Waste water should be emitted to the on-site industrial WWTP for specialized removal. Emissions to air from the industrial processes or from the onsite WWTP should not exceed a total concentration of 19.9 mg/m^3 of air. This is approximately equivalent to a total loss to air of 70,000 kg/day. Sludge from the on-site WWTP should not be spread to soil. Any solid waste will be sent as waste for landfill, incineration or recycling.
Organizational measures to prevent/limit releases from site
Workers are fully trained in order to prevent accidental release and exposures may be monitored to ensure airborne concentrations are within acceptable levels.
Conditions and measures related to municipal STP
Direct emissions to the municipal STP should not be made.
Conditions and measures related to external treatment of waste for disposal
Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the industrial process. Sludge from the onsite WWTP should be recycled, incinerated or sent to landfill.
Conditions and measures related to external recovery of waste
There is no envisaged external recovery of waste. Waste sludge is reduced and then incinerated and emissions to air are not collected.

2.2	**Contributing scenario 2 controlling worker exposure during day to day use in closed processes with no likelihood of exposure.**
Worker exposure arising due to day to day use in closed processes with no likelihood of exposure during the industrial end use processes.	
Section 2.2 describes the potential exposure to workers during the industrial end use of ammonia as an intermediate from operation of closed systems. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.	
Product characteristics	
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.	

Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.3	**Contributing scenario 3 controlling worker exposure due to day to day use in closed continuous processes with occasional exposure (such as sampling)**

Worker exposure arising due to day to day use in closed continuous processes with occasional exposure (such as sampling).
Section 2.3 describes the potential exposure to workers during the industrial end use of preparations of ammonia from the operation of closed systems with the potential for occasional exposure during tasks such as sampling, cleaning and maintenance. The potential exposure arises from the operation of industrial end use equipment and its associated machinery and during routine sampling, cleaning and occasional maintenance.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in these tasks. Formulated solutions are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.4	**Contributing scenario 4 controlling worker exposure for day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance)**

Worker exposure arising due to day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance).

Section 2.4 describes the potential exposure to workers during day to day use of industrial machinery, pipelines and storage vessels. Potential exposure may occur during the day to day use however it is more likely to occur during tasks associated with the batch or other processes themselves such as sampling of produced intermediates, cleaning and routine maintenance.
Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Solutions of ammonia are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).
This contributing considers the potential exposures from batch and other processes (such as one off exposures) and though there is some potential for exposure generally systems are in place to control losses or unintended emissions of ammonia at the industrial facility.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial end use sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use during batch and other processes is generally a short duration task, with limited potential for exposure occurring in reality.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units. The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room.

Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.5	**Contributing scenario 5 controlling worker exposure for mixing and blending**

Worker exposure arising due to mixing and blending in batch processes during industrial end use

Section 2.5 describes the potential exposure to workers during mixing and blending of ammonia formulations. Potential exposure may occur during the day to day use of machinery and technologies associated with the blending and mixing process as part of the overall industrial end use of ammonia.
Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Stock ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.

Human factors not influenced by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.6	**Contributing scenario 6 controlling worker exposure for transfer to small containers**

Worker exposure arising due to transfer to small containers in a dedicated filling line.
Section 2.6 describes the potential exposure to workers during the filling of small containers in dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers themselves. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the small sized containers.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.
Human factors not influenced by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.

Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.7	**Contributing scenario 7 controlling worker exposure for transfer to and from large containers and vessels**

Worker exposure arising due transfer of ammonia to and from large containers and vessels
Section 2.7 describes the potential exposure to workers during the filling and loading to/from large vessels and containers in dedicated and non-dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers and vessels themselves. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Formulated liquid ammonia is then stored and transported as a liquid in the small sized containers.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial end use is generally a short duration task, with limited potential for exposure.
Human factors not influenced by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of anhydrous and aqueous forms of ammonia involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.8	**Contributing scenario 8 controlling worker exposure for roller and brushing applications of coatings**

Worker exposure arising due to roller and brushing applications of coatings
Section 2.8 describes the potential exposure to workers during the industrial end use of ammonia during roller and brushing applications to surfaces of coatings of ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.

Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial brushing and roller applications is generally a short duration task, with limited potential for exposure.
Human factors not influenced by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place. Workers should not be directly exposed to the application solutions.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial brushing and roller applications and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of surface applied ammonia during roller and brushing applications involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.9	**Contributing scenario 9 controlling worker exposure for treatment of articles by dipping and pouring**

Worker exposure arising due to treatment of articles by dipping and pouring.
Section 2.9 describes the potential exposure to workers during the industrial end use of ammonia during dipping and pouring treatment of articles using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial treatment of articles by dipping and pouring is generally a short duration task, with limited potential for exposure.
Human factors not influenced by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place. Workers should not be directly exposed to the article treatment solutions.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with industrial treatment of articles by dipping and pouring and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial treatment of articles by dipping and pouring involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). All operations are performed in a closed system. Pipelines and vessels are sealed and insulated and sampling is carried out with a closed sample loop. Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.10	**Contributing scenario 10 controlling worker exposure for laboratory use**
Worker exposure arising due to laboratory use of ammonia (small scale non-industrial laboratories).	
Section 2.10 describes the potential exposure to workers during laboratory use of ammonia especially during the filling and loading of small flasks and vessels using non-dedicated filling lines or small scale transfer methods. Potential exposure is most likely to occur during tasks associated with the actual transfer or mixing of the ammonia solutions. For dedicated small scale laboratories appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.	

Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. During laboratory use of ammonia solutions of aqueous ammonia in the 5 – 25% concentrations range are most liklety to be encountered. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.
Amounts used
Amounts use in a non-industrial setting are likely to be small with less than 1 litre or 1 kilogram present on site. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330 however actual emission of ammonia is likely to be much less frequent in practice.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Again use of ammonia is not likely to be this frequent in practice.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
During the laboratory end use of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. RPE is provided when required.
Technical conditions and measures at process level (source) to prevent release
During laboratory use LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases). All technological devices should have a proper quality certification, and should be regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not considered sufficient or in enclosed areas.
Organizational measures to prevent/limit release
Laboratory workers are fully trained in safe use of chemicals in general and in the use of appropriate PPE in order to prevent accidental release or exposure.
Conditions and measures related to personal protection, hygiene and health.
Workers may potentially be exposed to ammonia during laboratory use when filling containers and vessels or during transfer. Extract ventilation is provided at openings and points were emissions may occur. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in the required procedures and the use of appropriate protective equipment. Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise. Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.11	**Contributing scenario 11 controlling worker exposure for hand mixing with intimate contact and PPE only**
Worker exposure arising due to hand mixing with intimate contact and PPE only.	
Section 2.11 describes the potential exposure to workers during the industrial end use of ammonia during hand mixing of formulations (with intimate contact and PPE only) using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.	

Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia hand mixing in this case considered intimate contact and suitable PPE only.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Workers should not be directly exposed to the mixing solutions without PPE in place. LEV is generally not required.
Technical conditions to control dispersion from source towards worker
No specific measures aside from good industrial practice is required.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of mixing equipment and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial hand mixing of ammonia would generally be carried out indoors using low energy methods and in vessels which should reduce the potential for un-intended loss. The potential for industrial workers to be exposed to ammonia during these processes is therefore negligible since PPE and low emission methods are used. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the hand mixing of ammonia or ammonia solutions are well-trained in the required procedures and use of appropriate protective equipment.

