

ASSOCIATION OF AMMONIA REFRIGERATION IN INDIA
AARI — Chemical Training Program

NH₃ SAFETY TRAINING

Emergency Response in Ammonia Refrigeration

Industrial Refrigeration Safety — Chennai, Tamil Nadu

AARI

Amul Ltd. AARI Member

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OVERVIEW

Agenda

01

Ammonia Properties & Hazards

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Regulatory Standards & PSM

03

Standard Operating Procedures

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Hazard Recognition & Maintenance

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Exposure Levels (AEGL)

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Emergency Action Plan (EAP)

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Emergency Response Team & Roles

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Why Ammonia as a Refrigerant?

ENVIRONMENTAL BENEFITS

• Natural refrigerant — zero ODP, zero GWP

• Environmentally friendly — no ozone depletion

• Excellent thermodynamic properties

INDUSTRIAL APPLICATIONS

• Cold storage, food processing, ice plants

• Cost-effective and energy efficient

Strict Safety Management Required

Demands discipline to mitigate associated risks to people and property

NH₃

Anhydrous Ammonia

Molecular Weight: 17.03 g/mol

Boiling Point: -33.35°C at 1 atm

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Physical & Chemical Properties of Ammonia

PHYSICAL PROPERTIES

• Colourless gas with pungent ammonia-like odour

• Compressed gas — Flammable Gas category B2L

• Can decompose at high temperatures forming flammable hydrogen gas

• Not corrosive to carbon steel or aluminium alloys

HEALTH HAZARDS

• Corrosive to the respiratory tract

• Causes severe skin burns and eye damage

• May cause frostbite on contact with liquid ammonia

25 ppm

Odour RL

50 ppm

Odour threshold

300 ppm

IDLH level

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Ammonia — Chemical Hazards

1

Chemical Stability

Normally stable under standard conditions

2

Conditions to Avoid

• High temperatures

• Open flames, sparks, static discharge

• High energy sources (welding arcs)

3

Incompatible Materials

• Oxidizing agents (e.g. peroxides)

• Strong acids (e.g. hydrochloric acid)

• Halogens (e.g. chlorine)

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Compatible Materials

• Carbon steel — safe for use

• Aluminium alloys — safe for use

Always store away from ignition sources

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Acute Exposure Guideline Levels (AEGL)

LEVEL / EFFECT

10 MIN

30 MIN

60 MIN

8 HRS

AEGL-1

Discomfort — Not disabling

30 ppm

30 ppm

30 ppm

30 ppm

AEGL-2

Disability — Irreversible harm

220 ppm

220 ppm

160 ppm

110 ppm

AEGL-3

Life-threatening / Fatal

2700 ppm

1600 ppm

1100 ppm

390 ppm

• Emergency alarm activates at 150 ppm

• Source: IF-RR Ammonia as Refrigerant, Table 14

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COMPLIANCE FRAMEWORK

Regulatory Standards & Compliance

INDIAN STANDARDS

IS 14430

AAR Standard — Indian code for ammonia refrigeration

INTERNATIONAL (OSHA / OSHA)

PSM

OSHA 29 CFR 1910.119 — Process Safety Management

OSHA

Occupational Safety & Health Administration standards

EUROPEAN STANDARDS

EN 378

BS EN 378:2008 — Refrigerating systems and heat pumps safety

PED

EC Pressure Equipment Regulations 1999

GENERAL ENGINEERING PRACTICE

ISA-88

Recognized and Generally Accepted Good Engineering Practices

ISO

ISO-8K: Ammonia as Refrigerant — ASHRAE, ISO standards

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Safety Management — Key Actions

01

Form Safety Task Force

Dedicated team responsible for safety management

02

Create Documentation

SOPs, maintenance logs, incident records

03

Mechanical Integrity

Ensure integrity of all system components

04

Offsite Consequence Analysis

Assess impact of a potential ammonia release

05

Regular Training

Provide regular training to all personnel

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Most Important

WILLINGNESS to prioritize safety over cost

External safety evaluation every 2-5 years by an independent agency is mandatory

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Documentation Required for SOPs

REQUIRED DOCUMENTATION

- P&IDs, General Arrangement, Electrical & Layout Drawings
- List of all installed equipment with capacities
- O&M Manuals from equipment suppliers
- Design and operating parameters
- Safety instruction manuals

EQUIPMENT COVERED IN SOPs

Compressors

Condensers

Pressure Vessels

Evaporators

Piping & Valves

Air Purger

Oil Rectifiers

Electrical System

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SOP Conditions to Address

1

Initial Equipment Start-Up

Step-by-step procedures for safe start-up

2

Monitoring Normal Operations

Parameters to check during normal running

3

Temporary / Abnormal Operations

Actions during non-standard conditions

4

Normal Shutdown Procedure

Planned, controlled shutdown sequence

5

Emergency Shutdown

Rapid shutdown during ammonia emergency

6

Emergency Operations

Actions taken during ammonia leak/release

7

Restart After Emergency / Turnaround Shutdown

Each condition must have step-by-step written procedures with trained operators

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Compressor SOP — Startup & Normal Monitoring

