Loss Prevention Standards - Asset Classes

Ammonia Refrigeration Systems

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Introduction

Ammonia (a compound of nitrogen and hydrogen - NH_3) has bee used as a refrigerant (R717) since the 1800's. It is widely used in the food processing industry and for the storage of perishable products, because of its thermal properties; efficiency; low cost and ongoing operational costs; its impact on global warming and ozone depletion; and its tolerance to contamination.

Refrigerants are basically chemical compounds that work by taking heat from one enclosed area and transferring it to another, via its physical state and its thermodynamic properties.

A refrigeration system has two phases:

- A primary phase where the cold is generated
- A secondary phase where the cooling takes place

A basic refrigeration cycle involves an enclosed pumped/piped system with a controlling device. This could be a thermal expansion valve or capillary tube, that controls the flow of the refrigerant in liquid state into the evaporator (or cooling coil) as a low pressure, low temperature coolant. As the liquid refrigerant passes through the evaporator it expands and evaporates into a gas/vapour, removing heat from the area where the evaporator is situated. The evaporation phase causes the refrigerant liquid to 'boil' ($-33^{\circ}C$ for ammonia) at low temperature/pressure and evaporate into a vapour/gas, which is drawn into a compressor pump.

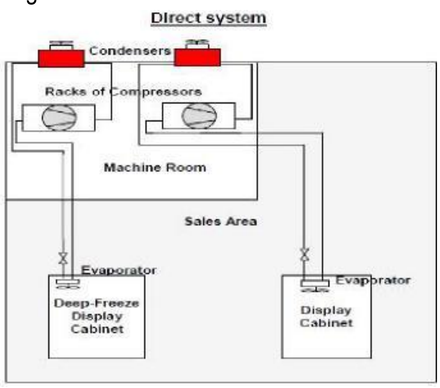
The gas is compressed into a high pressure (normally around 10 bars), high temperature gas and pumped into a condenser where the heat is removed by pipes passing through low temperature air/water-cooled units. As the heat is removed, the gas condenses back into a high temperature/high pressure liquid (at $25^{\circ}C$). The liquid is pumped into the controlling device through a small orifice where both the pressure and temperature of the liquid falls, which then flows into the evaporator where the cycle is repeated.

An expansion tank or receiver is sometimes installed between the condenser and the controlled metering device to store the refrigerant until it is needed to remove heat in the evaporator.

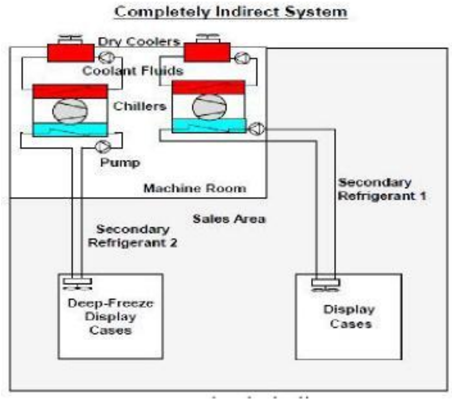
Unused heat from the refrigeration process can then be drawn-off to heat exchangers normally installed between the compressor and the condenser, that can be used to heat water or to heat other areas of the building.

Ammonia used in refrigeration systems must be pure anhydrous ammonia (i.e. free of water) and free from other contaminants/substances to prevent pipe blockages.

There are two types of ammonia refrigeration systems: commonly referred to as either a Direct or Indirect system. See example diagrams below:



Direct Systems, also referred to as Direct Expansion Systems, cool the air directly - the evaporators are in the area being cooled, regardless of any secondary coolant system provided.



An **Indirect or Closed Loop or Closed-Circuit System** is divided into two types of circuits, a primary refrigerant circuit and one or two secondary circuits, one on the (cold) evaporator side and one on the (warm) condenser side.

Indirect systems use a secondary refrigerant such as water, brine, etc. to remove/transfer the heat from the area being cooled to the primary chillers/evaporators located in the plant (machine) room outside the area being cooled.