2.12	**Contributing scenario 12 controlling worker exposure for industrial spraying**

Worker exposure arising due to industrial spraying and air dispersive techniques
Section 2.12 describes the potential exposure to workers during the industrial end use of ammonia for spray aplications using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used
Industrial sites may use up to a largest individual site tonnage of 25,000 tonnes per annum, with up to 354,000 tonnes used per year in the European Union. According to the guidance for this tonnage band, the default REACH number of emission days per year are 330.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during industrial spraying is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects is conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place. Workers should not be directly exposed to ammonia and ammonia containing solutions.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with this industrial end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects is conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Industrial end-uses of sprayed ammonia during air dispersive applications involve special equipment and high integrity specialized systems. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps or tanks etc). Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the industrial end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

3	**Exposure estimation and reference to its source**

The assessment of worker exposure to anhydrous and aqueous forms of ammonia in industrial end-use applications (ES 4) was carried out for processes relevant to this scenario as identified by PROC codes reflecting: use and storage of ammonia in closed systems with no likelihood of exposure (PROC 1), use in closed, continuous processes with occasional controlled exposure (PROC 2), formulation using closed batch processes (PROC 3), use in batch or other processes (PROC 4), mixing or blending in a batch process (PROC 5), industrial spraying (PROC 7), maintenance and clean down (PROC 8a), transfer (PROC 8b), transfer of ammonia into containers (PROC 9), brush and roller applications (PROC 10), treatment of articles by dipping and pouring (PROC 13), and analysis of samples (PROC 15) and hand-mixing (PROC 19).
A screening-level (Tier 1) assessment of worker exposure was carried out using the ECETOC Targeted Risk Assessment (TRA) model. The ECETOC TRA was used to predict dermal exposures (expressed as a daily systemic dose in mg/kg bw) and inhalation exposure concentrations (expressed as an airborne concentration in mg/m3) associated with each process defined by PROC codes.

Exposure to workers was assessed taking into account different operational conditions that may be associated with the industrial end-use of ammonia and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90% protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposure concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.
The ECETOC TRA model uses a simple algorithm to determine dermal exposures that does not take the physical-chemical properties of a substance into account. The same dermal exposure where therefore predicted for anhydrous and aqueous forms of ammonia. Parameters used in the ECETOC TRA model to assess inhalation exposures were: molecular weight (35 $g.mol^{-1}$ and 17 $g.mol^{-1}$ for aqueous and anhydrous forms respectively) and vapour pressure (the vapour pressure of anhydrous forms of ammonia is 8.6 x 10^5 Pa at 20°C, whereas the vapour pressure of aqueous ammonia solution between 5 and 25% w/w ranges from 5 x 10^3 Pa to 4 x10^4 Pa at 20°C. Systemic dermal exposures have been determined for a worker with bodyweight 70 kg.
For environmental emissions complete removal in the on-site WWTP was considered during derivation of the values below. Emission values and environmental concentrations were calculated using the EUSES 2.1 model.

Information for contributing scenario 1 (environmental exposure):

The following PEC values were calculated using EUSES 2.1

ERC	PEC	Values
ERCs 4, 5, 6b and 7	PEC in sewage effluent	0 (due to complete removal)
ERCs 4, 5, 6b and 7	PEC in aquatic compartment (mg/L):	
	Freshwater	ERC 4: 2.82 x 10^{-3} ERC 5: 1.46 x 10^{-3} ERC 6b: 4.54 x 10^{-5} ERC 7: 1.46x 10^{-4}
	Marine Water	ERC 4: 6.06 x 10^{-4} ERC 5: 3.17 x 10^{-4} ERC 6b: 5.19 x 10^{-6} ERC 7: 3.17 x 10^{-5}
ERCs 4, 5, 6b and 7	PEC in sediments (mg/kg):	
	Freshwater sediments	ERC 4: 3.05 x 10^{-3} ERC 5: 1.58 x 10^{-3} ERC 6b: 4.91 x 10^{-5} ERC 7: 1.58 x 10^{-4}
	Marine water sediments	ERC 4: 6.56 x 10^{-4} ERC 5: 3.43 x 10^{-4} ERC 6b: 5.62 x 10^{-6} ERC 7: 3.43 x 10^{-5}

ERCs 4, 5, 6b and 7	PEC in soil and groundwater:	Upon contact with soil, ammonia will be rapidly converted by a variety of bacteria, actinomycetes and fungi to ammonium (NH_4^+) by the process of ammonification or mineralization. Ammonium is then rapidly converted to nitrate. Nitrate is subsequently taken up and utilised by plants or returned to the atmosphere following denitrification; the metabolic reduction of nitrate into nitrogen or nitrous oxide (N2O) gas. The most likely fate of ammonium ions in soils is conversion to nitrates by nitrification. Therefore accumulation of concentrations of ammonia in soil and groundwater will not be expected.
ERCs 4, 5, 6b and 7	PEC in air: annual average (mg/M^3)	ERC 4: 18 ERC 5: 9.45 ERC 6b: 0.0189 ERC 7: 0.945

The following RCR values were obtained:

Compartments	**PEC**	**PNEC**	**PEC/PNEC**	**Discussion**
ERC 4 Freshwater (Tier 2)	2.82×10^{-3} mg/L (Total Ammonia) 1.08×10^{-4} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.098	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 4 Marine water (Tier 2)	6.06×10^{-4} mg/L (Total Ammonia) 2.31×10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.021	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 5 Freshwater (Tier 2)	1.46×10^{-3} mg/L (Total Ammonia) 5.58×10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.051	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

ERC 5 Marine water (Tier 2)	3.17 x 10^{-4} mg/L (Total Ammonia) 1.21 x 10^{-5} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	0.011	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 6b Freshwater (Tier 2)	4.54 x 10^{-5} mg/L (Total Ammonia) 1.73 x 10^{-6} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	1.58 x 10^{-3}	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 6b Marine water (Tier 2)	5.19 x 10^{-6} mg/L (Total Ammonia) 1.98 x 10^{-7} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	1.80 x 10^{-4}	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 7 Freshwater (Tier 2)	1.46 x 10^{-4} mg/L (Total Ammonia) 5.58 x 10^{-6} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	5.07 x 10^{-3}	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)
ERC 7 Marine water (Tier 2)	3.17 x 10^{-5} mg/L (Total Ammonia) 1.21 x 10^{-6} mg/L (Free Ammonia)	0.0011 mg/l (Free Ammonia)	1.10 x 10^{-3}	Conversion from Total Ammonia to Free Ammonia based on a fraction of 3.82% given for pH 8 and 25C. (Ref data tabulated in EPA document EPA-600/3-79-091)

The following values were obtained using ECETOC TRA for worker exposure

Dermal exposures predicted using the ECETOC TRA model

Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure mg/kg bw/d**	
		Duration	**Use of ventilation**	**No gloves worn**	**Gloves worn (90% reduction)**
Use in a closed process, no likelihood of exposure: storage (closed or bulk container)	PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14
			Indoors with LEV	0.14	0.01

Use in closed batch process (synthesis or formulation)	PROC 3	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Mixing or blending in batch process	PROC 5	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.07	0.01
Transfer into small containers	PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at dedicated facilities	PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
			Indoors with LEV	0.69	0.07
Roller application or brushing	PROC 10	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	27.43	0.14
		1-4 hrs or >4 hrs	Indoors with LEV	1.37	10.71
Treatment of articles by dipping and pouring	PROC 13	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Laboratory use : Quality control in a laboratory	PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01
Hand-mixing with intimate contact and PPE only	PROC 19	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	141.73	14.13
Industrial spraying	PROC 7	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	42.86	4.29
		1-4 hrs or >4 hrs	Indoors with LEV	2.14	0.21

Inhalation exposure concentrations predicted using the ECETOC TRA model

				Anhydrous ammonia		**Aqueous ammonia (5-25% w/w)**	
Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure Concentration mg/m3**			
		Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE (95% reduction)**
Used in a closed process, no likelihood	PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	0.01	NA

of exposure: Storage (closed bulk or container)		1-4 hrs or >4 hrs	Indoors without LEV	0.01	NA	0.01	NA
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	>4hrs	Outdoors	24.79	1.24	30.63	1.53
		>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.53	0.18	4.38	0.22
		1-4 hrs	Outdoors	14.88	0.74	18.38	0.92
		1-4 hrs	Indoors without LEV	22.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Use in closed batch process (synthesis or formulation)	PROC 3	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.50	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.5	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Mixing or blending in batch process	PROC 5	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Maintenance, clean down	PROC 8a	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66

