Guideline

on

Safe Management of Ammonia Refrigeration System

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ABBREVIATION

AIA	**Authorized Inspecting Authority**
CF	**Certificate of Fitness**
CHRA	**Chemical Health Risk Assessment**
CIMAH	**Control of Industrial Major Accident Hazard**
CLASS	**Classification, Labelling and Safety Data Sheet**
DOE	**Department of Environment**
DOSH	**Department of Occupational Safety and Health**
ERP	**Emergency Response Plan**
IMS	**Incident Management System**
NADOPOD	**Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease**
NDE	**Non-Destructive Examination**
NH_3	**Ammonia**
OEM	**Original Equipment Manufacturer**
OSH	**Occupational Safety and Health**
P&ID	**Piping and Instrumentation Diagram**
PEL	**Permissible Exposure Limit**
PPE	**Personal Protective**
ppm	**Parts per Million**
PPM	**Planned Preventive Maintenance**
psig	**Pound per Square Inch**
TWA	**Time-Weighted Average**
UPV	**Unfired Pressure Vessel**

1 INTRODUCTION

Ammonia has been used as a refrigerant in industrial applications for many years. It continues to be the refrigerant of choice in various applications and has seen an increased use in building services and process applications. Ammonia is an excellent natural refrigerant and offers a number of significant environmental and operational benefits over its synthetic rivals. However, recently, the number of incidents that involves industrial ammonia refrigeration system has increased year by year where some cases have led up to injuries and fatalities among workers, students, and the public at large. **Please refer Appendix 1 for the Case Study on Incidents Involving Ammonia Refrigeration System.**

1.1 Purpose

Hence, a guideline is developed for related industries with the purpose of promoting safe management on ammonia refrigeration system for industrial application at their workplace. Generally, this guideline provides minimum information and recommendations on how employers and employees can control the operation and maintenance of the system in order to reduce and manage its risk accordingly.

Apart from that, this guideline also explains the duty of all stakeholders such as owners, employers, employees and manufacturers as prescribed under the Factories and Machinery Act 1967 and the Occupational Safety and Health Act 1994 including all related regulations.

1.2 Application and Scope

This guideline applies to all the workplaces that utilize ammonia as a refrigerant in their refrigeration system. The purpose of the refrigeration system at a workplace may vary from one to another such as for ice production, cold storage, food processing, building services etc. The guideline also applies to new and existing installations of refrigeration system whether it is for permanent or temporary usage.

2 LEGISLATIONS

The legislation that stipulates the provision of general duties of employers and self-employed persons to their employees, plant, and substance can be found in the Factories and Machinery Act 1967, The Occupational Safety and Health Act 1994, and their respective regulations.

2.1 Factories and Machinery Act 1967

Provisions pertaining to safe system of plant and work are under:

i. Part II, Safety, Health and Welfare, provisions relating to safety, etc.
ii. Section 19, Certificate of Fitness;
iii. Section 21, Duties of Occupier;
iv. Section 22, Provisions Relating to Health;
v. Section 25, Provision Relating to Welfare;
vi. Part V, Notice of Occupation of Factory, and Registration and Use of Machinery.

2.2 Occupational Safety and Health Act 1994

Provisions pertaining to safe system of plant and work are under:

2.2.1 General duties of employers and self-employed persons to their employees.

Section 15:

(1) It shall be the duty of every employer and every self-employed person to ensure, so far as is practicable, the safety, health and welfare at work of all his employees.

(2) Without prejudice to the generality of subsection (1), the matters to which the duty extends include in particular-

(a) The provision and maintenance of plant and systems of work that are, so far as is practicable, safe and without risks to health;

(b) the making of arrangements for ensuring, so far as is practicable, safety and absence of risks to health in connection with the use or operation, handling, storage and transport of plant and substances;

(c) the provision of such information, instruction training and supervision as is necessary to ensure, so far as is practicable, the safety and health at work of his employees;

(d) so far as is practicable, as regards any place of work under the control of the employer or self-employed person, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of the means of access to and egress from it that are safe and without such risks;

(e) the provision and maintenance of a working environment for his employees that is, so far as is practicable, safe, without risks to health, and adequate as regards facilities for their welfare at work.

(3) For the purposes of subsections (1) and (2)-

(a) "employee" includes an independent contractor engaged by an employer or a self-employed person and any employee of the independent contractor; and

(b) the duties of an employer or a self-employed person under subsections (1) and (2) extend to such an independent contractor and the independent contractor's employees in relation to matters over which the employer or self-employed person-

(i) has control; or

(ii) would have had control but for any agreement between the employer or self-employed person and the independent contractor to the contrary.

2.2.2 Part V, general duties of designers, manufactures and suppliers;

Section 20: General duties of manufacturers, etc. as regards plant for use at work.

(1) It shall be the duty of a person who designs, manufactures, imports or supplies any plant for use at work-

(a) to ensure, so far as is practicable, that the plant is so designed and constructed as to be safe and without risks to health when properly used;

(b) to carry out or arrange for the carrying out of such testing and examination as may be necessary for the performance of the duty imposed on him by paragraph (a); and

(c) to take such steps as are necessary to secure that there will be available in connection with the use of the plant at work adequate information about the use for which it is designed and-has been tested, and about any condition necessary to ensure that, when put to that use, it will be safe and without risks to health.

(2) It shall be the duty of a person who undertakes the design or manufacture of any plant for use at work to carry out or arrange for the carrying out of any necessary research with a view to the discovery and, so far as is practicable, the elimination or minimisation of any risk to safety or health to which the design or plant may give rise.

(3) It shall be the duty of a person who erects or installs any plant for use by persons at work to ensure, so far as is practicable, that nothing about the way in which it is erected or installed makes it unsafe or a risk to health when properly used.

2.2.3 Section 21: General duties of manufacturers, etc. as regards substances for use at work.

(1) It shall be the duty of a person who formulates, manufactures, imports or supplies any substance for use at work-

(a) To ensure, so far as is practicable, that the substance is safe and without risks to health when properly used;

(b) To carry out or arrange for the carrying out of such testing and examination as may be necessary for the performance of the duty imposed on him by paragraph (a); and

(c) To take such steps as are necessary to ensure that there will be available in connection with the use of the substance at work adequate information about the results of any relevant test which has been carried out on or in connection with the substance and about any condition necessary to ensure that it will be safe and without risks to health when properly used.

(2) It shall be the duty of a person who undertakes the manufacture or supply of any substance for use at work to carry out or arrange for the carrying out of any necessary research with a view to the discovery and, so far as is practicable, the elimination or minimisation of any risk to safety or health to which the substance may give rise.

2.3 Regulations

a. Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996
b. Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulations 2000
c. Occupational Safety and Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013
d. Occupational Safety and Health (Noise Exposure) Regulations 2019
e. Factories and Machinery (Notification, Certificate of Fitness and Inspection) Regulations 1970
f. Factories and Machinery (Safety, Health and Welfare) Regulations 1970
g. Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations 1970
h. Occupational Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004

[Department of Occupational Safety and Health (1994). *Occupational Safety and Health Act and its Regulations.* MDC Publishers Sdn Bhd./percetakan nasional]

[Department of Occupational Safety and Health (1967). *Factories and Machinery Act and Its Regulations.* MDC Publishers Sdn Bhd./percetakan nasional]

3 DUTIES AND RESPONSIBILITIES

In general, five parties are involved directly to ensure the safety of using ammonia as a refrigerant.

3.1 Designer.

a. To ensure compliance to local legislations as highlighted in Paragraph 2.0.
b. To ensure, so far as is practicable, that the refrigeration system is designed to be safe and without risks to health when properly used.
c. To resolve all technical maintenance issues.
d. To design all maintenance programs.

3.2 Manufacturer.

a. To ensure compliance to local legislations as highlighted in Paragraph 2.0.
b. To ensure, so far as is practicable, that the refrigeration system is constructed as to be safe and without risks to health when properly used.
c. To set up and operate the refrigeration system in accordance with current good manufacturing practices and standard operating procedures.

3.3 Supplier/Installer of the refrigerant system.

a. To design, construct, test, commission, and maintain according to the local legislations.

b. To carry out running test for the refrigeration system before using it.

c. To issue instructions on proper use of the system to the employer and employees whom are then required to follow the instructions.

d. To provide and maintain the system of work that is safe and without risks to health.

3.4 Supplier of ammonia.

a. To supply ammonia with proper label as per the provisions of CLASS Regulations 2013. Please see **Appendix 2** for **the Example of Safety Data Sheet for Anhydrous Ammonia.**
b. To develop a Safe Operating Procedure for ammonia filling activities.
c. To ensure proper label and Safety Data Sheet are supplied as per the provision of CLASS Regulations 2013.
d. To obtain permission from the owner prior to charging in the ammonia refrigerant.
e. To provide training to ammonia handler.