These systems have two or more different coolants and there is no direct contact between air and the liquid being cooled. In addition to the direct system that has the primary refrigerant (Ammonia), a control device, evaporator(s), compressors/circulation pumps and condensers, the indirect system also has secondary refrigerants, secondary evaporators, secondary circuit circulation pumps and piping.

One advantage to this type of system is that the coolant liquid is less likely to be mixed with any other contaminants that may enter the system. The amount of ammonia is reduced and therefore the ammonia circuit is shorter and less exposed to leakage. Installation costs are slightly higher than a direct refrigeration system and maintenance costs are higher because of the additional equipment/plant.

Hazards and Properties of Ammonia

Ammonia is a strong-smelling stable gas in its natural state (lighter than air), and because of its relatively high boiling point (-33°C), is easily liquefiable. Since so much more material can occupy the same space in a liquid form rather than as a gas, ammonia is usually shipped as a liquid. It is colourless as a liquid and in low gas concentrations it is also colourless, but at higher concentrations it forms a dense white cloud. As it vaporises from the liquid form, it may take on a white appearance as it condenses water out of the ambient air.

- In the liquid form, should a release occur into the atmosphere, at ambient temperature it will expand 850 times, potentially covering a larger area
- A release will initially give-off a fine aerosol spray of small liquid droplets as well as a large vapour cloud that is dense (white) and very cold, which will stay at or near ground level until it is warmed and becomes lighter than air

Ammonia is very soluble in water, forming an alkaline solution of ammonium hydroxide. Its specific gravity as a liquid is 0.68, and its vapour density as a gas is 0.59. It freezes at -77.7°C.

Where low volumes of gaseous ammonia are accidently released, fire or toxicity problems may not arise due to the vapor density of the product. At a vapor density of 0.59, the gaseous product will quickly rise and disperse in air. The leaking material will be forced out by the internal pressure within the container, and if the gas is being forced upward, the danger is lessened.

Ammonia reacts dangerously with many materials and evolves heat as it dissolves in water. Ammonia reacts with acids, aldehydes, amides, isocyanate, organic anhydrides, strong oxidizers, and several metals.

Toxicity

Ammonia is highly toxic, requiring safe filling/handling controls and high standards of servicing and maintenance by trained engineers.

Exposure to ammonia of 300 parts per million (ppm) or 0.03% is life threatening and extremely hazardous to health. It is lethal above 500 ppm. An average healthy person can detect ammonia odour at 17 to 20 ppm. At 35 ppm severe irritation to eyes, nose, throat and lungs occurs.

The effects of ammonia on humans depends on the amount of ammonia and the length of time exposed.

Ammonium hydroxide can cause severe burns to the skin when high concentrations are in contact. As a vapour, 700 ppm to
1,000 ppm may cause serious eye damage all the way to blindness. At levels below these, the eyes will be tearing and smarting.

Flammability and Explosibility

Burning may not be the greatest hazard of ammonia, but its classification as a non-flammable gas can lead emergency responders into the dangerous assumption that it will not burn. Anhydrous ammonia is considered non-flammable and a ignition temperature is 651°C.

However, ammonia in air at concentrations of 15% to 25% volume is flammable and will burn or can explode, particularly if the gas/air mixture is in a confined space. When ammonia is mixed with other combustible materials such as lubricating oils, its flammability range increases.

Explosions can occur if anhydrous ammonia is directly exposed to a fire or if ammonia is released into a confined space with an ignition source present.

Because ammonia is commonly stored as a liquid under pressure, boiling liquid expanding vapour explosions (BLEVEs) are theoretically a hazard:

- A BLEVE can occur when a liquid is stored in a pressurised container above its boiling point. If the vessel fails, exposing the liquid to atmospheric pressure, the liquid will begin to boil, rapidly expanding into vapour
- Similarly, if a valve is opened to a low-pressure pipe, then the liquid may partially flash into vapour, rapidly accelerating the liquid flow into the pipe. The high-velocity liquid is called a vapour-propelled liquid

Ammonia may form explosive compounds with calcium hypochlorite, gold, mercury and silver.