Transfer of ammonia (charging/discharging) from/to vessels or large containers at dedicated facilities	PROC 8b	>4hrs	Outdoors	74.38	3.72	91.88	4.59
		>4hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		>4hrs	Indoors with LEV	3.19	0.16	3.94	0.20
		1-4 hrs	Outdoors	44.63	2.23	55.13	2.76
		1-4 hrs	Indoors without LEV	63.75	3.19	78.75	3.94
		1-4 hrs	Indoors with LEV	1.91	0.1	2.36	0.12
Transfer into small containers	PROC 9	>4hrs	Outdoors	99.17	4.96	122.50	6.13
		>4hrs	Indoors without LEV	141.67	7.08	175.00	8.75
		>4hrs	Indoors with LEV	14.17	0.71	17.50	0.88
		1-4 hrs	Outdoors	59.50	2.98	73.50	3.68
		1-4 hrs	Indoors without LEV	85.00	4.25	105.00	5.25
		1-4 hrs	Indoors with LEV	8.5	0.43	10.50	0.53
Roller application or brushing	PROC 10	>4hrs	Outdoors	NA	NA	153.13	7.66
		>4hrs	Indoors without LEV	NA	NA	218.75	10.94
		>4hrs	Indoors with LEV	NA	NA	21.88	1.09
		1-4 hrs	Outdoors	NA	NA	91.88	4.59
		1-4 hrs	Indoors without LEV	NA	NA	131.25	6.56
		1- 4 hrs	Indoors with LEV	NA	NA	13.13	0.66
Treatment of articles by dipping and pouring	PROC 13	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Quality control in a laboratory	PROC 15	>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.54	0.18	4.38	0.22
		1-4 hrs	Indoors without LEV	21.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Hand-mixing with intimate contact and PPE only	PROC 19	<4 hrs	Outdoors	NA	NA	153.13	7.66
		<4 hrs	Indoors without LEV	NA	NA	218.75	10.94
		1-4 hrs	Outdoors	NA	NA	91.88	4.59
		1-4 hrs	Indoors without LEV	NA	NA	131.25	6.56
Industrial spraying		>4hrs	Outdoors	NA	NA	306.25	15.31

	PROC 7	>4hrs	Indoors without LEV	NA	NA	437.5	21.88
		>4hrs	Indoors with LEV	NA	NA	21.88	1.09
		1-4 hrs	Outdoors	NA	NA	183.75	9.19
		1-4 hrs	Indoors without LEV	NA	NA	262.5	13.13
		1-4 hrs	Indoors with LEV	NA	NA	13.13	0.66

The following RCR values were obtained using ECETOC TRA and the relevant DNELs

Quantitative risk characterisation of dermal exposures to anhydrous or aqueous (in preparations of 5- 25 % w/w) ammonia for industrial workers (ES 4 – Industrial end-use)

PROC code	**Exposure assumptions**		**ES 4- exposure concentrations (EC) mg/kg bw/d**		**Acute / long term systemic effects DNEL = 6.8 mg/kg bw/d**	
					Risk characterisation ratio	
	Duration	**Use of ventilation**	**No gloves worn**	**Gloves worn (90% reduction)**	**No gloves worn**	**Gloves worn (90% reduction)**
PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14	0.20	0.02
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 3	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 4	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 5	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.07	0.01	0.01	<0.01
PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 10	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	27.43	2.74	4.03	0.40
		Indoors with LEV	1.37	0.14	0.20	0.02
PROC 13	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.69	0.07	0.10	0.01
		Outdoors / Indoors without LEV	0.34	0.03	0.05	0.01

PROC 15	1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 19	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	141.73	14.14	20.80	2.08 *
*Adjusting for 10% dermal absorption gives a dermal exposure of 1.41 mg/kg bw/d assuming gloves affording 90% protection are worn and the RCR = 0.2						

PROC 7	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	42.86	4.29	6.30	0.63
		Indoors with LEV	2.14	0.21	0.32	0.03

Quantitative risk characterisation of inhalation exposure concentrations of anhydrous ammonia for industrial workers (ES 4 – Industrial end-use)

PROC code	**Exposure assumptions**		**ES 4-exposure concentrations (EC) mg/m³**		**Acute / long-term systemic effects DNEL = 47.6 mg/m3**		**Acute-local effects DNEL = 36 mg/m3**		**Long-term local effects DNEL = 14 mg/m3**	
					RCR		**RCR**		**RCR**	
	Duration	**Use of ventilation**	**No RPE**	**RPE -95% reduction**	**No RPE**	**RPE – 95%**	**No RPE**	**RPE 95% reduction**	**No RPE**	**RPE -95% reduction**
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09
		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05
		Indoors without LEV	22.25	1.06	0.47	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 3	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 4	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
		Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11

	1-4 hrs	Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 5	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8a	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8b	>4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	3.19	0.16	0.07	0.00	0.09	<0.01	0.23	0.01
	1-4 hrs	Outdoors	44.63	2.23	0.94	0.05	1.24	0.06	3.19	0.16
		Indoors without LEV	63.75	3.19	1.34	0.07	1.77	0.09	4.55	0.23
		Indoors with LEV	1.91	0.10	0.04	0.00	0.05	<0.01	0.14	0.01
PROC 9	>4 hrs	Outdoors	99.17	4.96	2.08	0.10	2.75	0.14	7.08	0.35
		Indoors without LEV	141.67	7.08	2.98	0.15	3.94	0.20	10.12	0.51
		Indoors with LEV	14.17	0.71	0.30	0.01	0.39	0.02	1.01	0.05
	1-4 hrs	Outdoors	59.50	2.98	1.25	0.06	1.65	0.08	4.25	0.21
		Indoors without LEV	85.00	4.25	1.79	0.09	2.36	0.12	6.07	0.30
		Indoors with LEV	8.5	0.43	0.18	0.01	0.24	0.01	0.61	0.03
PROC 13	>4 hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 15	>4 hrs	Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Indoors without LEV	21.25	1.06	0.45	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01

Quantitative risk characterisation of inhalation exposure concentrations of aqueous ammonia (in preparations of 5-25% w/w) in industrial workers (ES 4 – Industrial end-use)

PROC code	Exposure assumptions		ES 4- exposure concentrations (EC) mg/m³		Acute /long-term systemic effects DNEL = 47.6 mg/m3		Acute – local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE (95% reduction)	No RPE	RPE - 95% reduction	No RPE	RPE -95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	30.63	1.53	0.64	0.03	0.85	0.04	2.19	0.11
		Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Outdoors	18.38	0.92	0.39	0.02	0.51	0.03	1.31	0.07
		Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 3	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.50	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 4	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.5	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 5	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
		Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33

	1-4 hrs	Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8a	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8b	>4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	3.94	0.20	0.08	0.00	0.11	0.01	0.28	0.01
	1-4 hrs	Outdoors	55.13	2.76	1.16	0.06	1.53	0.08	3.94	0.20
		Indoors without LEV	78.75	3.94	1.65	0.08	2.19	0.11	5.63	0.28
		Indoors with LEV	2.36	0.12	0.05	0.00	0.07	<0.01	0.17	0.01
PROC 9	>4hrs	Outdoors	122.50	6.13	2.57	0.13	3.40	0.17	8.75	0.44
		Indoors without LEV	175.00	8.75	3.68	0.18	4.86	0.24	12.50	0.63
		Indoors with LEV	17.50	0.88	0.37	0.02	0.49	0.02	1.25	0.06
	1-4 hrs	Outdoors	73.50	3.68	1.54	0.08	2.04	0.10	5.25	0.26
		Indoors without LEV	105.00	5.25	2.21	0.11	2.92	0.15	7.50	0.38
		Indoors with LEV	10.50	0.53	0.22	0.01	0.29	0.01	0.75	0.04
PROC 10	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 13	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05