3.5 Owner

a. To conduct a risk assessment for the overall operation of the refrigeration system. Please see **Appendix 3** for the **Example Of Risk Assessment.**
b. To engage or to appoint/assign a trained person for periodic examination and maintenance of the refrigeration system.
c. To ensure that the trained person carries out periodic maintenance and inspection according to manufacturer requirement, preferably every month.
d. To ensure that any certificated machinery has a valid Certificate of Fitness.
e. To ensure any repair and modification work on Unfired Pressure Vessels to be conducted by a registered Competent Firm.
f. To keep maintenance and operational records readily available upon request from the authority. Any relevant documents including the Piping and Instrumentation Diagram (PID), approved drawing, certificate of fitness, manual operation, maintenance, and operational records are properly kept and readily available upon request from the authority.
g. To conduct Chemical Health Risk Assessment (CHRA) if chemicals hazardous to health are being used.
h. To report immediately any occupational accident, dangerous occurrence and occupational disease and to submit the JKKP 6 form to the nearest DOSH office as per the provisions of NADOPOD Regulations 2014.
i. To provide information, instruction, training, and supervision to ensure the safety and health of his employees at work.

j. To identify and eliminate or minimize any risks to safety and health due to failure in the design of a refrigerant system.

k. To develop Safe Work Procedures for the safe use, operation, and handling of the refrigeration systems and the refrigerants and to ensure any risks to safety and health are properly managed.

l. To provide emergency response plans and preparedness.

m. To determine the total quantity of the hazardous substance (such as ammonia) used in the refrigeration system and to ensure that the industrial activity involved is in accordance with the provisions of the Occupational Safety and Health (Control of Industrial Major Accident Hazards CIMAH) Regulations 1996. **Please refer Appendix 4 for the Example of Calculation for an Ammonia's Quantity in Refrigeration System**

4 AMMONIA CHARACTERISTICS AND HAZARDS

Ammonia (NH_3) is a colourless, pungent gas composed of nitrogen and hydrogen. It is the simplest stable compound of these elements and serves as a starting material for the production of many commercially important nitrogen compounds. Ammonia is used in industry and commerce, and also exists naturally in humans and in the environment. Its usage includes the textile industry, the manufacture of synthetic fibres, the catalyst in the production of some synthetic resins, the petroleum refining industry, and the rubber industry.

Ammonia is essential for many biological processes and serves as a precursor for amino acid and nucleotide synthesis. In the environment, ammonia is part of the nitrogen cycle and is produced in soil from bacterial processes. Ammonia is also produced naturally from the decomposition of organic matter, including plants and animals.

4.1 Physical properties

Anhydrous ammonia is a clear liquid that boils at a temperature of -33.33°C (-28°F). In refrigeration systems, the liquid is stored in closed containers under pressure. When the pressure is released, the liquid evaporates rapidly, generally forming an invisible vapour or gas. The rapid evaporation causes the temperature of the liquid to drop until it reaches the normal boiling point of -33.3°C (-28°F), a similar effect occurs when water evaporates off the skin, thus cooling it. This is why ammonia is used in refrigeration systems. Liquid anhydrous ammonia weighs less than water. About 30.3 litres of ammonia weighs the same as 19 litres of water

Liquid and gas ammonia expands and contracts with changes in pressure and temperature. For example, if liquid anhydrous ammonia is in a partially filled, closed container is heated from -17.8°C (0°F) to 20.0°C (68°F), the volume of the liquid will increase by about 10 percent. If the tank is 90 percent full at 0°F, it will become 99 percent full at 68°F. At the same time, the pressure in the container will increase from 16 pounds per square inch (psi) to 110 psi.

Liquid ammonia will expand by 850 times when evaporating. Anhydrous ammonia gas is considerably lighter than air and will rise in dry air. However, because of ammonia tremendous affinity for water, it reacts immediately with the humidity in the air and may remain close to the ground.

The odour threshold for ammonia is between 5 - 50 parts per million (ppm) of air. The permissible exposure limit (PEL) is 25ppm or 17mg/m^3 for eight-hour time weighted average airborne concentration. It is recommended that if an employee can smell it they ought to back off and determine if they need to be using respiratory protection.

Table 1: Summary of ammonia properties

Boiling Point	-33.3°C (-28°F)
Weight per gallon of liquid at -33.3°C (-28°F)	2.58 kg
Weight per gallon of liquid at 15.6°C (60°F)	2.34 kg
Specific gravity of the liquid (water=1)	0.619
Specific gravity of the gas (air=1)	0.588
Flammable limits in air	16-25%
Ignition temperature	651°C (1204°F)
Vapour pressure at -17.8°C (0°F)	16 psi
Vapour pressure at 20.0°C (68°F)	110 psi
Vapour pressure at 37.8°C (100°F)	198 psi
One cubic foot of liquid at 15.6°C (60°F) expands to	24 cubic metre of gas (850 cubic foot)

4.2 Chemical properties

Anhydrous ammonia is easily absorbed by water. At 20.0°C (68°F), about 700 volumes of vapour can be dissolved in one volume of water to make a solution containing 34 percent ammonia by weight. Ammonia in water solution is called aqua ammonia or ammonium hydroxide.

Ammonia, especially in the presence of moisture, reacts with and corrodes copper, zinc, and many alloys. Only iron, steel, certain rubbers and plastics, and specific non-ferrous alloys resistant to ammonia should be used for fabrications of anhydrous ammonia containers, fittings, and piping. Ammonia will combine with mercury to form a fulminate which is an unstable explosive compound.

Anhydrous ammonia is non-flammable material. However, ammonia vapour in high concentrations (16 to 25 percent by weight in air) will burn. It is unlikely that such concentrations will occur except in confined spaces or in the proximity of large spills. The fire hazard from ammonia is increased by the presence of oil or other combustible materials. Anhydrous ammonia is an alkali.

4.3 Health Hazards and its effects

Ammonia is a gas with a distinctive pungent odour which can normally be detected by smell at concentrations as low as 5 parts per million (ppm). Higher concentrations are easily detected. It is colourless, lighter than air and chemically reactive.

The acute toxicity of ammonia is a major consideration in the safe design and operation of refrigeration systems. Although the odour of ammonia can be detected by smell at concentrations above 5 to 10ppm, people who are used to it can work without discomfort in concentrations of approximately 100ppm. Concentrations between approximately 150ppm and 200ppm will cause irritation of the mucous membranes and the eyes, but normally with no lasting consequences. From approximately 500ppm to 700ppm, the eyes are affected more and more quickly, streaming with tears after 30 seconds or less, but the air is still breathable.

At approximately 1000ppm, breathing is intolerable and vision is impaired but not lost. Eye injuries constitute the most serious hazards at this concentration in terms of possible permanent disability. Exposure to concentrations of approximately 1500ppm and above will damage or destroy tissue, and the instant human reaction, even for trained people, is to quickly evacuate the area. Concentrations of approximately 2500ppm and above will rapidly increase the risk of fatality.

It should be noted that the effect of ammonia is a function of concentration level and length of exposure time. Higher concentrations can be tolerated for short periods but the effect of ammonia breathed into the lungs or in the eyes can persist for long periods after the person affected has returned to an area where there is fresh air. All of the acute toxic effects of ammonia are due to the removal of water from affected tissue, which is why even small liquid splashes can cause permanent damage. There are no chronic toxicity effects of ammonia. The Permissible Exposure Limits (PEL) have been set to 25ppm in order to protect workers from effects of exposure to ammonia. The time-weighted average (TWA) is eight 8 hours.

Ammonia forms a flammable atmosphere at concentrations between 16% and 25% by volume in air.

Ammonia is classified as flammable and toxic and should labelled with the following hazard statements and precautionary statements. The table below shows the hazard statement of anhydrous ammonia according to CLASS Regulations 2013. Please refer **Appendix 5** for **an example of Anhydrous Ammonia Classification from ILO and WHO.**

Table 2: Hazard statement

H280	Contains gas under pressure; may explode if heated
H281	Contains refrigerated gas; may cause cryogenic burns or injury
H221	Flammable gas
H331	Toxic if inhaled
H314	Causes severe skin burns and eye damage
H318	Causes serious eye damage
H400	Very toxic to aquatic life.

5 DESIGN

5.1 General

This section describes the unfired pressure vessel (UPV), its mandatory requirement including those using ammonia as a medium of service.

Under the Factories and Machinery Act 1967, each UPV must have a valid certificate of fitness (CF) before it can be operated. For this purpose, approval for the design of the UPV has to be obtained in advance from the Department of Occupational Safety and Health (DOSH) before it can be fabricated, installed or used except those exempted under the Factories and Machinery (Exemption of Certificate of Fitness for Unfired Pressure Vessel) Order 2017. The UPV shall pass the inspection by DOSH state offices before the CF can be issued.

5.2 Schematic diagram

Figure 1 shows the basic refrigeration system that normally can be found in most industry application. It consists of four (4) major parts which are the condenser, compressor, evaporator and receiver.