Corrosivity

Anhydrous ammonia is an alkali and is easily absorbed by water or absorbs water vapour in air, and when mixed with water it creates ammonium hydroxide.

Ammonia, particularly with moisture present, reacts with and corrodes copper, zinc, and many alloys.

Contamination

Ammonia is a pollutant/contaminant. Consideration should be given to the path of a potential release within a building or in the environment and the impact this could have. Also consider the implications of clean-up and recovery.

Consider air intakes into a building; instrument air; air compressors; drains; water courses; products; fixtures and fittings, etc.

Neutralization. After the ammonia has been dissolved in water and formed the basic ammonium hydroxide, weak acids may be used to convert the ammonium hydroxide to a harmless salt. The producers of ammonia should be consulted to determine what a suitable neutralising agent might be.

If product does enter a waterway that cannot be diverted and/or contained in some manner, all downstream users of the water must be notified of the contamination as should the local environmental and water authorities.

Sewage treatment plants should be notified, for obvious reasons, and may be helpful in removing the dissolved ammonia from the water passing through the system.

Phase Change and Shock

Associated with ammonia in refrigeration systems is the potential for condensation-induced shock. This is the result of rapid condensation, which, in a closed system, can create a vacuum, and subsequently produce a rapid inrush of fluid from other parts of the system. When the high velocity fluid ultimately reaches an obstruction, it rapidly decelerates, and the forces exerted can result in component failure. This is called hydraulic shock or an abnormal transient condition that results in a sharp pressure rise with the potential to cause catastrophic failure of piping, valves, and other components caused by a rapid deceleration of liquid. This is a similar effect to a water hammer.

Risk and Hazard Assessments

Hazardous Materials (HAZMAT), Hazard and Operability (HAZOP), Safety Integrity Level (SIL) assessments, including Layers of Protection Analysis (LOPA), should be completed for systems involving ammonia. These should include operational faults, process control/cause and effects, etc.

Appropriate hazardous atmosphere assessments should be completed. The regulatory requirement for this is different and is based on territory, e.g. ATEX Directive, Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR), etc.

Ammonia refrigeration systems holding 50 tonnes (anhydrous ammonia) or above in the UK are subject to the Control of Major Accident Hazards Regulations 2015 (COMAH).

All assessments should be formally documented, reviewed regularly and after any changes, and any short comings or enhancements proposed or recommended should be formally tracked through to completion.

Construction

Rooms housing ammonia equipment should be ideally detached from other main structures. If this is not possible, they should be constructed of fire resistive or non-combustible materials with at least 1-hour fire resistant vapour tight blank walls and floors at the interface where the room adjoins another building. Appropriate signage and labelling (information and safety) should be displayed externally and internally.

Any pipework, cable penetrations, etc. through a communicating wall must be appropriately sealed and vapour tight, to preserve the fire resistance. Pipework is usually constructed from steel or stainless steel and any pipe insulation should be non-combustible and non-absorbent.

Because of the potential for explosion, over-pressurisation or explosion relief should be provided. This should be designed to an internationally recognised standard and discharge to a safe area, away from personnel route, equipment, other buildings, etc.

External equipment (accumulators, receivers, condensers, etc.) mounted on or above the roof of the room should be supported independently of the roof in case of roof collapse.

Access to the room should ideally be via external perimeter doors and should be restricted to authorised trained personnel.

If internal doors are unavoidable these should be configured with a double door/air lock arrangement, using two sets of vapour tight, sealed doors where one door is kept closed, whilst the other one is opened. Doors need to be fire resistant to the same rating as the separating fire walls.

Ceiling and floor voids should be avoided.

Electrical Systems

All electrical systems and associated equipment, wiring, switches, lighting, motors, distribution boards, panels, etc. should be designed for safe use with ammonia in flammable and explosive atmospheres.