PROC 15	>4 hrs	Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 19	>4 hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
PROC 7	>4hrs	Outdoors	306.25	15.31	6.43	0.32	8.51	0.43	21.88	1.09
		Indoors without LEV	437.5	21.88	9.19	0.46	12.15	0.61	31.25	1.56
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	183.75	9.19	3.86	0.19	5.10	0.26	13.13	0.66
		Indoors without LEV	262.5	13.13	5.51	0.28	7.29	0.36	18.75	0.94
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05

4 Guidance to DU to evaluate whether he works inside the boundaries set by the ES

Environmental releases:

In order to work within the boundaries of the ES the following conditions should be met:

- Local emission to air less than 70,000 kg/day
- When the on-site WWTP is used the WWTP sludge should not be spread to soil
- Emissions from the waste-water stream should be completely removed
- Residues may be sent to external waste treatment, on-site effluent treatment or recycled back into the manufacturing process.
- Measured emissions should be ensured to lead to concentrations in the environment which are less than the relevant PNEC
- Emissions to wastewater from laboratory use should not be to the municipal STP

Worker exposure:

In order to work within the boundaries of the ES the following conditions should be met:

- LEV should be in place in indoor facilities at times when natural ventilation is not sufficient.
- Where the potential for dermal exposure exists, gloves with a minimum efficiency of 90% and RPE with 95% efficiency should be worn.
- Health monitoring should be conducted regularly to ascertain the potential levels of exposure.
- Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) should be worn when any potential contact may arise.
- All technological devices should have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
- Workers should be fully trained.

- Any measured worker exposure levels should be confirmed to be below the relevant DNEL as presented in section 3 above.

Downstream User Exposure Scenario for Ammonia
Exposure Scenario 5: Wide-dispersive Professional Use of Anhydrous and Aqueous Ammonia

1	Exposure Scenario 5

Wide dispersive professional uses of anhydrous and aqueous Ammonia as processing aids, non – processing aids and auxiliary agents.
Processes Covered:
Environmental Releases

ERC 8a: Wide dispersive indoor use of processing aids in open systems
ERC8b: Wide dispersive indoor use of reactive substances in open systems
ERC8d: Wide dispersive outdoor use of processing aids in open systems
ERC 8e: Wide dispersive outdoor use of reactive substances in open systems
ERC 9a: Wide dispersive indoor use of substances in closed systems
ERC 9b: Wide dispersive outdoor use of substances in closed systems
ERC11a: Wide dispersive indoor use of long-life articles and materials with low release

Worker Processes

PROC01: Use in closed process, no likelihood of exposure.
PROC02: Use in closed, continuous process with occasional controlled exposure.
PROC03: Use in closed batch processes
PROC04: Use in batch and other processes where the potential for exposure occurs
PROC05: Mixing and blending
PROC08a: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities.
PROC08b: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities.
PROC09: Transfer of formulations to small containers.
PROC10: Roller application or brushing of coatings
PROC11: Non-professional spraying
PROC13: Treatment of articles by dipping and pouring
PROC15: Laboratory use
PROC19: Low energy hand mixing
PROC20: Heat and pressure transfer fluids

Anhydrous liquid ammonia (>99.5 % wt) and aqueous ammonia solution (5-25% wt) are used by professional workers in a broad number of applications. Common applications include: use as a laboratory chemical, a refrigerant in cooling systems, a water treatment chemical, a fertiliser, a coating, paint thinner or paint remover, a photochemical, a cleaning product, a leather or other surface treatment product, a pH regulator or neutralisation agent and a process aid for nutrition.
Typical activities associated with the professional uses of ammonia where exposures can arise include operating equipment containing ammonia (e.g. opening and closing valves), transferring ammonia from storage containers using pipe or hoses, maintaining equipment and applying ammonia-based products (e.g. fertiliser, cleaning or surface treatment products).

Operational conditions pertaining to the broad range of professional end-use scenarios involving anhydrous and aqueous forms of ammonia vary considerably across applications. A full characterisation of the frequency and duration of tasks is therefore beyond the scope of this exposure scenario. For the purposes of worker exposure estimation, operational conditions have been represented generically based on the assumption that tasks may be either 1-4 hours or >4 hours in duration and that processes may be carried out either outdoors, indoors without LEV or indoors with LEV. These assumptions cover the broad range of tasks associated with professional uses of ammonia.

Contributing Environmental Scenario: Environmental exposure arising due to Wide dispersive professional uses of anhydrous and aqueous ammonia.

Contributing Worker Scenarios: Worker exposure arising due to day to day use in closed processes with no likelihood of exposure, day to day use in closed continuous processes with occasional exposure (such as sampling), day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance), mixing and blending, transfer to small containers, transfer of substance to and from large vessels and containers, roller and brushing application of coatings, treatment of articles by dipping and pouring, laboratory use, use in heat and pressure transfer fluids, hand mixing and non-professional spraying.

2.1	**Contributing scenario 1 controlling environmental exposure for ES 5**

Environmental exposure arising due to wide dispersive professional uses of anhydrous and aqueous ammonia.

Section 2.1 describes the environmental releases that may occur during the wide dispersive professional uses of anhydrous and aqueous ammonia. These releases may occur due to emission to wastewater or through emission to the atmosphere. Due to the wide dispersive nature of these uses local source emissions are expected to be very small and significant concentrations in the environment are not expected.

Low level emission may be outdoor or indoor with emission directed to air or to the STP. In reality removal of ammonia in sewage treatment plants is highly efficient as ammonia solutions are readily biodegradable.

The majority of ammonia in the environment originates from natural sources, predominantly decaying organic matter. Wide dispersive professional uses of ammonia are diverse and widespread. The resulting environmental exposure is not expected to add significantly to already present background levels of ammonia in the environment. An additional assessment for environmental exposure for wide dispersive uses has therefore not been presented in section 3 below.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Professional use is expected to see very small amounts used on a local scale with use widespread throughout the EU.

Frequency and duration of use

Variable low level use.

Environmental factors influenced by risk management

Large regional dilution and wide dispersive use pattern.

Other operational conditions affecting environmental exposure

Professional workers should be informed in order to prevent accidental release. Closed systems are employed in articles 9such as fridges) in order to prevent un-intended emissions.

Technical conditions and measures at process level (source) to prevent release

Closed articles for long-life use.

Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil

None-specifically required beyond standard good practice for professional workers.

Organizational measures to prevent/limit releases from site

Workers are trained in order to prevent accidental releases.

Conditions and measures related to municipal STP
Small low level local emissions may be released to the STP where removal is expected to be efficient due to the readily biodegradable nature of low concentration ammonia solutions.
Conditions and measures related to external treatment of waste for disposal
Any residual waste (such as empty bottles or old fridges and cooling systems) should be sent to landfill or for specialized disposal.
Conditions and measures related to external recovery of waste
There is no envisaged external recovery of ammonia waste.

2.2	**Contributing scenario 2 controlling worker exposure day to day use in closed processes with no likelihood of exposure.**

Worker exposure arising due to day to day use in closed processes with no likelihood of exposure during the professional end use processes.
Section 2.2 describes the potential exposure to workers during the professional end use of ammonia as an intermediate from operation of closed systems. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible.

Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise.
All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.3	**Contributing scenario 3 controlling worker exposure due to day to day use in closed continuous processes with occasional exposure (such as sampling)**

Worker exposure arising due to day to day use in closed continuous processes with occasional exposure (such as sampling).

Section 2.3 describes the potential exposure to workers during the professional end use of preparations of ammonia from the operation of closed systems with the potential for occasional exposure during tasks such as sampling, cleaning and maintenance. The potential exposure arises from the operation of professional end use equipment and its associated machinery and during routine sampling, cleaning and occasional maintenance.

Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in these tasks. Formulated solutions are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use may generally arise during a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units. The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.4	**Contributing scenario 4 controlling worker exposure for day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance)**

Worker exposure arising due to day to day use in batch or other processes with some potential for exposure (such as sampling, cleaning, maintenance).
Section 2.4 describes the potential exposure to workers during day to day use of professional machinery, pipelines and storage vessels. Potential exposure may occur during the day to day use however it is more likely to occur during tasks associated with the batch or other processes themselves such as cleaning and routine maintenance. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Solutions of ammonia are stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia). This contributing considers the potential exposures from batch and other processes (such as one off exposures) and though there is some potential for exposure generally systems are in place to control losses or unintended emissions of ammonia at the professional facility.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use during batch and other processes is generally a short duration task, with limited potential for exposure occurring in reality.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.

Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units. The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.5	**Contributing scenario 5 controlling worker exposure for mixing and blending**

Worker exposure arising due to mixing and blending in batch processes during professional end use
Section 2.5 describes the potential exposure to workers during mixing and blending of ammonia formulations. Potential exposure may occur during the day to day use of machinery and technologies associated with the blending and mixing process as part of the overall professional end use of ammonia. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task. Stock ammonia is stored and transported as a liquid under pressure by rail, road or water in specialised, authorised containers (e.g. tanks and tank trucks approved for transporting ammonia).
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.6	**Contributing scenario 6 controlling worker exposure for transfer to small containers**

Worker exposure arising due to transfer to small containers in a dedicated filling line.
Section 2.6 describes the potential exposure to workers during the filling of small containers in dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers themselves. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.7	**Contributing scenario 7 controlling worker exposure for transfer to and from large containers and vessels**

Worker exposure arising due transfer of ammonia to and from large containers and vessels
Section 2.7 describes the potential exposure to workers during the filling and loading to/from large vessels and containers in dedicated and non-dedicated filling lines. Potential exposure is most likely to occur during tasks associated with the actual filling of the containers and vessels themselves. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional end use is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional end use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of anhydrous and aqueous forms of ammonia are diverse and should generally be carried out using specialized contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professionals to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room whenever possible. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps, tanks or during mixing etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for professional worker exposure. Workers involved in the wide dispersive professional uses of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.8	**Contributing scenario 8 controlling worker exposure for roller and brushing applications of coatings**
Worker exposure arising due to roller and brushing applications of coatings	
Section 2.8 describes the potential exposure to workers during the professional end use of ammonia during roller and brushing applications to surfaces of coatings of ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.	
Product characteristics	
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.	
Amounts used	
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.	
Frequency and duration of use exposure	
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional brushing and roller applications is generally a short duration task, with limited potential for exposure.	
Human factors not influence by risk management	
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).	
Other given operational conditions affecting worker exposure	
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.	
Technical conditions and measures at process level (source) to prevent release	

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible. Workers should not be directly exposed to the application solutions.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with professional use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Professional end-uses of surface applied ammonia during roller and brushing applications involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professional workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room.

Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, brushing equipment, pumps or tanks etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the professional end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.9	**Contributing scenario 9 controlling worker exposure for treatment of articles by dipping and pouring**

Worker exposure arising due to treatment of articles by dipping and pouring.

Section 2.9 describes the potential exposure to workers during the professional end use of ammonia during dipping and pouring treatment of articles using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional treatment of articles by dipping and pouring is generally a short duration task, with limited potential for exposure.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible. Workers should not be directly exposed to the article treatment solutions.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with professional use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Professional end-uses of surface applied ammonia during roller and brushing applications involve special equipment and high integrity contained systems with little or no potential for worker exposure. Facilities may be housed outdoors, with workers being segregated in separate control rooms with no direct contact with chemical processing units The potential for professional workers to be exposed to ammonia during these processes is therefore negligible since they are located in a separate control room.

Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, pumps or tanks etc). Extract ventilation is provided at openings and points were emission may occur. Anhydrous ammonia is stored in closed containers and tanks. Ammonia is transferred under containment. A good standard of general or controlled ventilation is applied when maintenance activities are carried out. Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise.

All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the professional end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.10	**Contributing scenario 10 controlling worker exposure for laboratory use**

Worker exposure arising due to laboratory use of ammonia.

Section 2.10 describes the potential exposure to workers during laboratory use of ammonia especially during the filling and loading of small flasks and vessels using non-dedicated filling lines or small scale transfer methods. Potential exposure is most likely to occur during tasks associated with the actual transfer or mixing of the ammonia solutions.
For dedicated small scale laboratories appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable.
During laboratory use of ammonia solutions of aqueous ammonia in the 5 – 25% concentrations range are most liklety to be encountered. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable. It is this aqueous ammonia that is most likely to cause potential exposure for this contributing scenario.

Amounts used

Amounts use in a professional setting are likely to be small with less than 1 litre or 1 kilogram present on site. According to the guidance for this tonnage band, the default REACH number of emission days per year are 365 for wide dispersive uses however actual emission of ammonia is likely to be much less frequent in practice.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Again use of ammonia is not likely to be this frequent in practice.

Human factors not influence by risk management

Respiration volume under conditions of use: 10 m^3/d
Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).

Other given operational conditions affecting worker exposure

During the laboratory end use of ammonia indoors local exhaust ventilation may be in place. Personal protective equipment is also used to minimize the potential for dermal exposure during the transfer process. RPE is provided when required.

Technical conditions and measures at process level (source) to prevent release

During laboratory use LEV may or may not be in place (refer to section 3 below for relevant exposure levels for these cases).
All technological devices should have a proper quality certification, and should be regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not considered sufficient or in enclosed areas.

Organizational measures to prevent/limit release

Laboratory workers are fully trained in safe use of chemicals in general and in the use of appropriate PPE in order to prevent accidental release or exposure.

Conditions and measures related to personal protection, hygiene and health.

Workers may potentially be exposed to ammonia during laboratory use when filling containers and vessels or during transfer. Extract ventilation is provided at openings and points were emissions may occur.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers are well-trained in the required procedures and the use of appropriate protective equipment.
Where good natural ventilation is found to be inadequate, mechanical (general) ventilation or local exhaust ventilation (LEV) is provided. Personal protective clothing (e.g. face/eye/ear protection, helmet, gloves boots and protective overall) is worn when any potential contact may arise.
Level A clothing (full encapsulating suit with self contained breathing apparatus) is used when handling large liquid spills or vapour clouds. Impervious clothing and rubber gloves are used for small liquid spills and normal loading and unloading operations. Safety shower/eye wash facilities are provided at sites which handle or store ammonia. Filtering respiratory masks are worn in case on the accidental release of ammonia.

2.11	**Contributing scenario 11 controlling worker exposure for hand mixing with intimate contact and PPE only**

Worker exposure arising due to hand mixing with intimate contact and PPE only.

Section 2.11 describes the potential exposure to workers during the professional end use of ammonia during hand mixing of formulations (with intimate contact and PPE only) using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.

Product characteristics

Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.

Amounts used

Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.

Frequency and duration of use exposure

Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia hand mixing in this case considered intimate contact and suitable PPE only.

Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Workers should not be directly exposed to the mixing solutions without PPE in place. LEV is generally not required.
Technical conditions to control dispersion from source towards worker
No specific measures aside from good professional practice is required.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of mixing equipment and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional hand mixing of ammonia would generally be carried out indoors using low energy methods and in vessels which should reduce the potential for un-intended loss. The potential for professional workers to be exposed to ammonia during these processes is therefore negligible since PPE and low emission methods are used. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the hand mixing of ammonia or ammonia solutions are well-trained in the required procedures and use of appropriate protective equipment.