Initial Startup Checks

- Verify suction/discharge pressure and temperature
- Confirm oil level and temperature
- Confirm electrical connections and valve positions
- Check lubrication oil cooling system status

Normal Operation Monitoring

- Discharge pressure & temperature
- Oil pressure, temperature, filter pressure drop
- Shaft seal leakage within manufacturer limits
- No unusual noises or vibrations
- No ammonia or oil leaks beyond allowable limits

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Condenser & Pressure Vessel SOP

CONDENSER — STARTUP & MONITORING

- Verify pressure, temperature and water flow conditions
- Check condenser isolation/service valve positions
- Monitor discharge pressure & water treatment limits
- Proper water spray on coils; fan belt tension
- No ammonia or water leaks from condenser

HIGH PRESSURE RECEIVER — KEY PARAMETERS

Max Pressure

250 psig

Max Fill Level

75%

Relief Valve Set Point

275 PSI

- Dual pressure relief valves on manifold
- Level glass and alarm systems must be functional

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Line Opening Permits & HAZOP

PERMIT-TO-WORK REQUIREMENTS

- All line opening activities require a formal permit
- Mandatory HAZOP study before any line work
- Required PPE must be specified in the permit
- Never open process lines without isolation verification
- Use lockout/tagout (LOTO) procedures at all times

HAZOP Study

Hazard and Operability study systematically examines deviations from design intent to identify safety hazards before work begins

LOTO Protocol

Lockout/Tagout isolates all energy sources before any line opening — mandatory for all ammonia system work

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Mechanical Integrity — Critical Checks

- Regular inspection of pressure vessels, piping, and relief valves
- Corrosion monitoring on pipes, flanges, and fittings
- Safety valve piping must discharge above building roof
- Quick-drain valves for oil draining must be operable
- Emergency & normal ventilation systems tested regularly
- Ammonia leak detection sensors calibrated and functional
- Cold storage alarm for trapped persons must be operational
- Portable blower for emergency ventilation available on-site

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Poor Maintenance — What to Look For

Warning signs of inadequate maintenance that increase ammonia leak risk

- Corroded pipe fittings, valves, and flanges
- Oil and ammonia stains around compressors
- Non-functional pressure gauges and safety valves
- Missing insulation on suction lines
- Blocked emergency exits near machine rooms
- Overdue inspection tags on pressure vessels

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Real Maintenance Failures — Piping & Vessels



- Severely corroded ammonia suction/discharge piping
- Leaking flange gaskets with ammonia staining
- Rusted pressure vessel surfaces and supports
- Cracked or broken insulation exposing bare pipes
- Blocked or frozen relief valve outlets
- Missing or broken pressure gauges on receivers

Severely corroded ammonia piping — neglected industrial plant

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Real Maintenance Failures — Equipment & Safety Systems

DETECTION & PROTECTION SYSTEMS

- Ammonia detectors with dead batteries or uncalibrated sensors
- PPE cabinets that are locked, empty, or inaccessible
- Emergency eyewash stations clogged or non-functional

EQUIPMENT FAILURES

- Fire box housing for safety equipment damaged or missing items
- Compressor oil leaks left unattended for extended periods
- Safety relief valves past inspection date

Each of these failures is a potential cause of catastrophic ammonia release — inspect and rectify immediately

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Emergency Action Plan

Purpose, key components, alarm protocols, evacuation procedures, and emergency ventilation

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Emergency Action Plan — Purpose & Overview

The EAP is a document required by OSHA standards and local regulations

PURPOSE
Facilitate and organize employer and employee actions during workplace emergencies

KEY REQUIREMENTS

- Each facility is unique — EAP must be customized for your plant
- Ammonia must have a SEPARATE response from other emergencies
- All employees must be trained on the plan
- EAP must be reviewed and updated annually

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Emergency Action Plan — Key Components

- Means of reporting leaks, fires, and other emergencies
- Evacuation procedures and emergency escape route assignments
- Procedures for employees operating critical plant before evacuation
- Accounting for all employees after evacuation
- Rescue and medical duties for designated employees
- Names/job titles of persons to contact for further information
- Ammonia alarm response procedures and assembly points

Remember
Drills must be conducted at least twice per year. Failure to participate should result in disciplinary action.