Ventilation

Rooms housing ammonia equipment should be provided with 'normal' ventilation systems:

- Either appropriately rated mechanical or natural air ventilation
- Low-level fresh air inlets and high-level extracts
- Discharging to a safe area away from personnel, fresh air intake vents, etc.
- Design should be based on the stored volumes of gas, the room size, etc. However, a good rule of thumb is not less than $0.305m^3/m^2$/minute

Emergency ventilation should also be provided. This should be designed to an increased extraction/flow rate and should be actuated automatically by an ammonia detection system and manually. It should be approximately ten times the normal extraction volume flow rate or a minimum of $3.05m^3/m^2$/minute.

Other items to consider for the reliable operation of the ventilation include:

- Ventilation failure alarms
- Low flow/volume flow rate alarms

Monitoring only the fan motor is not acceptable. There have been instances where the fan/motor connecting shaft has failed, the fans stops but the motor remains operating. This has led to overheating and burn-out of the motor.

Detection Systems

Detection systems in their entirety must be safe for use in potentially flammable and explosive environments. Refer to Electrical Systems earlier in this document.

Ammonia Leak Detection

Two stage ammonia leak detection should be installed in all areas where substantial leaks could occur to provide a phased warning with automatic interlocks:

- 25% Lower Explosion Limit (LEL) alarm and interlocked to actuate emergency ventilation system
- 50% LEL alarm and interlocked to the safe shut down of the ammonia equipment

All alarms should signal locally to a permanently occupied security room and/or engineers control room, and to a third party off-site monitoring and receiving centre.

Ammonia detectors should be calibrated and tested regularly, and interlocks tested at least annually.

Automatic Fire Detection

Automatic fire detection for property protection coverage (in all areas), including any ceiling and floor voids, must be installed and interfaced with the building s main fire alarm system with local and remote alarm signalling to an off-site insurance recognised Alarm Receiving Centre.

The ammonia equipment should be interlocked to shut down upon activation of the fire alarm.

Protection Systems

If the main building is protected by automatic sprinklers these should extend to protect the ammonia equipment room, and the design should be based for a high hazard occupancy. Consideration should be given to potential sprinkler pipework corrosion issues.

On activation of the sprinklers, if not already shut down/isolated, the ammonia equipment/refrigeration plant should automatically shut down and isolate operations.

If automatic sprinkler protection is not provided across the wider site, consideration should be given to providing a series of open sprinkler heads across any door or ventilation openings into the equipment room and over the main ammonia storage volume/equipment. The purpose of this should be to 'knock' any ammonia gas/anhydrous ammonia out of the air and absorb it in the water. Ideally this should be designed to provide 10mm/min/m^2 but any available water discharged over the area will knock ammonia out of the air. This should be actuated:

- By the 50% LEL ammonia detection system
- Manually at a safe distance from the ammonia room

Protection systems in their entirety must be safe for use in potentially flammable and explosive environments. Refer to Electrical Systems earlier in this document.

Note: As previously indicated (see Hazards and Properties of Ammonia), Ammonia absorbed in water forms an alkaline solution.

Housekeeping

Rooms housing ammonia equipment and any associated control rooms should be kept 'sterile' and clear of all ordinary combustible materials, storage, oils, etc.

Ammonia cylinder storage:

- Stores should be well separated from equipment rooms and provided with good high and low ventilation
- Oxygen or chlorine cylinders should not be housed in the same store as ammonia cylinders
    - Reactive or dissimilar materials should not be stored together
- Cylinders must be secured in the appropriate position with valves uppermost
- Valve caps must be securely fitted to cylinders not in use
- Empty and full cylinders can be kept in the same storage area but must be kept spatially separate and suitably identified as 'empty' or 'full'

Training

All personnel should be provided with appropriate training on the hazards of ammonia (including the signs, symptoms and detection of an ammonia release) and emergency response procedures, including where appropriate individuals identified and trained in the correct/safe use of breathing apparatus (if provided) and first aid. Additionally, key individuals should receive comprehensive training on the safe operation and maintenance of the system.