2.12	**Contributing scenario 12 controlling worker exposure for professional spraying**

Worker exposure arising due to professional spraying and air dispersive techniques
Section 2.12 describes the potential exposure to workers during the professional end use of ammonia for spray applications using ammonia or ammonia containing solutions. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during professional spraying is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release

Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however system closure should still be in place when possible. Workers should not be directly exposed to the spraying solutions.
Technical conditions to control dispersion from source towards worker
LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.
Organizational measures to prevent/limit release
Workers are fully trained in safe use of the machinery associated with professional intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Conditions and measures related to personal protection, hygiene and health.
Professional end-uses of sprayed ammonia during air dispersive applications involve special equipment and high integrity specialized systems. Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps or tanks etc). Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise. All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia. Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the professional end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

2.13	**Contributing scenario 13 controlling worker exposure for** use in heat and pressure transfer fluids

Worker exposure arising due to use in heat and pressure transfer fluids
Section 2.2 describes the potential exposure to workers during the professional end use of ammonia use in heat and pressure transfer fluid applications of ammonia based solutions in dispersive but closed systems. Appropriate PPE and onsite controls are in place to limit the risk of exposure to workers involved in this task.
Product characteristics
Anhydrous ammonia is a colourless gas at room temperature and pressure with a typical purity of around 99.9%. The vapour pressure of ammonia, anhydrous is reported to be 8611 hPa at 20 °C. Anhydrous ammonia is very soluble in water: reported water solubility values are 482000-531000 mg/L. Anhydrous ammonia is considered to be flammable. Formulated aqueous ammonia has a vapour pressure of 287 hPa and is considered readily biodegradable.
Amounts used
Small amounts are expected to be used on professional sites each year. As wide dispersive uses significant on-site tonnages are not expected for professional use.
Frequency and duration of use exposure
Workers perform standard shifts of 8 hours per day and have standard working years of 220 days per year. Potential exposure to ammonia during use in heat and pressure transfer fluids is generally a short duration task, with limited potential for exposure.
Human factors not influence by risk management
Respiration volume under conditions of use: 10 m^3/d Area of skin contact with the substance under conditions of use: 480cm^2 (ECETOC default).
Other given operational conditions affecting worker exposure
Workers are fully trained in safe use and the use of appropriate PPE in order to prevent accidental release. Frequent monitoring for health effects may be conducted by medical surveillance programs.
Technical conditions and measures at process level (source) to prevent release
Systems and transfer pipelines should be closed and sealed. During indoor processes or in cases where natural ventilation is not sufficient LEV should be in place. For outdoor processes LEV is not generally required however

system closure should still be in place when possible. Workers should not be directly exposed to the treatment solutions.

Technical conditions to control dispersion from source towards worker

LEV should be in place during indoor operations when natural ventilation is not sufficient. Reactors and pipelines should be closed and sealed systems when possible.

Organizational measures to prevent/limit release

Workers are fully trained in safe use of the machinery associated with professional intermediate use and in the use of appropriate PPE in order to prevent accidental release or unintended exposure. Frequent monitoring for health effects may be conducted by medical surveillance programs.

Conditions and measures related to personal protection, hygiene and health.

Professional end-uses of ammonia lubricants for use in heat and pressure transfer fluid applications involve special equipment and high integrity specialized systems.
Workers may potentially be exposed to ammonia when conducting field activities (e.g. when operating valves, spraying machinery, pumps or tanks etc). Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) is worn when any potential contact may arise.
All technological devices have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
Good occupational hygiene and exposure control measures are implemented to minimise the potential for worker exposure. Workers involved in the professional end use of ammonia are well-trained in the required procedures and use of appropriate protective equipment.

3	**Exposure estimation and reference to its source**

The assessment of worker exposure to anhydrous and aqueous ammonia during professional uses (ES 5) was carried out for process categories relevant to this scenario as identified by PROC codes: use and storage of ammonia in closed systems with no likelihood of exposure (PROC 1), use in closed, continuous processes with occasional controlled exposure (PROC 2), formulation using closed batch processes (PROC 3), use in batch or other processes (PROC 4), mixing or blending in a batch process (PROC 5), maintenance and clean-down (PROC 8a), transfer (PROC 8b), transfer of ammonia into containers (PROC 9), brush and roller applications (PROC 10), spraying (PROC 11), treatment of articles by dipping and pouring (PROC 13), and analysis of samples (PROC 15), hand-mixing (PROC 19) and heat and pressure transfer in closed systems (PROC 20).
A screening-level (Tier 1) assessment of worker exposure was carried out using the ECETOC Targeted Risk Assessment (TRA) model. The ECETOC TRA was used to predict dermal exposures (expressed as a daily systemic dose in mg/kg bw) and inhalation exposure concentrations (expressed as an airborne concentration in mg/m^3) associated with each process defined by PROC codes.
Exposure to workers was assessed taking into account different operational conditions that may be associated with the professional use of ammonia and the impact of different exposure control measures. Exposures were determined for task durations of 1- 4 hours or >4 hours and assuming that process are carried out either outdoors, indoors without use of local exhaust ventilation (LEV) or indoors with the use of LEV. To reflect the use of personal protective equipment (PPE), dermal exposures were determined assuming either no gloves or gloves affording 90% protection of the hands are worn. To reflect the use of respiratory protective equipment (RPE), inhalation exposures concentrations were determined assuming either no RPE or RPE affording 95% protection is worn.
The ECETOC TRA model uses a simple algorithm to determine dermal exposures that does not take the physical-chemical properties of a substance into account. The same dermal exposures where therefore predicted for anhydrous and aqueous forms of ammonia. Parameters used in the ECETOC TRA model to assess inhalation exposures were: molecular weight (35 $g.mol^{-1}$ and 17 $g.mol^{-1}$ for aqueous and anhydrous forms respectively and vapour pressure (the vapour pressure of anhydrous forms of ammonia is 8.6×10^5 Pa at 20°C, whereas the vapour pressure of aqueous ammonia solution between 5 and 25% w/w ranges from 5×10^3 Pa to 4×10^4 Pa at 20°C. Systemic dermal exposures have been determined for a worker with bodyweight 70 kg.

The following values were obtained using ECETOC TRA for worker exposure

Dermal exposures predicted using the ECETOC TRA model

Description of activity	PROC	Exposure assumptions		Estimated Exposure mg/kg bw/d	
		Duration	Use of ventilation	No gloves worn	Gloves worn (90% reduction)
Use in a closed process, no likelihood of exposure: storage (closed or bulk container)	PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14
			Indoors with LEV	0.14	0.01
Use in closed batch process (synthesis or formulation)	PROC 3	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Mixing or blending in batch process	PROC 5	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.07	0.01
Transfer into small containers	PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Transfer (charging/discharging) from or to vessels or large containers at non-dedicated facilities	PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
			Indoors with LEV	0.14	0.01
Transfer (charging/discharging) from or to vessels or large containers at dedicated facilities	PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69
			Indoors with LEV	0.69	0.07
Roller application or brushing	PROC 10	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	27.43	0.14
		1-4 hrs or >4 hrs	Indoors with LEV	1.37	10.71
Treatment of articles by dipping and pouring	PROC 13	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37
		1-4 hrs or >4 hrs	Indoors with LEV	0.69	0.07
Laboratory use : Quality control in a laboratory	PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03
		1-4 hrs or >4 hrs	Indoors with LEV	0.03	<0.01

Hand-mixing with intimate contact and PPE only	PROC 19	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	141.73	14.13
Non industrial spraying	PROC 11	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	107	10.71
		1-4 hrs or >4 hrs	Indoors with LEV	2.14	0.21
Heat and pressure transfer fluids in dispersive use but closed systems	PROC 20	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	1.71	0.17
		1-4 hrs or >4 hrs	Indoors with LEV	0.14	0.01