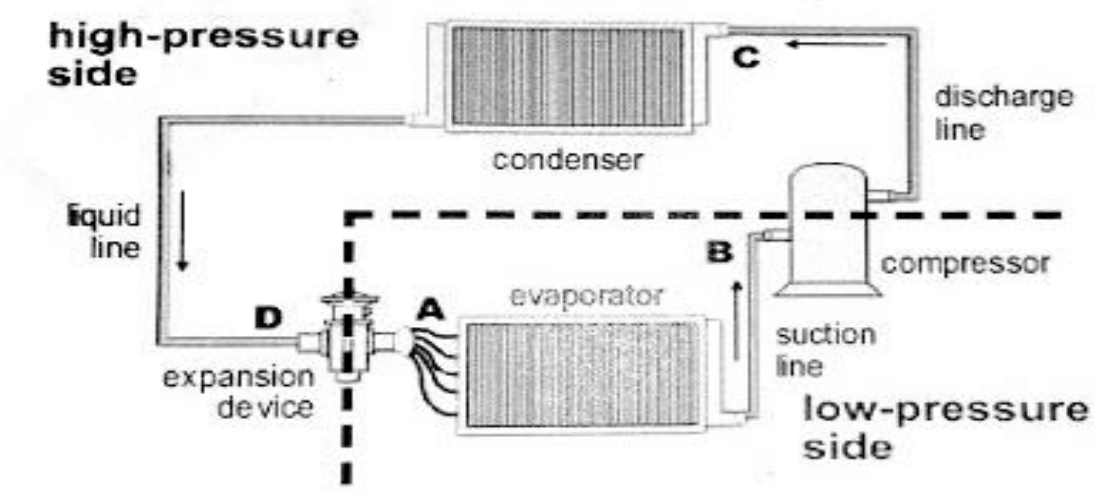
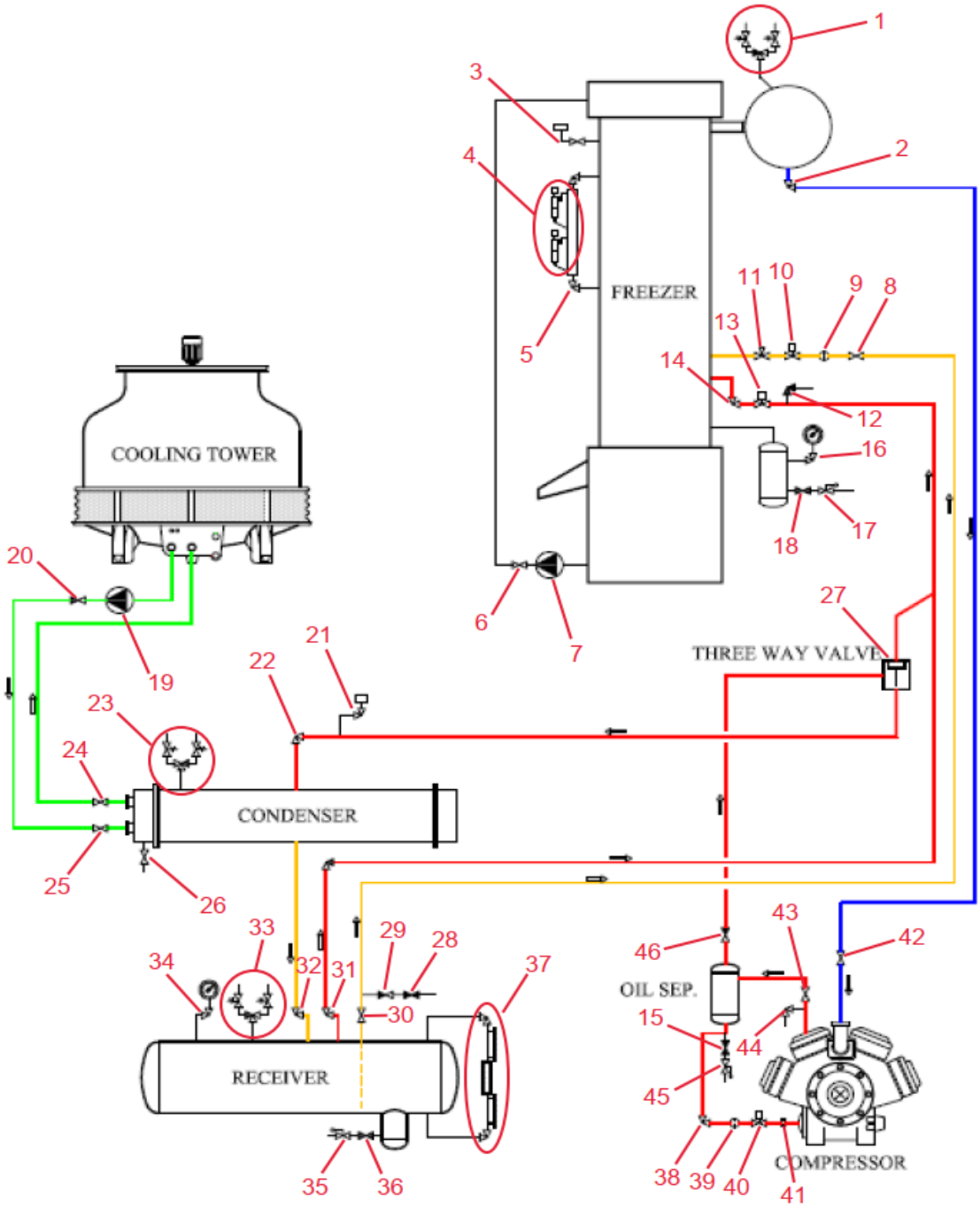


Figure 1: Basic Refrigeration System

[Chemical Awareness – Ammonia as a Refrigerant by Johnson Controls (S) Pte Ltd]

There are various types of ammonia refrigeration system. Figures 2 and 3 below show the example of different types of tube ice production system typically used in ice factories.

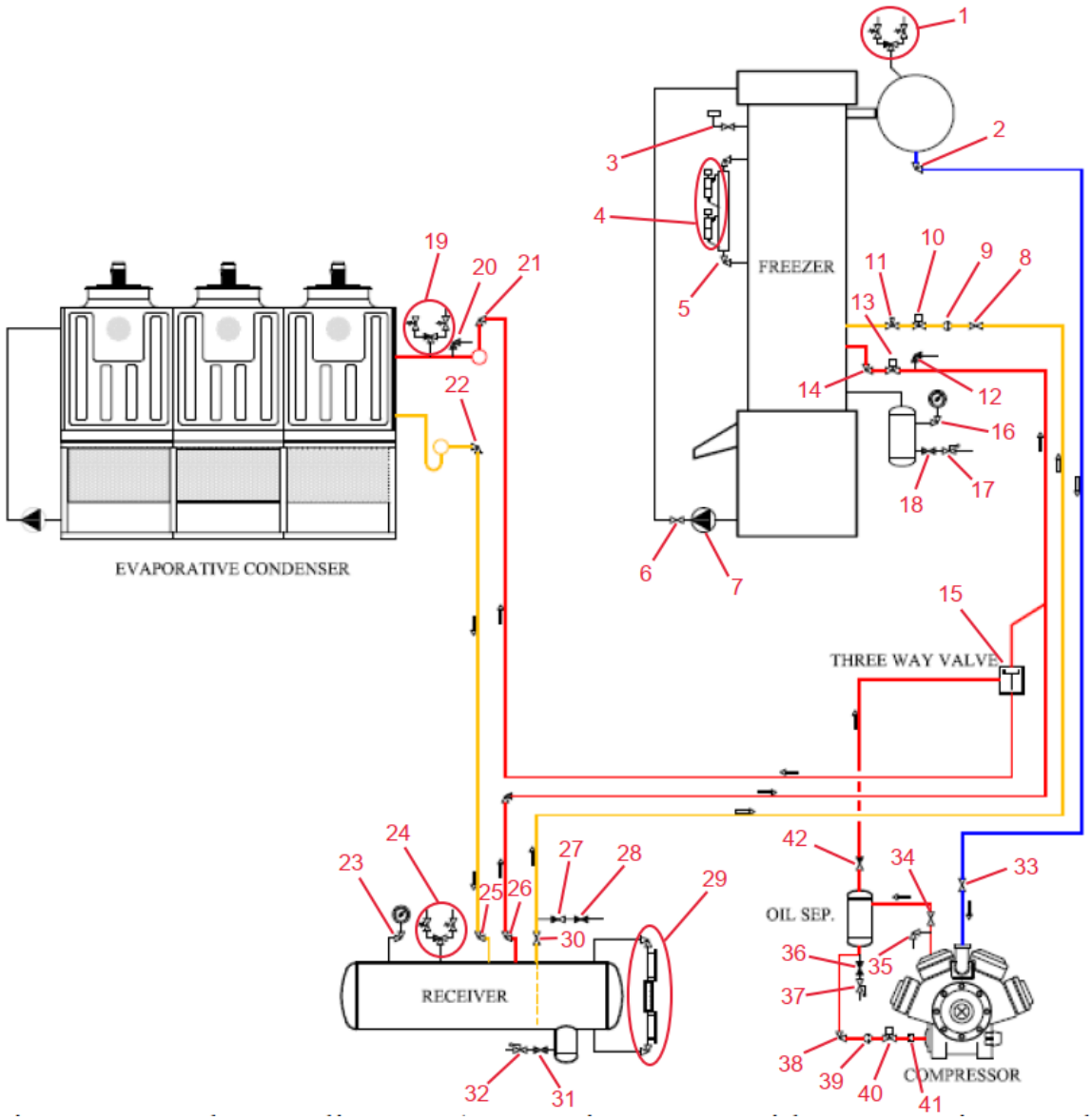


Legend :

- Hot gas ammonia line
- Liquid ammonia line
- Cold gas ammonia line
- Water line

NO.	COMPONENT
1	Safety valve
2	Angle valve
3	Temperature Sensor
4	Float switch • Higher Float Switch • Lower Float Switch
5	Angle Valve
6	Butterfly Valve
7	Chilled Water Pump
8	Straight Valve
9	Strainer
10	Liquid Solenoid Valve
11	Needle Valve
12	Drain Valve
13	Hot Gas Valve or Hot Gas Solenoid Valve
14	Angle Valve
15	Angle Valve
16	Angle Valve
17	Oil Drain Valve
18	Angle Valve
19	Condenser Pump
20	Angle Valve
21	High Pressure Control
22	Angle Valve
23	Safety Valve
24	Angle Valve
25	Angle Valve
26	Drain Valve
27	Three Way Valve
28	Check Valve
29	Straight Valve
30	Angle Valve
31	Angle Valve
32	Angle Valve
33	Safety Valve
34	Angle Valve
35	Oil Drain Valve
36	Angle Valve
37	Sight Glass
38	Angle Valve
39	Orifice
40	Oil Solenoid Valve
41	Sight Glass
42	Straight Valve
43	Angle Valve
44	Drain Valve
45	Oil Drain Valve
46	Straight Valve

Figure 2: Tube ice diagram (Ammonia system with shell and tube condenser)



Legend :

- Hot gas ammonia line
- Liquid ammonia line
- Cold gas ammonia line
- Water line