Access to ammonia areas should be restricted to authorised and trained personnel.

Personal Protective Equipment (PPE)

Correct PPE should be issued to any individual entering the ammonia refrigeration plant room or if entering an area which could be affected by an ammonia release. This should protect full- head, face, body and feet, e.g. protective clothing, full-head and face protection, eye protection, ear, feet and respiratory protection.

Permit to Work System

Entry to the ammonia plant room should be restricted to authorised and fully trained personnel only.

A permit to work should be issued for all work involving the refrigeration system/ammonia network:

- All permits should be strictly controlled and managed
- Permits should be issued for a single shift or a day, whichever is the shortest period
- Appropriate risk assessments and method statements should be employed
- Lockout/tagout procedures should be in place

No hot work should be permitted in a room where ammonia equipment or ammonia storage is maintained.

Maintenance

Ammonia refrigeration systems should be constantly monitored 24 hours per day by a Building Management System (BMS), connected to a control room, an engineer's workshop or a security gatehouse.

- Large ammonia refrigeration systems should be constantly monitored 24 hours per day remotely, off-site by a refrigeration company. This could be mimicked to the site, e.g. on-site engineers by smart phone technologies or SMS

Engineer's workshops/stores must be kept separate from any ammonia control room.

Maintenance regimes for the ammonia network, refrigeration equipment and all the prevention/mitigation measures should be formal, recorded and based on the manufacturer's recommendations. This should be reviewed at least annually and updated where necessary to ensure that the regimes in place are still effective, this is particularly important as the system ages.

All interlocks and safety features should be confirmed at least annually.

Emergency Planning and Response

Consideration should be given to the provision of wind direction identification (e.g. windsock; rotameter) to help support appropriate emergency response/evacuation procedures.

Only professional trained fire fighters should tackle fires involving ammonia. Similarly, only trained responders with appropriate PPE should respond to an ammonia release.

A formal Emergency Action Plan should be written and practiced. This should include a basic weather resistant site plan (including location of all ammonia refrigeration system components) to ensure individuals know how to react and respond to an emergency. The following should be included:

- How to raise the alarm
- Systems for communications
- Who to alert including public emergency services
- Emergency contact list
- Evacuation roles
- Escape routes and assembly points (based on different wind directions and environmental conditions)
- Roll call checklists
- Procedures required by trained engineers and crisis manager who remain

First Aid response should be considered, ensuring trained personnel and adequate first aid supplies are readily available. This should also consider decontamination for any casualties, and issues such as flushing eyes and effected body parts with copious amounts of water.

Ensure all personnel have the correct personal protective clothing and equipment including where appropriate, approved positive pressure self-contained breathing apparatus individuals should be trained and competent in its use. Limit the number of trained responding personnel and provide trained back-up teams.

Plans need to be reviewed and updated at least annually.

Emergency Response Plans should be co-ordinated and agreed with Emergency Services; Fire Brigade/Chemical Response Brigade, e.g. should include; Incident Controller/Command System - Identify the ammonia hazards and conditions.

Professional Fire Brigades are likely to involve their specially trained Chemical Response Teams and put in place a wide exclusion zone surrounding the incident, whilst the chemical team respond. For example, in the UK this can be up to 500 metres surrounding the area concerned, preventing any one other than authorised fire fighters from entering the excluded zone for up to 48-hours or more.

This can seriously impact the site's business operations and any neighbouring business operations and/or commercial or residential areas. This needs to be discussed and confirmed with your local authorities.

Loss History

There have been several losses involving ammonia resulting in explosions and fire, and many more releases where there has been injury or loss of life.

Mechanical failure is the most common cause of losses, particularly compressors. This is followed by electrical failures, often due to short circuits, failures of compressor motors, temperature sensors, control devices and electrical arching.