Inhalation exposure concentrations predicted using the ECETOC TRA model

				Anhydrous ammonia		**Aqueous ammonia (5-25% w/w)**	
Description of activity	**PROC**	**Exposure assumptions**		**Estimated Exposure Concentration mg/m3**			
		Duration	**Use of ventilation**	**No RPE**	**RPE (95% reduction)**	**No RPE**	**RPE (95% reduction)**
Used in a closed process, no likelihood of exposure: Storage (closed bulk or container)	PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	0.01	NA
		1-4 hrs or >4 hrs	Indoors without LEV	0.01	NA	0.01	NA
Use in a closed, continuous process with occasional controlled exposure (e.g. sampling)	PROC 2	>4hrs	Outdoors	24.79	1.24	30.63	1.53
		>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.53	0.18	4.38	0.22
		1-4 hrs	Outdoors	14.88	0.74	18.38	0.92
		1-4 hrs	Indoors without LEV	22.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Use in closed batch process (synthesis or formulation)	PROC 3	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84
		1-4 hrs	Indoors without LEV	42.5	2.13	52.50	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Use in batch process (synthesis) where opportunity for exposure arises	PROC 4	>4hrs	Outdoors	49.58	2.48	61.25	3.06
		>4hrs	Indoors without LEV	70.83	3.54	87.5	4.38
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	29.75	1.49	36.75	1.84

		1-4 hrs	Indoors without LEV	42.5	2.13	52.5	2.63
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26
Mixing or blending in batch process	PROC 5	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Maintenance, clean down	PROC 8a	>4hrs	Outdoors	123.96	6.20	153.13	7.66
		>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Transfer of ammonia (charging/discharging) from/to vessels or large containers at dedicated facilities	PROC 8b	>4hrs	Outdoors	74.38	3.72	91.88	4.59
		>4hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		>4hrs	Indoors with LEV	3.19	0.16	3.94	0.20
		1-4 hrs	Outdoors	44.63	2.23	55.13	2.76
		1-4 hrs	Indoors without LEV	63.75	3.19	78.75	3.94
		1-4 hrs	Indoors with LEV	1.91	0.1	2.36	0.12
Transfer into small containers	PROC 9	>4hrs	Outdoors	99.17	4.96	122.50	6.13
		>4hrs	Indoors without LEV	141.67	7.08	175.00	8.75
		>4hrs	Indoors with LEV	14.17	0.71	17.50	0.88
		1-4 hrs	Outdoors	59.50	2.98	73.50	3.68
		1-4 hrs	Indoors without LEV	85.00	4.25	105.00	5.25
		1-4 hrs	Indoors with LEV	8.5	0.43	10.50	0.53
Roller application or brushing	PROC 10	>4hrs	Outdoors	NA	NA	153.13	7.66
		>4hrs	Indoors without LEV	NA	NA	218.75	10.94
		>4hrs	Indoors with LEV	NA	NA	21.88	1.09
		1-4 hrs	Outdoors	NA	NA	91.88	4.59
		1-4 hrs	Indoors without LEV	NA	NA	131.25	6.56
		1-4 hrs	Indoors with LEV	NA	NA	13.13	0.66
		>4hrs	Outdoors	123.96	6.20	153.13	7.66

Treatment of articles by dipping and pouring	PROC 13	>4hrs	Indoors without LEV	177.08	8.85	218.75	10.94
		>4hrs	Indoors with LEV	17.71	0.89	21.88	1.09
		1-4 hrs	Outdoors	74.38	3.72	91.88	4.59
		1-4 hrs	Indoors without LEV	106.25	5.31	131.25	6.56
		1-4 hrs	Indoors with LEV	10.63	0.53	13.13	0.66
Quality control in a laboratory	PROC 15	>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	3.54	0.18	4.38	0.22
		1-4 hrs	Indoors without LEV	21.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	2.13	0.11	2.63	0.13
Hand-mixing with intimate contact and PPE only	PROC 19	>4 hrs	Outdoors	NA	NA	153.13	7.66
		>4 hrs	Indoors without LEV	NA	NA	218.75	10.94
		1-4 hrs	Outdoors	NA	NA	91.88	4.59
		1-4 hrs	Indoors without LEV	NA	NA	131.25	6.56
Non-industrial (professional) spraying	PROC 11	>4hrs	Outdoors	NA	NA	613.20	30.66
		>4hrs	Indoors without LEV	NA	NA	876.00	43.80
		>4hrs	Indoors with LEV	NA	NA	175.20	8.76
		1-4 hrs	Outdoors	NA	NA	367.92	18.40
		1-4 hrs	Indoors without LEV	NA	NA	525.60	26.28
		1-4 hrs	Indoors with LEV	NA	NA	105.12	5.26
Heat and pressure transfer fluids in dispersive use but closed systems	PROC 20	>4hrs	Outdoors	24.79	1.24	30.63	1.53
		>4hrs	Indoors without LEV	35.42	1.77	43.75	2.19
		>4hrs	Indoors with LEV	7.08	0.35	8.75	0.44
		1-4 hrs	Outdoors	14.88	0.74	18.38	0.92
		1-4 hrs	Indoors without LEV	21.25	1.06	26.25	1.31
		1-4 hrs	Indoors with LEV	4.25	0.21	5.25	0.26

The following RCR values were obtained using ECETOC TRA and the relevant DNELs

Quantitative risk characterisation of dermal exposures to anhydrous or aqueous (in preparations of 5- 25 % w/w) ammonia for professional workers (ES 5 – Professional end-use)

PROC code	Exposure assumptions		ES 5- exposure concentrations (EC) mg/kg bw/d		Acute / long term systemic effects DNEL = 6.8 mg/kg bw/d	
					Risk characterisation ratio	
	Duration	Use of ventilation	No gloves worn	Gloves worn (90% reduction)	No gloves worn	Gloves worn (90% reduction)
PROC 1	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
PROC 2	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	1.37	0.14	0.20	0.02
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 3	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 4	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 5	1-4 hrs or >4 hrs	Outdoors /Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.07	0.01	0.01	<0.01
PROC 8a	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.14	0.01	0.02	<0.01
PROC 8b	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 9	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	6.86	0.69	1.01	0.10
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 13	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	13.71	1.37	2.02	0.20
		Indoors with LEV	0.69	0.07	0.10	0.01
PROC 15	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	0.34	0.03	0.05	0.01
		Indoors with LEV	0.03	<0.01	0.01	<0.01
PROC 20	1-4 hrs or >4 hrs	Outdoors / Indoors without LEV	1.71	0.17	0.25	0.03
		Indoors with LEV	0.14	0.01	0.02	<0.01

Quantitative risk characterisation of inhalation exposure concentrations of anhydrous ammonia for professional workers (ES 5 – Professional end-use)

PROC code	Exposure assumptions		ES 5-exposure concentrations (EC) mg/m³		Acute / long-term systemic effects DNEL = 47.6 mg/m3		Acute-local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE -95% reduction	No RPE	RPE – 95%	No RPE	RPE 95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09
		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05
		Indoors without LEV	22.25	1.06	0.47	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 3	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 4	>4hrs	Outdoors	49.58	2.48	1.04	0.05	1.38	0.07	3.54	0.18
		Indoors without LEV	70.83	3.54	1.49	0.07	1.97	0.10	5.06	0.25
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	29.75	1.49	0.63	0.03	0.83	0.04	2.13	0.11
		Indoors without LEV	42.5	2.13	0.89	0.04	1.18	0.06	3.04	0.15
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02
PROC 5	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8a	>4hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63