NO.	COMPONENT
1	Safety valve
2	Angle valve
3	Temperature sensor
4	Float Switch • Higher Float Switch • Lower Float Switch
5	Angle Valve
6	Butterfly Valve
7	Chilled Water Pump
8	Straight Valve
9	Strainer
10	Liquid Solenoid Valve
11	Needle Valve
12	Drain Valve
13	Hot Gas Valve or Hot Gas Solenoid Valve
14	Angle Valve
15	Three Way Valve
16	Angle Valve
17	Oil Drain Valve
18	Angle Valve
19	Safety Valve
20	Drain Valve
21	Angle Valve
22	Angle Valve
23	Angle Valve
24	Safety Valve
25	Angle Valve
26	Angle Valve
27	Straight Valve
28	Check Valve
29	Sight Glass
30	Angle Valve
31	Angle Valve
32	Oil Drain Valve
33	Straight Valve
34	Angle Valve
35	Drain Valve
36	Angle Valve
37	Oil Drain Valve
38	Angle Valve
39	Orifice
40	Oil Solenoid Valve
41	Sight Glass
42	Straight Valve

Figure 3 : Tube Ice Diagram (Ammonia system with evaporative condenser)

[Manual – Tube Ice, Patkol Public Limited Company]

5.3 Design criteria

The design criteria should be as follows:

a. UPV should be built in accordance with the design codes recognized by DOSH Malaysia

b. In respect of design, method of construction workmanship and tests it shall comply with the provisions of one of the codes, rules or specifications set out in the Second or Third Schedule of the; Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970.

c. All materials used in the construction of the vessel shall be suitable for ammonia refrigerant at the design temperature and pressure to which the component shall be subjected.

d. A name Plate should be installed on the metal cladding of the insulation for easy inspection in future.

e. When a vessel is to contain lethal substances either liquid or gaseous, all butt-welded joints shall be fully radiographed.

[UW-2 (a) and UW-11(a)(1) ASME Sect VIII Div.1 2019 Edition]

f. Fabrication drawings, pressure vessel calculations, pressure testing certificates and bills of materials shall be inspected by an authorized inspecting authority (AIA) in the Fourth Schedule; Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970 if required by DOSH (more than 3000 psig.inches). Please see **Appendix 6** for the **Worked Example of Pressure Design of Pipe under Internal Pressure**

g. Machine Room Design

   i. The machine room should have enough ventilation for releasing the heat from compressor motors.

   ii. Ventilation fans can be added if necessary for emergency ammonia leakage or for insufficient ventilation.

   iii. It is recommended to install ammonia gas detectors.

6 INSTALLATION

a. The ammonia refrigeration system shall be designed by, and installed under the supervision of, persons who by reason of knowledge, training and experience are competent for the tasks.

b. The refrigeration system installer shall be equipped with the necessary drawings and relevant diagrams, including a refrigeration circuit, flow diagram and electrical circuit diagram.

7 CHECKING AND TESTING

a. The ammonia refrigeration system shall be checked before start-up:
   i. All piping, electrical equipment and insulation to be correctly installed.
   ii. All protection devices to be tested and set.
   iii. The system to be pressure tested
   iv. Functional tests of all safety devices including the warning and alarming system to be conducted.

b. The system cannot operate until it has passed all tests and inspections as follows:
   i. Non-destructive test performed on any welded part to ensure there is no defect on the part
   ii. Pressure test performed to ensure no leaking of refrigerant upon charging.
      (i) Max Test Pressure: 90% of relief valve pressure using nitrogen or 1.1 x of highest operating pressure.
      (ii) Hold pressure for at least 24 hours or minimum period specified by the manufacturer.
      (iii) All suction and discharge valves must be completely closed
      (iv) Brush or spray all welding joints with soapy water to check for any leaks.

      [ASME B31.5:2006 Refrigeration Piping and Heat Transfer Components]
   iii. Vacuum test performed to remove water content and moisture from the piping.
      (i) Vacuum pump to pull down pressure to vacuum condition.
      (ii) Hold pressure for at least 24 hours or according to manufacturer specifications.
      (iii) Charge in ammonia until above atmospheric pressure in the process of breaking vacuum.

d. The owner and contractor should witness and verify the pressure test and vacuum test.

8 AMMONIA CHARGING

a. Before charging the system with ammonia, it is essential to verify that the machine room on site and any other spaces that contain industrial refrigeration systems are built in accordance with all safety requirements

b. Before the ammonia refrigeration unit can be charged with ammonia, all first aid and safety equipment must be made available and accessible.

    i. Before installation, the installation technician must check that the facility is equipped with a full-face respirator and protective clothing, including protective gloves, gas masks, and compressed air breathing sets.

    ii. The items listed above should all be safely and carefully stored in an accessible storage area so they can be utilized when needed.

c. Before charging an ammonia refrigeration system, local emergency authorities and all on-site staff should be made aware that ammonia is being used at that location. Notices and signages also need to be placed in all relevant locations informing personnel that the ammonia system will be charged.

9 MAINTENANCE

a. The owner must ensure the refrigeration system is well maintained. Periodical maintenance should comply with manufacturer recommendations.

b. For a repair work where component replacement is required, original equipment manufacturer (OEM) parts shall be used or parts that at least meet with manufacturer's original specifications.

c. The manufacturer or supplier shall give the user sufficient written information concerning the plant's design, construction, examination, operation and maintenance as may reasonably be necessary to enable the user to continue to operate it safely.

d. The refrigeration system must be properly maintained and operate efficiently without any serious risk to safety and health. Subject to para 3.5 (a), the risk assessment conducted may identify critical measures to be put in place and may include any control requirements arising from the maintenance program. Planned maintenance programs may indicate potential risks, thus proper scheduled inspection or maintenance according to manufacturer recommendation may reduce any residual risk.

e. Any maintenance work in the plant shall be undertaken by a trained person with sufficient experience, knowledge, training and skills of the systems to ensure any faults from each stage of the process can be identified and rectified before serious consequences occur.

f. Any refrigeration system with compressors, condensers, evaporators and associated components are regularly maintained and periodically inspected by trained/competent personnel to ensure:

   i. Planned Preventative Maintenance (PPM) procedures are in line with the manufacturer's recommendations.

   ii. All PPM activities must adapt to technical progress and be revised if necessary.

   iii. All safety equipment is correctly installed and well-functioning

   iv. Functional tests are regularly carried out to confirm the correct operation of safety equipments.

   v. Maintenance and operational records are properly kept and readily available upon request from the authority.

10 MODIFICATION AND REPAIR

a. The owner or employer who is involved with ammonia-based refrigeration systems operation, shall ensure that nothing about the way in which the system may be modified or repaired gives rise to danger or otherwise impairs the operation of any safety equipment or inspection facility.

b. No modification or repair can be executed without prior approval from the Director General of DOSH.

c. Modifications or repairs shall take into account the original design specification, the duty after repair or modification and the effect of the work on the integrity of the system. The adequacy of safety equipment and the continued suitability must be confirmed or suitably modified by the trained person before the system is returned to service. In particular:

   i. Modification of unfired pressure vessel (UPV) must be notified to and approval obtained DOSH (refer Regulation 66 Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970).

   ii. All repairs and modifications shall be carried out according to the appropriate unified codes/standards that apply to the system.

iii. Non-Destructive Examination (NDE) shall be carried out in accordance with the relevant code(s).

iv. Upon modification of the certificated machineries, they need to be retested according to the DOSH approval letter in order to obtain new and valid certificates of fitness (CF).

11 TRAINING

An employer needs to conduct a series of effective training scheme on the ammonia refrigeration system used at their workplace. The training shall contain the effect of ammonia to health and environment, the safety aspects during handling the system, safety and health management and emergency response plan. An effective training program can minimize the number of incidents which may lead to injuries and deaths, property damage, legal liability, illnesses, workers' compensation claims, and lost time injury from work. The training programmes shall also be recorded and the training conducted should involve all workers and contractors who work directly or indirectly with the refrigeration system at the workplace.

The table below shows the proposal of a minimum basic training matrix for the personnel involve directly or indirectly with to the ammonia refrigerant system.

Table 3 : Proposal of minimum basic training matrix

LIST OF TRAINING	OWNER	PLANT MANAGER	SUPERVISOR	WORKER
Acts and Regulations:				
1. Occupational Safety and Health 1994	X	X		
2. Factory and Machinery Act 1967	X	X		
3. Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000	X	X		
4. Occupational Safety and Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013	X	X		

5. Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996 6. Occupational Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004	X X	X X		
Occupational Safety and Health Management 1) Safety Committee 2) OSH Management 3) Risk Assessment 4) Developing Safe Working Procedure 5) Safety Audit Committee 6) Emergency Response Preparedness		 X X X X X X	 X X X X X X	
Practical training 1) PPE Wearing 2) ERP Drills 3) Fulfill of checklists 4) Manual Study 5) Ergonomic				 X X X X X
System maintenance 1. Daily 2. Weekly 3. Monthly 4. Annually			 X X X X	 X

12 AMMONIA EMERGENCY RESPONSE PLAN

This document section provides an overview of emergency response related to ammonia. The existing site or plant emergency response plan should incorporate specific recommendations in handling ammonia leakage emergency. Should there be any emergency related to ammonia, the response plan triggered should follow the existing protocol at the particular sites. The plan should be established in conjunction with local authorities and Bomba. The plan should address personnel, equipment, counter measures, and shutdown procedures to effectively combat the emergency situation. The procedures should include assigning personnel, personal protective equipment to be used, establishing team communication, ensuring use of buddy system, setting proper decontamination procedures, conducting reconnaissance operations, establishing action plan to gather information about the incident and other relevant information, termination and medical follow up.