- April 2017 - Ammonia plant in Telemark, Norway: caused by a compressor fault and oil leak inside the factory that led to an explosion and fire. There was no ammonia escape, and no one was seriously injured. It is thought that power was lost to the industrial area at around 3am due to a power station fault and the fire was reported to be extinguished at around 5am.
- 17th April 2013 - Fertiliser plant in Texas: an explosion occurred that destroyed the entire plant and the surrounding four blocks, killing many people. The explosion was felt up to 50 miles from the site. The plant **produced and stored a volatile and potentially dangerous form of nitrogen-based fertilizer known as anhydrous ammonia. Cause is not known.**
- **17th September 1984 - Frozen meat, cold storage facility in Louisiana, USA: with ammonia refrigeration had an ammonia leak that site engineers initially tried to repair but were forced to exit the area because of the effects of the escaping ammonia. Fire fighters were called and entered the area of the building (approx. 4000m^2 in size) to complete the emergency repair. Unfortunately, an explosion occurred lifting part of the roof from the building and damaging the interior solid walls. The fire that followed the explosion trapped two fire fighters who were badly burned/injured, and one later died of their injuries. Fire investigators reported that the major contributing factors to the loss included workers lack of proper precautions to prevent an accumulation of** anhydrous ammonia, the fire fighters lack of awareness that a hazardous amount of ammonia gas had accumulated **in the room and the ignition of the gas during the emergency repairs.**

Checklist

A generic Ammonia Refrigeration Systems Checklist is presented in Appendix 1 which can be tailored to your own organisation.

Additional Information and References

- Health and Safety Executive (HSE) A Guide to the Control of Major Accident Hazards Regulations 2015 (COMAH) L111
- HSE - Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) Approved Code of Practice and Guidance L138
- HSE Electricity at Work Safe Working Practices HSG85
- HSE Pressure Systems Safety Regulations 2000 Approved Code of Practice and Guidance L122

References

- Safe Management of Ammonia Refrigeration Systems Guidance for the food and drinks industries and other workplaces prepared by the Food Storage and Distribution Federation's Technical and Safety Committee, British Engineering Services, Institute of Refrigeration and other stakeholders, with support from the Health and Safety Executive

FM Global Property Loss Prevention Data Sheets: 7-13 Mechanical Refrigeration

XL Catlin GAP.7.2.1.2 Ammonia Hazards

https://www.ammoniaknowhow.com/review-of-global-regulations-for-anhydrous-ammonia-production-use-and-storage/

ATEX 94/9/EC - Equipment Directive Equipment and protective systems intended for use in potentially explosive atmospheres

ATEX 99/92/EC - Workplace Directive Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

BS EN 378-1 - Refrigerating systems and heat pumps - Safety and environmental requirements. Part 1-Basic requirements, definitions, classification and selection criteria

BS EN 60079-17 - Explosive atmospheres. Part 17 - Electrical installations inspection and maintenance

Further risk management information can be obtained from Aviva Risk Management Solutions

Appendix 1 Ammonia Refrigeration Systems Checklist

Location	
Date	
Completed by (name and signature)	

	Ammonia Refrigeration Systems	**Y/N**	**Comments**
1.	Is the following known: • Stored volume of ammonia? • Operating temperatures? • Operating pressures?		
2.	Have formal risk assessments been completed arising from the use of ammonia: • Hazardous assessments? • Operability assessments? • Regulatory assessments, e.g. DSEAR, ATEX or COMAH? • Are any recommendations or improvements raised by these assessments tracked? • Are these improvements all completed? • Are the assessments up to date? • Are the assessment return periods known?		
3.	If there was a release of ammonia does this expose any other assets? Has this formed part of a formal risk assessment? Examples: • Air intakes • Compressed or instrument air supplies • Products susceptible to contamination • Incompatible materials or chemicals		
4.	Is the room housing the ammonia equipment/network dedicated to this activity? • Is it located on an outside wall or detached? • Is it cut-off from surrounding buildings by at least 1-hour rated construction? • Are there any floor or ceiling voids?		
5.	Is access to the room from an external door only? Are there any doorways from within a principle building?		