		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 8b	>4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	3.19	0.16	0.07	0.00	0.09	<0.01	0.23	0.01
	1-4 hrs	Outdoors	44.63	2.23	0.94	0.05	1.24	0.06	3.19	0.16
		Indoors without LEV	63.75	3.19	1.34	0.07	1.77	0.09	4.55	0.23
		Indoors with LEV	1.91	0.10	0.04	0.00	0.05	<0.01	0.14	0.01
PROC 9	>4 hrs	Outdoors	99.17	4.96	2.08	0.10	2.75	0.14	7.08	0.35
		Indoors without LEV	141.67	7.08	2.98	0.15	3.94	0.20	10.12	0.51
		Indoors with LEV	14.17	0.71	0.30	0.01	0.39	0.02	1.01	0.05
	1-4 hrs	Outdoors	59.50	2.98	1.25	0.06	1.65	0.08	4.25	0.21
		Indoors without LEV	85.00	4.25	1.79	0.09	2.36	0.12	6.07	0.30
		Indoors with LEV	8.5	0.43	0.18	0.01	0.24	0.01	0.61	0.03
PROC 13	>4 hrs	Outdoors	123.96	6.20	2.60	0.13	3.44	0.17	8.85	0.44
		Indoors without LEV	177.08	8.85	3.72	0.19	4.92	0.25	12.65	0.63
		Indoors with LEV	17.71	0.89	0.37	0.02	0.49	0.02	1.26	0.06
	1-4 hrs	Outdoors	74.38	3.72	1.56	0.08	2.07	0.10	5.31	0.27
		Indoors without LEV	106.25	5.31	2.23	0.11	2.95	0.15	7.59	0.38
		Indoors with LEV	10.63	0.53	0.22	0.01	0.30	0.01	0.76	0.04
PROC 15	>4 hrs	Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	3.54	0.18	0.07	0.00	0.10	<0.01	0.25	0.01
	1-4 hrs	Indoors without LEV	21.25	1.06	0.45	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	2.13	0.11	0.04	0.00	0.06	<0.01	0.15	0.01
PROC 20	>4 hrs	Outdoors	24.79	1.24	0.52	0.03	0.69	0.03	1.77	0.09
		Indoors without LEV	35.42	1.77	0.74	0.04	0.98	0.05	2.53	0.13
		Indoors with LEV	7.08	0.35	0.15	0.01	0.20	0.01	0.51	0.03
	1-4 hrs	Outdoors	14.88	0.74	0.31	0.02	0.41	0.02	1.06	0.05
		Indoors without LEV	21.25	1.06	0.45	0.02	0.59	0.03	1.52	0.08
		Indoors with LEV	4.25	0.21	0.09	0.00	0.12	0.01	0.30	0.02

Quantitative risk characterisation of inhalation exposure concentrations of aqueous ammonia (in preparations of 5-25% w/w) in professional workers (ES 5 – Professional end-use)

PROC code	Exposure assumptions		ES 5- exposure concentrations (EC) mg/m³		Acute /long-term systemic effects DNEL = 47.6 mg/m3		Acute – local effects DNEL = 36 mg/m3		Long-term local effects DNEL = 14 mg/m3	
					RCR		RCR		RCR	
	Duration	Use of ventilation	No RPE	RPE (95% reduction)	No RPE	RPE - 95% reduction	No RPE	RPE -95% reduction	No RPE	RPE -95% reduction
PROC 1	1-4 hrs or >4 hrs	Outdoors	0.00	NA	<0.01	NA	<0.01	NA	<0.01	NA
		Indoors without LEV	0.01	NA	<0.01	NA	<0.01	NA	<0.01	NA
PROC 2	>4hrs	Outdoors	30.63	1.53	0.64	0.03	0.85	0.04	2.19	0.11
		Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02
	1-4 hrs	Outdoors	18.38	0.92	0.39	0.02	0.51	0.03	1.31	0.07
		Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 3	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.50	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 4	>4hrs	Outdoors	61.25	3.06	1.29	0.06	1.70	0.09	4.38	0.22
		Indoors without LEV	87.5	4.38	1.84	0.09	2.43	0.12	6.25	0.31
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	36.75	1.84	0.77	0.04	1.02	0.05	2.63	0.13
		Indoors without LEV	52.5	2.63	1.10	0.06	1.46	0.07	3.75	0.19
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02
PROC 5	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05

PROC 8a	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 8b	>4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	3.94	0.20	0.08	0.00	0.11	0.01	0.28	0.01
	1-4 hrs	Outdoors	55.13	2.76	1.16	0.06	1.53	0.08	3.94	0.20
		Indoors without LEV	78.75	3.94	1.65	0.08	2.19	0.11	5.63	0.28
		Indoors with LEV	2.36	0.12	0.05	0.00	0.07	<0.01	0.17	0.01
PROC 9	>4hrs	Outdoors	122.50	6.13	2.57	0.13	3.40	0.17	8.75	0.44
		Indoors without LEV	175.00	8.75	3.68	0.18	4.86	0.24	12.50	0.63
		Indoors with LEV	17.50	0.88	0.37	0.02	0.49	0.02	1.25	0.06
	1-4 hrs	Outdoors	73.50	3.68	1.54	0.08	2.04	0.10	5.25	0.26
		Indoors without LEV	105.00	5.25	2.21	0.11	2.92	0.15	7.50	0.38
		Indoors with LEV	10.50	0.53	0.22	0.01	0.29	0.01	0.75	0.04
PROC 10	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 13	>4hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
		Indoors with LEV	21.88	1.09	0.46	0.02	0.61	0.03	1.56	0.08
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
		Indoors with LEV	13.13	0.66	0.28	0.01	0.36	0.02	0.94	0.05
PROC 15	>4 hrs	Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	4.38	0.22	0.09	0.00	0.12	0.01	0.31	0.02

	1-4 hrs	Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	2.63	0.13	0.06	0.00	0.07	<0.01	0.19	0.01
PROC 19	>4 hrs	Outdoors	153.13	7.66	3.22	0.16	4.25	0.21	10.94	0.55
		Indoors without LEV	218.75	10.94	4.60	0.23	6.08	0.30	15.63	0.78
	1-4 hrs	Outdoors	91.88	4.59	1.93	0.10	2.55	0.13	6.56	0.33
		Indoors without LEV	131.25	6.56	2.76	0.14	3.65	0.18	9.38	0.47
PROC 11	>4hrs	Outdoors	613.20	30.66	12.88	0.64	17.03	0.85	43.80	2.19
		Indoors without LEV	876.00	43.80	18.40	0.92	24.33	1.22	62.57	3.13
		Indoors with LEV	175.20	8.76	3.68	0.18	4.87	0.24	12.51	0.63
	1-4 hrs	Outdoors	367.92	18.40	7.73	0.39	10.22	0.51	26.28	1.31
		Indoors without LEV	525.60	26.28	11.04	0.55	14.60	0.73	37.54	1.88
		Indoors with LEV	105.12	5.26	2.21	0.11	2.92	0.15	7.51	0.38
PROC 20	>4hrs	Outdoors	30.63	1.53	0.64	0.03	0.85	0.04	2.19	0.11
		Indoors without LEV	43.75	2.19	0.92	0.05	1.22	0.06	3.13	0.16
		Indoors with LEV	8.75	0.44	0.18	0.01	0.24	0.01	0.63	0.03
	1-4 hrs	Outdoors	18.38	0.92	0.39	0.02	0.51	0.03	1.31	0.07
		Indoors without LEV	26.25	1.31	0.55	0.03	0.73	0.04	1.88	0.09
		Indoors with LEV	5.25	0.26	0.11	0.01	0.15	0.01	0.38	0.02

4	**Guidance to DU to evaluate whether he works inside the boundaries set by the ES**

Environmental releases:

- As no environmental exposure is presented no specific requirements aside from standard good professional practices are needed

Worker exposure:

In order to work within the boundaries of the ES the following conditions should be met:

- LEV should be in place in indoor facilities at times when natural ventilation is not sufficient.
- Where the potential for dermal exposure exists, gloves with a minimum efficiency of 90% and RPE with 95% efficiency should be worn.
- Health monitoring should be conducted regularly to ascertain the potential levels of exposure.
- Personal protective clothing (e.g. face/eye protection, helmet, gloves, boots and protective overalls) should be worn when any potential contact may arise.
- All technological devices should have a proper quality certification, and are regularly controlled and maintained to avoid the uncontrolled discharge of ammonia.
- Workers should be fully trained.
- Any measured worker exposure levels should be confirmed to be below the relevant DNEL as presented in section 3 above.