An ammonia release can readily have an impact beyond the boundary of the workplace. Regardless of the size of the workplace, the largest potential release of an ammonia spill or leak must be assessed. It has been reported that almost as many small-scale releases has led to evacuations and injuries as large-scale releases; so it is important that emergency planning covers both small and large-scale releases. The recovery measures should include the following:

a) evacuation
b) notification of all persons who may be affected, including surrounding communities
c) co-ordination with local emergency services
d) communications system with site and/or external emergency services
e) wind speed and direction indication (often a windsock)
f) additional breathing apparatus

Procedures associated with general emergency principles are as follows:

a) Alarm sequence
    i. In most workplaces, during an emergency any person should be able to trigger an emergency alarm and alert others in the surrounding, thus allowing the earliest possible action to be taken to manage and mitigate any hazardous situation. Various alarm systems may be used to suit the size of the work environment.

ii. There should be an adequate number of points from which the alarm can be triggered, especially in critical areas e.g. refrigerator, either directly, via a signal or message to a permanently manned location. The alarm should alert the authorized incident or emergency commander, who should assess the situation and activate appropriate emergency procedures. In the areas where there is a high level of noise, it may be necessary to install more than one audible alarm transmitter or flashing lights. Automatic alarms may be appropriate on some sites.

b) Emergency action. If ammonia leakage occurs, immediately:

i. Notify, isolate and secure the spill area:

ii. Evacuate to the immediate evacuation area and notify the emergency response team with information such as location and extent of spill or leak.

iii. Cordon off the area around the spill with barrier tapes. Ensure that the area is safe before the emergency response team enters and reacts to the situation.

iv. Once evacuated to a safe distance (preferably upwind of leakage), observe the area where vapour clouds travel to using windsock

v. Keep away all persons not involved in the clean-up. Close doors to other areas near the leakage. Post warning signs and barriers to prevent entry to the spillage or leakage area by unauthorized persons.

vi. Turn off any ventilating or air conditioning system that circulates air from the spill area to other parts of the workplace

vii. Assemble trained emergency response members outside the cordoned area.

viii. Initiate ammonia level measurements

ix. Determine ammonia levels in and around the leakage area using an ammonia direct reading instrument.

x. Extend the restriction zone as appropriate depending on ammonia levels

c) Evacuation/search and rescue/first aid measures

The roles and responsibilities for those involved in managing an ammonia incident must be identified depending on the types and levels of emergencies according to the proper designated working environment. For large scale industry or plant with potential for more serious consequences, the establishment of emergency management structures should be conducted by emergency service organizations.

The workplace's incident management system (IMS) must be:

i. compatible with the routine organizational structure
ii. locally used emergency response agency and IMS systems
iii. resourced and sustainable.

Plese see **Appendix 7** for the example of Ammonia Emergency Response Plan Work Flow

- **Risk**

Inhalation of corrosive ammonia gas can cause irritation and inflammation of the respiratory system, difficulty breathing, nausea, chest pain and vomiting. Irritation or burns may occur after direct skin contact with anhydrous ammonia, solutions or concentrated ammonia gas. Direct contact of ammonia with eyes may cause irritation, tearing, severe injury or blindness.

- **First Aid Measures**

Immediate first aid treatment can help reduce the impact of injuries and prevent further injuries from occurring. Below is outlined some basic first aid measures for inhalation, skin contact and eye contact. In all circumstances, send for medical help, as soon as possible.

- I**nhalation**

a) Assess the victim's breathing.

b) If breathing has stopped, begin artificial respiration and continue until the victim resumes breathing. If the victim is having difficulty breathing (gasping, coughing), place the victim in the most comfortable position, usually semi-sitting.

c) If an oxygen therapy unit and trained personnel are available, administer oxygen.

d) Ensure that the victim is transported to the hospital in case of a delayed reaction in the form of pulmonary oedema. Any physical exertion, excitement or apprehension increases the chances and severity of a delayed reaction. Keep the victim warm and completely at rest. Reassure the victim while waiting for assistance.

- **Skin Contact**

a) As soon as the victim resumes breathing, flush the victim's contaminated skin and clothing with large amounts of water for 30 minutes.

b) Remove all contaminated clothing while flushing.

c) Continue flushing until all traces of ammonia have been removed.

d) Dress obvious burns in sterile gauze and bandage them loosely. Apply insulated cold packs to help reduce pain.

e) Call for an ambulance to take the victim to a hospital.

- **Eye Contact**

  a) Flush the eyes immediately with large amounts of running water (preferably lukewarm) if any amount of liquefied ammonia has entered the eyes or exposure to gaseous ammonia causes persistent eye irritation.

  b) Hold the eyelids apart forcibly to ensure full flushing of the eyes and eyelids.

  c) After flushing has removed all traces of ammonia, cover both eyes with moistened sterile gauze pads and bandage enough to keep light out.

  d) Apply insulated cold packs to help reduce pain.

  e) Call for an ambulance to take the victim to a hospital.

  f) Do not attempt to neutralize the ammonia with other chemicals or apply oils, ointments or medication to the eyes.

d) Communication with external emergency services. The aims of notification and communication are:

i. To summon for assistance from local emergency services such as Bomba, police, ambulance, hospital, neighbouring plants etc.

ii. To provide for statutory notifications to organisations such as the DOSH, DOE, etc.

iii. To provide a warning to neighbours close to the facility and public or community in the surrounding area to initiate contingency plans without delay. This allows the industry contingency plan or the state contingency plan to be placed on alert status.

iv. To inform families of injured/deceased employees. The families of casualties need to be informed and helped promptly. It may not be possible to have a standard method for informing next of kin that some general rules are applied.

v. It is essential that the next of kin of deceased or seriously injured personnel are notified at the earliest opportunity

vi. Prompt action is required by the doctor in providing an initial report. Notification to the relevant authorities is on the basis of this initial report

vii. Any information provided to next of kin should be given in person, preferably by a doctor. A senior supervisor or manager known by the family and a social worker should help where necessary.

e) Termination of emergency.

i. Procedures for termination of an emergency should be listed in the emergency procedures. When the Bomba officer's role is completed, he is to hand back control to the company Emergency Commander who will then carefully consider the overall situation.

ii. The company Emergency Commander may have complementary actions to resolve the situation before declaring the emergency is over. His next task would be facilitating reorganisation and reconstruction activities so that normal operation can be resumed.

iii. The conditions for the termination of the emergency should be clearly addressed. When these conditions are met, the emergency commander declares that the emergency is over.

iv. Generally, a specific signal or alarm would be given to announce that the emergency is over. Before people and workers are allowed to return to the emergency area, or its surroundings, an assessment of health risk is mandatory.

13 RECORD KEEPING

The employer shall ensure that all records and reports are to be maintained in good order and condition, and are to be up-dated from time to time. All the records and reports are readily available upon request from the relevant authorities for inspection, investigation and audit. Similarly, these documents should be made available to the manufacturer or trained person so that the maintenance, repair and modification process can be carried out safely. It is also important to have a proper record keeping in order for the employer to carry out continuous improvement of their safe management on the ammonia refrigeration system from time to time. The records can be kept in either hard copy or electronic format.

It should be the duty of the employer to keep the following relevant records but not limited to: -

a. Designer's/manufacturer's/supplier's approved documents relating to parts of the system, system design and plant design.

b. Maintenance programme developed by the manufacturer of the system.

c. Safe Working Procedures pertaining to operation, maintenance, refrigerant handling etc.
d. Risk Assessment Report on the activities related to the refrigeration system.
e. Chemical Health Risk Assessment Report on any chemicals hazardous to health chemical used at the plant.
f. Record of permit system being developed and used at the plant.
g. Agreement between the owner and the supplier/manufacturer, trained person etc. regarding the system periodical inspection and maintenance
h. Certificates of Fitness by DOSH on any certificated machineries.
i. Record of modification and repair works done throughout the service of the system.
j. Record of maintenance and operation throughout the service of the system.
k. Piping and Instrumentation Diagram of the refrigerant system.
l. Manual Operation by the manufacturer.
m. Legal register including logbook for any findings on the system that were recorded by authorities, workers, trained persons etc.
n. Record of Training involving the owner or the worker.
o. All documents related to the Emergency Response Plan.
p. All documents (if required) related to the compliance with the provision of the Occupational Safety and Health (Control of Industrial Major Accident Hazards CIMAH) Regulations 1996.

14 REFERENCES

1. **Department of Occupational Safety and Health (1994). Occupational Safety and Health Act and its Regulations. MDC Publishers Sdn Bhd./percetakan nasional**
2. **Department of Occupational Safety and Health (1967). Factories and Machinery Act and Its Regulations. MDC Publishers Sdn Bhd./percetakan nasional**
3. **http://www.chm.bris.ac.uk/motm/ammonia/Ammonia%20MOTM.html**
4. **https://www.britannica.com/science/ammonia**
5. **https://www.osha.gov/SLTC/etools/ammonia_refrigeration/ammonia/**
6. **Safe Management of Ammonia Refrigeration Systems**
7. **Chemical Awareness – Ammonia as A Refrigerant by Johnson Controls (S) Pte Ltd**
8. **Manual – Tube Ice, Patkol Public Limited Company**
9. **ASME B31.5:2006 Refrigeration Piping and Heat Transfer Components**
10.

APPENDIX 1 : Case Study on Incidents Involving Ammonia Refrigeration System

CASE 1

Accident case Involving Release of Ammonia Vapours at A Poultry Processing Plant Using an Ammonia Refrigerant System.

About the Accident

An accident involving an ammonia leak from a piping of a cooling system that supplies ammonia refrigerant to a blast freezer occurred at the end of the pipe connection, releasing large quantities of ammonia within the factory area.

The release of vapour cloud ammonia of gas had caused 28 workers to suffer breathing difficulties and three (3) workers were rushed to the hospital for intensive care unit (ICU) treatment. The Fire and Rescue Department personnel who arrived at the scene had successfully stopped the release of ammonia from spreading beyond the factory premises by using water blanket method to dilute the discharge of ammonia clouds and halt the source of the leak at the broken pipe.