	Ammonia Refrigeration Systems	Y/N	Comments
6.	Does the ammonia plant room have appropriate signage and labelling - information and safety should be displayed externally and internally?		
7.	Are there any penetrations from the room into other buildings? • Is appropriate fire stopping provided? • Are there any larger openings? ○ Are these appropriately protected against an ammonia leak?		
8.	Does the room have explosion relief? If yes, is the: • Relieving area away from buildings, equipment and personnel exposures? • Design standard known? • Design area known? • Relief inspected, tested and maintained?		
9.	Are all electrical systems and devices appropriately rated for safe use in the expected atmosphere? Are electrical systems/devices risk assessed?		

10.	Does the room have low-level air intakes and high-level air extraction?
	•
	  ○ Is this a minimum of 0.305m^3/m^2/min?
	• Is emergency ventilation at a higher rate also provided?
	• Is the emergency extraction rate known?
	  ○ Is this a minimum of 3.05m^3/m^2/min?		

11.	Is the ventilation system monitored? • Are there failure alarms? • Is low flow or low volume monitored?		
12.	Does the room have automatic ammonia leak detection? • Is more than one detection device provided? • Are the locations of these devices appropriate for ammonia? • Is this calibrated and tested regularly?		
13.	Is the 1st stage of the ammonia alarm set at 25% of the LEL? • Is the ventilation rate interlocked to increase upon this alarm?		

	• Is this tested regularly?		
14.	Is the 2nd stage of the ammonia alarm set at 50% of the LEL? • Is the ammonia equipment interlocked to shut down upon this alarm? • Is this tested regularly?		
15.	Are the following connected to a constantly attended location: • Ammonia system operability/interlocks/process alarms? • Ammonia leak detection system? • Ventilation/extraction?		
16.	Is automatic fire detection provided within the room connected to a constantly attended location? Is the ammonia equipment interlocked to shut down upon this alarm?		
17.	Is automatic sprinkler protection provided to the room?		
18.	Is a water-based vapour/gas knock down system provided in the room or at the perimeter of the room? • Is this manually activated? • Is this automatically activated?		
19.	Is all the ammonia leak detection, ammonia release, fire detection and fire suppression systems inspected, tested and maintained in accordance with the manufacturers guidelines and local regulatory requirements? Are all interlocks tested at least annually?		
20.	Is the room clear of all ordinary combustible materials and maintained as sterile? Does the room only house the operational ammonia hardware?		
21.	Are regular recorded housekeeping checks completed to ensure the area is maintained and kept to appropriate standards? Is the room visited on every shift to make visual checks?		
22.	Is a regular recorded visual inspection of accessible pipes and vessels undertaken for evidence of leaks/damage, etc?		
23.	Is access to the room restricted to named personnel?		
24.	Are personnel with access appropriately trained on the hazards associated with ammonia?		

	Is all training and refresher training recorded?		
25.	Is a formal permit to work system in place as part of the management of any works to be completed on the ammonia systems? Are appropriate risk assessments and method statements in place prior to completion for any work associated with the ammonia system?		
26.	Are the ammonia system components inspected, tested and maintained in accordance with the manufacturer guidelines?		
27.	and stores in separate areas to the ammonia equipment?		
28.	Are any spare cylinders or volumes of ammonia stored in a separate storage area away from incompatible materials? • Are full and empty cylinders stored in segregated areas? • Are all cylinders secured?		
29.	Is there a formal Emergency Response Plan for an incident involving the ammonia system? • Fire? • Loss of containment? • Is there a windsock or alternate means of knowing the wind direction? • Are there appropriate evacuation routes and assembly points based on wind direction? • Are key individuals identified and trained? • Is appropriate PPE provided? • Are any individuals trained with self-contained breathing apparatus? • Has liaison occurred with the public fire authorities, environmental, water company and any other public bodies? • Has the public response been supported by on-site visits? • Is there safe access for Emergency Services for fire-fighting? • Is the plan practiced at least annually?		

30.	Additional comments:		

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