Background

Type of Industry: Manufacturing (Food Processing)

Work Process: Refrigeration of poultry

Work activity: Operation of ammonia refrigeration system, using blast freezer

Victims: 31 workers in the factory (including 3 hospitalized in the ICU

Type of Injury: Breathing difficulties due to inhaling of gas

Location of injury: Respiratory system

Type of Accident: Leakage and explosion of ammonia gas

Findings

Forensic investigation revealed that the accident was caused by one of the blast freezer units' pipelines used to freeze fresh raw poultry. The cooling process was disturbed by a solenoid safety valve failure which was supposed to stop excessive ammonia supply into the blast freezer, resulting in a ruptured explosion at the end of the ammonia outlet pipe due to the process disturbance. Thorough examination of the cooling system discovered that the reason behind the malfunction of the solenoid valve was caused by leakage of the rubber seal inside the valve body housing due to foreign oil particles found in the pipeline system. The system was equipped with a strainer filter to filter out any impurities trapped in the ammonia refrigerant, but it had failed to function properly as intended, affecting critical components such as the solenoid valve.

Cause of Accidents and Lesson Learn

The accident clearly shows the failure of the owner and supplier in performing a proper maintenance program on the refrigerant system. Systematic maintenance procedures were not available for safe refrigerator handling to ensure the entire system operating without any risk. There was no checklist for the purpose of inspection on critical components that was provided during the investigation of the accident. The owner of the poultry plant was supposed to have a contract agreement with a competent third-party service provider on the periodic and comprehensive maintenance program so that any critical components could be inspected practically and adequately. The life cycle of any component requiring replacement should be specified in the inspection checklist so that it can be changed before the component's life exceeds the safe operating period.

CASE 2

Accident Case Involving Ammonia Gas Leaks from A Refrigeration System Ice Manufacturing Factory

About the Accident

An ammonia gas leak occurred at an ice manufacturing factory, as reported by a factory supervisor on Jan 14, 2020, around 1.00 am. Prompt action was taken by the factory owner to cease the freezer machine operations once they become aware of the hazardous event. The Fire and Rescue Department, arrived at the premise at around 7.00 am after receiving a call from people living nearby the area who smelled high concentrations of uncomfortable gas. The dilution process of ammonia gas was carried out by The Fire and Rescue Department until 11.30am.

The Department of Occupational Safety and Health (DOSH) conducted an investigation at the factory after being notified of the incident. The investigations revealed that the accident was caused by an ammonia gas leak in the freezer tower machine used for the ice production. An immediate notice of prohibition of the machinery involved was issued. No injuries were caused by the leak, were reported.

Background

Type of Industry: Manufacturing (Production and supply of ice) / Small and medium industry

Work Process: Manufacturing of cube ice

Work activities: Operation of ice cube refrigeration machine operation

Victims: None

Type of Injury: N/A

Location of injury: N/A

Type of Accident: Leakage of ammonia gas (dangerous occurrence)

Findings

Records show that the ice manufacturing plant has been operating since 2007. Two units of ice refrigerator systems each with capacity of 100 tonnes and 30 tonnes respectively (for mass ice cube production) has been installed and were operating in the factory. The one involved with the accident was the 100-tonne machine. Each refrigeration system has components which require design approval and certificate of fitness from DOSH such as ammonia receivers (2 units) and ice tube freezers (2 units) but the owner failed to register the machinery and illegally operated the machinery without any valid certification of fitness (CF). None of the installation, maintenance and repair of the machinery was carried out by a Competent Firm registered with DOSH. Repair works were carried out on the leaking area (inner freezing tube) by the owner without any notification to DOSH. The machinery was operated without any safe operation procedures and documents such as P&ID diagrams and emergency response plans which were supposed to be developed by the owner for proper safe handling were not available. To make it worse, there were no gas sensors to detect the presence of ammonia in the work area and its surrounding to alert workers. Furthermore, adjacent to the production building, were hostels to accommodate their workers. The owner also failed to carry out mandatory chemical risk health assessments.

Cause of Accidents and Lesson Learnt

The leak was found to occur from one of the inner tubes used for the ice formation process (an ice-producing tube) based on a leakage test conducted by the supplier of the refrigeration system. Leakage testing (using foam test) was conducted by pumping in nitrogen gas into the freezer shell body (surrounding the inner tubes) and observing the bubbles of the leaking gas. The identified leak area was an inner tube with plugged ends on both top and bottom ends by welding (previous repair works). However, the owner had failed to provide any records on the repair works except for some work-in progress. It was conducted by a non-competent service provider that was not registered with DOSH. Any repair works are supposed to be notified to DOSH and approval should be received upon repair of any certificated machinery. Any person who intends to operate unfired pressure vessels are supposed to register their machinery by applying for design approval and receive a certificate of fitness from DOSH to ensure their machinery were safely constructed as per design without posing any risks of harm to anyone especially to their workers. Risk assessment should be conducted as a proactive measure to prevent any unnecessary dangerous occurrences. Emergency response plans and the risk assessments can reduce the risk of serious injury to the workers.

Appendix 2 : Example of Anhydrous Ammonia Safety Data Sheet

Safety data sheet
Ammonia, anhydrous.

Creation date :	28.01.2005	Version : 1.0	BE / E	SDS No. : 002
Revision date :	04.01.2011			page 1 / 3

1 IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY

Product name
Ammonia, anhydrous.
Trade name
Ammoniak
Ammoniak 3.6 Detector
Ammoniak 3.8
Ammoniak vloeibaar

EC No (from EINECS): 231-635-3
CAS No: 7664-41-7
Index-Nr. 007-001-00-5
Chemical formula NH3
REACH Registration number:
Not available.
Known uses
Industrial application.
Company identification

E-Mail Address
Emergency phone numbers (24h):
Poison center:

2 HAZARDS IDENTIFICATION

Classification of the substance or mixture

Classification acc. to Regulation (EC) No 1272/2008/EC (CLP/GHS)
Press. Gas (Liquefied gas) - Contains gas under pressure; may explode if heated.
Flam. Gas 2 - Flammable gas.
Acute Tox. 3 - Toxic if inhaled.
Skin Corr. 1B - Causes severe skin burns and eye damage.
Acute Tox. 1 - Very toxic to aquatic life.
- Corrosive to the respiratory tract.

Classification acc. to Directive 67/548/EEC & 1999/45/EC
R10 | T; R23 | C; R34 | N; R50
Flammable
Toxic by inhalation.
Cause burns (to eyes, respiratory system and skin).
Very toxic to aquatic organisms.
Risk advice to man and the environment
Liquefied gas.

Label Elements

- Labelling Pictograms

- Signal word

Danger

- Hazard Statements

H280	Contains gas under pressure; may explode if heated.
H221	Flammable gas.
H331	Toxic if inhaled.
H314	Causes severe skin burns and eye damage.
H400	Very toxic to aquatic life.
EUH071	Corrosive to the respiratory tract.

- Precautionary Statements

Precautionary Statement Prevention

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P260	Do not breathe gas, vapours.
P273	Avoid release to the environment.

Precautionary Statement Reaction

P377	Leaking gas fire: Do not extinguish, unless leakcan be stopped safely.
P381	Eliminate all ignition sources if safe to do so.
P303+P361+P353+P315	IF ON SKIN (or hair): Remove / Take off immediately all contaminated clothes. Rinse skin with water/shower. Get immediate medical advise/attention.
P304+P340+P315	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Get immediate medical advise/attention.
P305+P351+P338+P315	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get immediate medical advise/attention.

Precautionary Statement Storage

P403	Store in a well-ventilated place.
P405	Store locked up.

Precautionary Statement Disposal

None.

3 COMPOSITION/INFORMATION ON INGREDIENTS

Substance/Preparation: Substance.
Components/Impurities
Ammonia, anhydrous.
CAS No: 7664-41-7
Index-Nr.: 007-001-00-5
EC No (from EINECS): 231-635-3
REACH Registration number:
Not available.
Contains no other components or impurities which will influence the classification of the product.

4 FIRST AID MEASURES

Inhalation
Toxic by inhalation. Irritating to respiratory system. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.
Skin/eye contact
May cause chemical burns to skin and cornea (with temporary disturbance to vision) Immediately flush eyes thoroughly with water

for at least 15 minutes. Remove contaminated clothing. Drench affected area with water for at least 15 minutes. Obtain medical assistance.

Ingestion
Ingestion is not considered a potential route of exposure.

5 FIRE FIGHTING MEASURES

Specific hazards
Exposure to fire may cause containers to rupture/explode.
Hazardous combustion products
If involved in a fire the following toxic and/or corrosive fumes may be produced by thermal decomposition:
Suitable extinguishing media
All known extinguishants can be used.
Specific methods
If possible, stop flow of product. Move container away or cool with water from a protected position. Prevent water used in emergency cases from entering sewers and drainage systems.
Special protective equipment for fire fighters
Use self-contained breathing apparatus and chemically protective clothing.

6 ACCIDENTAL RELEASE MEASURES

Personal precautions
Evacuate area. Use self-contained breathing apparatus and chemically protective clothing. Ensure adequate air ventilation. Monitor concentration of released product.
Environmental precautions
Try to stop release. Reduce vapour with fog or fine water spray.
Clean up methods
Ventilate area. Hose down area with water. Wash contaminated equipment or sites of leaks with copious quantities of water. Keep area evacuated and free from ignition sources until any spilled liquid has evaporated. (Ground free from frost).

7 HANDLING AND STORAGE

Handling
Use only properly specified equipment which is suitable for this product, its supply pressure and temperature. Contact your gas supplier if in doubt. Do not allow backfeed into the container. Suck back of water into the container must be prevented. Keep away from ignition sources (including static discharges). Purge air from system before introducing gas. Refer to supplier's handling instructions. Avoid exposure, obtain special instructions before use. Avoid suckback of water, acid and alkalis. Purge system with dry inert gas (e.g. helium or nitrogen) before gas is introduced and when system is placed out of service. Assess the risk of potentially explosive atmosphere and the need for explosion-proof equipment. Consider the use of only non-sparking tools. Do not smoke while handling product. Only experienced and properly instructed personsshould handle gases under pressure. Protect cylinders from physical damage; do not drag, roll, slide or drop. Never use direct flame or electrical heating devices to raise the pressure of a container. Do not remove or deface labels provided by the supplier for the identification of the cylinder contents. When moving cylinders, even for short distances,use a cart (trolley, hand truck, etc.) designed to transport cylinders. Leave valve protection caps in place until the container has been secured against either a wall or bench or placed in a container stand and is ready for use. Ensure the complete gas system has been (or is regularily) checked for leaks before use. If user experiences any difficulty operating cylinder valve discontinue use and contact supplier. Close container valve after each use and when empty, even if still connected to equipment. Never attempt to repair or modify container valves or safety relief devices. Keep container valve outlets clean and free fromcontaminates particularly oil and water. Never attempt to transfer gases from one cylinder/container to another. Installation of a cross purge assembly between the cylinder and the regulator is recommended.
Storage
Secure cylinders to prevent them falling. Keep container below 50°C in a well ventilated place. Segregate from oxidant gases and other oxidants in store. Observe all regulations and local requirements regarding storage of containers. Containers should not be stored in conditions likely to encourage corrosion. Containers should be stored in the vertical position and properly secured to prevent falling over. Stored containers should be periodically checkedfor general conditions and leakage. Container valve guards or caps should be in place. Store containers in location free from fire riskand away from sources of heat and ignition. Keep away from combustible materials All electrical equipment in the storage areas should be compatible with the risk of potentially explosive atmosphere.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure limit value

Value type	value	Note
TLV (ACGIH)	25 ppm	ACGIH 1995 - 1996
Belgium - STEL	50 ppm	
Belgium - TWA	20 ppm	

Personal protection
Protect eyes, face and skin from liquid splashes.

9 PHYSICAL AND CHEMICAL PROPERTIES

General information
Appearance/Colour: Colourless gas.
Odour: Ammoniacal

Important information on environment, health and safety
Molecular weight: 17 g/mol
Melting point: -77,7 °C
Boiling point: -33 °C
Critical temperature: 132,4 °C
Autoignition temperature: 630 °C
Flammability range: 15 %(V) - 30 %(V)
Relative density, gas: 0,6
Relative density, liquid: 0,7
Vapour Pressure 20 °C: 8,6 bar
Solubility mg/l water: Hydrolyses.
Other data
Although this substance has flammability data, itis difficult to ignite in air and is classified as non-flammable.

10 STABILITY AND REACTIVITY

Stability and reactivity
May react violently with oxidants. May react violently with acids. Reacts with water to form corrosive alkalis. Can form explosive mixture with air.
Hazardous decomposition products
Statements on decomposition
None.

11 TOXICOLOGICAL INFORMATION

Acute toxicity
Inhalation of large amounts leads to bronchospasm, laryngeal oedema and pseudomembrane formation. May cause inflammation of the respiratory system and skin.

LC50/1h (ppm) 4000 ppm

12 ECOLOGICAL INFORMATION

General
May cause pH changes in aqueous ecological systems.

13 DISPOSAL CONSIDERATIONS

General
Do not discharge into any place where its accumulation could be dangerous. Avoid discharge to atmosphere. Contact supplier if guidance is required. Gas may be scrubbed in sulphuric acid solution. Gas may be scrubbed in water. Toxic and corrosive gases formed during combustion should be scrubbed before discharge to atmosphere.
EWC Nr. 16 05 04*

14 TRANSPORT INFORMATION

ADR/RID

Class	2	Classification Code	2TC

UN number and proper shipping name
UN 1005 Ammonia, anhydrous
UN 1005 Ammonia, anhydrous

Labels	2.3, 8	Hazard number	268
Packing Instruction	P200		

IMDG

Class	2.3

UN number and proper shipping name
UN 1005 Ammonia, anhydrous

Labels	2.3, 8
Packing Instruction	P200
EmS	FC, SU

IATA

Class	2.3

UN number and proper shipping name
UN 1005 Ammonia, anhydrous

Labels	2.3, 8
Packing Instruction	P200

Other transport information
Ensure vehicle driver is aware of the potential hazards of the load and knows what to do in the event of an accident or an emergency. Before transporting product containers ensure that they are firmly secured. Ensure that the cylinder valve is closed and not leaking. Ensure that the valve outlet cap nut or plug (where provided) is correctly fitted. Ensure that the valve protection device (where provided) is correctly fitted. Ensure adequate ventilation. Ensure compliance with applicable regulations.

15 REGULATORY INFORMATION

Further national regulations
This substance or preparation above certain volume may have to be included in a SEVESO II submission or any other applicable national regulation.

16 OTHER INFORMATION

Ensure all national/local regulations are observed. Ensure operators understand the toxicity hazard. Users of breathing apparatus must be trained. Before using this product in any new process or experiment, a thorough material compatibility and safety study should be carried out.

Advice
Whilst proper care has been taken in the preparation of this document, no liability for injury or damage resulting from its use can be accepted. Details given in this document are believed to be correct at the time of going to press.
Further information
Hommel: Handbook of dangerous goods
Kühn-Birett: Merkblätter gefährliche Arbeitsstoffe
Linde safety advice

End of document

Appendix 3 : Example of Risk Assesment

Department	Production	**Risk Assessor**	**Shannon**	**Approved by**	**RA Reference No:**
Process	Ice Packaging	**RM Team Member 1**	Kamal Abdul	**Signature**	
Location	production line	**RM Team Member 2**	Sanjit Kumar	**Name**	Francis Kong
Assesment Date	4 Mac 2020	**RM Team Member 3**	Ngeng Weng Yin	**Designation**	Production manager
Last Assessment/ Review Date	N/A	**RM Team Member 4**	Fakrul	**Date**	**13/3/2020**

No.	**HAZARD IDENTIFICATION**								**RISK EVALUATION**				**RISK CONTROL**	**RISK RE-EVALUATION**				**REMARK**
	Work Activity	**Hazard**	**Category of Hazard**					**Event and Consequences**	**Existing Risk Control (if any)**	**Justification of likelihood**	**Likelihood (L)**	**Severity (S)**	**RMN**	**Additional Risk Control**	**Likelihood (L)**	**Severity (S)**	**RMN**	**PIC (due date)**	
			Physical	**Chemical**	**Biological**	**Ergonomic**	**Psychosocial**												
1	sticky Ice loosen process in chute drum using stick	Slippery Working Platform	X					Slip and fall from platform and may fall from height causing bodily injury		No Past Accident Record. Have never been reported. Workers might be required to stand on the platform at each cycle of the production. For at least 20 minutes for each cycle (high frequency), small working platform and high exposure)	5	4	20	Workers are provided with non-slippery safety boots and anti-slippery mat (PU) were installed on top of working platform surface. Continuous monitoring for any development of puddles of water must be cleaned up and included in SWP. Use worker rotation program.	2	4	8	Shamsul (7.3.2002)	
		Awkward posture when handling stick to loosen hard sticky ice				X		Muscle stress and may cause back pain/Multiskeletal disorder						Conduct initial ergonomic risk assessment. Any requirement for advance assessment must follow the Ergonomic guidelines				Shamsul (7.3.2020)	

		High Working Platform	X					Slip and fall from platform during work process or climbing up the platform and may fall from height causing bodily injury,			5	4	20	Redesign of chute drum using auto loosen components without the need of workers to be on the platform for the process (excluding ice monitoring process)	2	4	8	Badrul (30.5.2020)	The proposal requires reengineering of machine and cost benefit analysis must be conducted on practicality
2	Filling of ice into plastic bag	Slippery production line	X					Slip and fall from platform and may fall on the floor causing minor bodily injury		No Past Accident Record never been reported. Workers might be required to work in the cold production line for the whole day from 8.00 am to 5.00 pm	4	2	8	Workers are provided with non - slippery safety boots and anti - slippery mat (PU) were installed on top of working platform surface. Continuos development of monitor for any development of puddles of water must be cleaned up and include in SWP. Use worker rotation program.	3	2	6	Shamsul (7.3.2020)	
3	Topping up ammonia gas at receiver	Ammonia leak	X					burning sensation to eyes and skin	SWP. Ensure hose is properly tightened before transfer of gas	No Past Accident Record never been reported. Workers required to follow the SWP	3	1	3	Workers are provided with mask, wear when leak occurs to futjer tighten hose. Continuos monitor and include in SWP.	2	1	2	Aqil to purchase (30/5/2020) . Mask and cartridges provided	

Appendix 4 : Example Of Calculation For An Ammonia's Quantity In Refrigeration System

1 **Premise A**

If the owner has one (1) unit of an ammonia refrigeration system -

Plant A : Capacity of 100 tonnes ice/day
(using about four (4) tonnes of liquid ammonia)

Therefore, the calculation is as below;

Liquid Receiver	:	4000 kg
Freezer	:	25% x 4000kg
	:	1000 kg
Pipeline	:	1000 kg (same as freezer)
Total ammonia	:	4000 kg + 1000 kg + 1000 kg
	:	**6000 kg (6 tonnes)**
		(Not to comply (NTC) for CIMAH Reg. 1996)

2 **Premise B**

If the owner has two (2) units of ammonia refrigeration system

Plant A : Capacity of 100 tonnes ice/day
(using about four (4) tonnes of liquid Ammonia)

Therefore, the calculation is as below;

Liquid Receiver	:	4000 kg
Freezer	:	25% x 4000kg
	:	1000 kg
pipeline	:	1000 kg (same as freezer)
Total ammonia	:	4000 kg + 1000 kg + 1000 kg
	:	6000 kg (6 tonnes)

Plant B : Capacity of 40/50 tonnes ice/day
(using about one (1) tonne of liquid Ammonia)

Therefore, the calculation is as below;

Liquid Receiver	:	1000 kg
Freezer	:	25% x 1000kg
	:	250 kg
Pipeline	:	250 kg (same as freezer)
Total ammonia	:	1000 kg + 250 kg + 250 kg
	:	1500 kg (1.5 tonnes)

So, total ammonia for Plant A + Plant B:

: 5000 kg + 1500 kg
: **6500 kg (6.5 tonnes)**
(Not to comply (NTC) for CIMAH Reg. 1996)

3 **Premise C**

If the owner has three (3) units of ammonia refrigeration system

Plant A : Capacity of 100 tonnes ice/day
(using about four (4) tonnes of liquid ammonia)

Therefore, the calculation is as below;

Liquid Receiver	:	4000 kg	
Freezer	:	25% x 4000kg	
	:	1000 kg	
pipeline	:	1000 kg (same as freezer)	
Total ammonia	:	4000 kg + 1000 kg + 1000 kg	
	:	6000 kg	(6 tonnes)

Plant B : capacity of 40/50 tonnes ice/day
(using about one (1) tonne of liquid Ammonia)

Therefore, the calculation as below;

Liquid Receiver	:	1000 kg	
Freezer	:	25% x 1000kg	
	:	250 kg	
Pipeline	:	250 kg (same as freezer)	
Total ammonia	:	1000 kg + 250 kg + 250 kg	
	:	1500 kg	(1.5 tonnes)

Plant C : Capacity of 150 tonnes ice/day
(using about six (6) tonnes of liquid ammonia)

Therefore, the calculation is as below;

Liquid Receiver	:	6000 kg	
Freezer	:	25% x 6000kg	
	:	1500 kg	
Pipeline	:	1500 kg (same as freezer)	
Total ammonia	:	6000 kg + 1500 kg + 1500 kg	
	:	9000 kg	(9 tonnes)

So, total ammonia Plant A + Plant B + Plant C:

: **6000 kg + 1500 kg + 9000 kg**

: **16,500 kg (16.50 tonnes)**
(EXCEED 10% OF THE THRESHOLD QUANTITY OF AMMONIA)

NOTE: 10% X 10000 KG = 10,000 KG @ 10 TONNES !!
CATEGORIZED AS **NON MAJOR HAZARD INSTALLATION (NMHI)** !!!

Appendix 5 : Example of Anhydrous Ammonia Classification from ILO and WHO

AMMONIA (ANHYDROUS) R717 Refrigerant gas 717	**ICSC: 0414** **October 2013**
CAS #: 7664-41-7 **UN #: 1005** **EC Number: 231-635-3**	

	ACUTE HAZARDS	PREVENTION	FIRE FIGHTING
FIRE & EXPLOSION	Flammable. Cylinder may explode in heat of fire. Gas/air mixtures are explosive.	NO open flames, NO sparks and NO smoking. Closed system, ventilation, explosion-proof electrical equipment and lighting.	In case of fire in the surroundings, use appropriate extinguishing media. In case of fire: keep cylinder cool by spraying with water.

AVOID ALL CONTACT! IN ALL CASES CONSULT A DOCTOR!			
	SYMPTOMS	**PREVENTION**	**FIRST AID**
Inhalation	Burning sensation. Cough. Laboured breathing. Shortness of breath. Sore throat.	Use ventilation, local exhaust or breathing protection.	Fresh air, rest. Half-upright position. Administration of oxygen may be needed. Refer immediately for medical attention.
Skin	Redness. Pain. Blisters. Skin burns. ON CONTACT WITH LIQUID: FROSTBITE.	Cold-insulating gloves. Protective clothing.	Rinse skin with plenty of water or shower for at least 15 minutes. ON FROSTBITE: rinse with plenty of water, do NOT remove clothes. Refer immediately for medical attention .
Eyes	Redness. Pain. Severe burns. ON CONTACT WITH LIQUID: FROSTBITE.	Wear face shield or eye protection in combination with breathing protection.	Rinse with plenty of water for several minutes (remove contact lenses if easily possible). Refer immediately for medical attention.
Ingestion			

SPILLAGE DISPOSAL	**CLASSIFICATION & LABELLING**
Evacuate danger area! Consult an expert! Personal protection: gas-tight chemical protection suit including self-contained breathing apparatus. Ventilation. Shut off cylinder if possible. Isolate the area until the gas has dispersed. Remove gas with fine water spray. NEVER direct water jet on liquid.	**According to UN GHS Criteria**  **DANGER** Flammable gas Contains gas under pressure; may explode if heated Toxic if inhaled Causes severe skin burns and eye damage Very toxic to aquatic life **Transportation** **UN Classification** UN Hazard Class: 2.3; UN Subsidiary Risks: 8
STORAGE	
Fireproof. Separated from oxidants, acids and halogens. Cool. Keep in a well-ventilated room.	
PACKAGING	

International Labour Organization
World Health Organization
Prepared by an international group of experts on behalf of ILO and WHO, with the financial assistance of the European Commission.

European Commission

AMMONIA (ANHYDROUS)	ICSC: 0414

PHYSICAL & CHEMICAL INFORMATION

Physical State; Appearance
COLOURLESS GAS OR COMPRESSED LIQUEFIED GAS WITH PUNGENT ODOUR.

Physical dangers
The gas is lighter than air.

Chemical dangers
Mixtures with mercury, silver and gold oxides are shock-sensitive. The substance is a strong base. It reacts violently with acid and is corrosive. Reacts violently with strong oxidants, halogens and many other substances. Attacks copper, aluminium, zinc and their alloys. Dissolves in water evolving heat. The substance reacts with most organic and inorganic compounds, causing fire and explosion hazard.

Formula: NH_3
Molecular mass: 17.0
Boiling point: -33°C
Melting point: -78°C
Relative density (water = 1): 0.7 (-33°C)
Solubility in water, g/100ml at 20°C: 54
Vapour pressure, kPa at 26°C: 1013
Relative vapour density (air = 1): 0.60
Auto-ignition temperature: 630°C
Explosive limits, vol% in air: 15-33.6

EXPOSURE & HEALTH EFFECTS

Routes of exposure
The substance can be absorbed into the body by inhalation.

Effects of short-term exposure
Rapid evaporation of the liquid may cause frostbite. The substance is corrosive to the eyes, skin and respiratory tract. Exposure could cause asphyxiation due to swelling in the throat. Inhalation may cause lung oedema, but only after initial corrosive effects on eyes and/or airways have become manifest.

Inhalation risk
A harmful concentration of this gas in the air will be reached very quickly on loss of containment.

Effects of long-term or repeated exposure
Repeated or chronic inhalation of the vapour may cause chronic inflammation of the upper respiratory tract. Lungs may be affected by repeated or prolongated exposure. This may result in chronic obstructive pulmonary disorders (COPD).

OCCUPATIONAL EXPOSURE LIMITS

TLV: 25 ppm as TWA; 35 ppm as STEL.
EU-OEL: 14 mg/m^3, 20 ppm as TWA; 36 mg/m^3, 50 ppm as STEL.
MAK: 14 mg/m^3, 20 ppm; peak limitation category: I(2); pregnancy risk group: C

ENVIRONMENT

The substance is very toxic to aquatic organisms. It is strongly advised not to let the chemical enter into the environment.

NOTES

Ammonia is normally supplied in compressed liquified form in cylinders.
See ICSC 0215.
Turn leaking cylinder with the leak up to prevent escape of gas in liquid state.

ADDITIONAL INFORMATION

EC Classification
Symbol: T, N; R: 10-23-34-50; S: (1/2)-9-16-26-36/37/39-45-61; Note: U

Appendix 6 : Worked Example of Pressure Design of Pipe under Internal Pressure

Using ASME B31.5

Given,
P = 2St/D (Refer ASME B31.5, section 504.1.2)

P = Internal design pressure, psi (kPa)
D = outside diameter of pipe, in. (mm)
S = applicable allowable hoop stress, psi (kPa)
t = pressure design wall thickness in. (mm)

Example 1:

What is the maximum internal pressure when the pipe is made out of ASTM A106 Grade B, NPS 3, Sch 40 with design condition of 100˚F?

For NPS 3 SCH 40 pipe, the D, outside diameter is 3.5 in. (Refer API 574 Table 1) and t, wall thickness is 0.216 in. (Refer API 574 Table 1)

S is 17100psi (refer ASME B31.5 Table 502.3.1) at 100˚F

Hence, the maximum internal pipe pressure is 2 x 17100 x 0.216 / 3.5 = <u>2110.6 psi</u>

Example 2:

Is the pipe made out of API 5L grade A, NPS 1 Sch 40 with design conditions of 100psi and 250˚F suitable to be used?

Rearrange the formula,

t_{min} = PD/2S

P = 100psi
D = 1.315 (Refer API 574 Table 1)
S = 13700 psi (Refer ASME B31.5 Table 502.3.1)
The minimum thickness required is 100 x 1.315 /2 x 13700 = 0.0048 in.

Referring to API 574 Table 1, NPS 1 Sch 40 pipe will have a thickness of 0.133 in. > 0.0048in.

Hence, it is suitable to be used.

Appendix 7 : Ammonia Emergency Response Plan Work Flow