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Ammonia Alarm System & Immediate Actions

ON ALARM ACTIVATION (150 PPM)

- Stop working IMMEDIATELY
- Proceed to nearest exit quickly — do not collect belongings
- Put on escape-type respirator if available
- If someone is overcome, do NOT go back — wait for emergency team
- Do NOT re-enter until ALL CLEAR from emergency crew



Ammonia gas detector with emergency alarm panel

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Emergency Ventilation System

150 ppm
Detection threshold that activates Emergency Alarm + Ventilation

- Emergency fans must exhaust to safe outdoor location
- Ventilation must create negative pressure in machine room
- Backup portable blowers for supplementary ventilation
- Ventilation system tested monthly — no exceptions
- Never rely on natural ventilation alone during emergency
- All ventilation exhaust outlets marked and kept clear

Ammonia alarms must be audible throughout ALL areas of the facility — regular testing mandatory

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Emergency Response Team — Structure

Incident Commander
Senior Emergency Response Official

- Safety Officer** — identifies hazards, provides direction
- Operations Chief** — coordinates field responders
- Response Team Members** — trained and equipped
- Evacuation Wardens** — account for all personnel

External Contacts
Fire Brigade · Hospital · Regulatory Authority



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Roles of Senior Emergency Response Official

- Coordinate and control ALL emergency responders
- Identify ammonia hazards and conditions on-site
- Implement emergency response operations
- Ensure appropriate PPE is worn by all responders
- Ensure all responders wear positive-pressure SCBA
- Limit the number of emergency personnel at the site
- Ensure back-up personnel stand by with equipment ready
- Conduct post-emergency debriefing and documentation

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Emergency Response — Key Actions

- Follow SOP immediately upon alarm activation

- Immediately report leaks, spills, or safety equipment failures

- In event of spill or leak: put on escape respirator and EXIT

- Do NOT work alone in ammonia areas — buddy system

- Get medical attention for ALL exposures — symptoms can be delayed

- Use corrosion-resistant tools and equipment

- Eliminate heat and ignition sources — sparks, open flames, hot surfaces and static discharge

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Spill & Leak Response Procedure

1

Wear appropriate PPE before approaching

2

Do NOT touch spill material directly

3

Stop the leak if safely possible to do so

4

Remove all sources of heat and ignition

5

Ventilate the area — open doors, activate emergency fans

6

Use water spray to absorb and knock down ammonia vapour

7

Prevent spillage from spreading to larger area

8

Account for all personnel and report to incident commander

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Evacuation Procedures & Assembly Points

DURING EVACUATION

- Pay attention to wind direction — move crosswind or upwind
- Proceed to designated assembly point outside the building
- Ensure ALL personnel are accounted for
- Do not return until ALL CLEAR from emergency crew

ASSEMBLY POINT PROTOCOL

- Assembly points clearly marked on plant layout
- Both indoor and outdoor assembly points designated
- Evacuation drills conducted at least twice per year
- Drill results recorded and reviewed by emergency team

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Personal Protective Equipment (PPE) — Overview

PPE is the LAST line of defense — never the first

REQUIRED PPE FOR AMMONIA

- Gas mask with SCBA (Self-Contained Breathing Apparatus)
- Chemical cartridge respirator with ammonia cartridge
- Eye goggles (splash-proof)
- Full ammonia suit (liquid-tight)
- Chemical-resistant gloves and boots



PPE must be stored in accessible, clearly marked locations — inspect regularly

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Respiratory Protection — Selection Guide

CONCENTRATION

Up to 250 ppm

REQUIRED RESPIRATORY PROTECTION

Chemical cartridge respirator with ammonia cartridge (APF=10)
Or any supplied-air respirator

250 – 300 ppm

Full-face supplied-air respirator in pressure-demand mode
Or SCBA (positive pressure)

Above IDLH (300 ppm)

Positive-pressure, full-face SCBA — MANDATORY
Or combination SCBA with escape cylinder

Source: NIOSH Pocket Guide to Chemical Hazards

IDLH = Immediately Dangerous to Life or Health

Note: Ammonia causes eye irritation — always add eye protection regardless of concentration

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Ammonia Suit — When & How to Use

WHEN IS THE AMMONIA SUIT REQUIRED?

- Leak isolation and emergency containment
- Victim rescue from ammonia-contaminated area
- Confined space entry in ammonia environment

Buddy System — Mandatory

Never enter alone in ammonia suit — minimum 2 persons required at all times

DONNING, INSPECTION & DOFFING

- Donning procedure practiced regularly — minimum 2 persons
- Suit inspection before each use: seams, zipper, gloves, boots
- Doffing: decontaminate suit with water before removal
- Suits stored in designated fire box housing — always stocked

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Fire Box — Safety Equipment Housing

Fire box housing provides quick access to all emergency safety equipment during an ammonia incident

STANDARD CONTENTS (MINIMUM)

- Ammonia suit(s) — minimum 2 sets
- SCBA sets with spare cylinders
- Chemical goggles
- Portable ammonia gas detector
- Emergency first aid kit
- Leak sealing plugs and clamps

Inspection & Maintenance

- Fire box must be inspected monthly
- Location clearly marked with emergency signage
- Never store non-emergency items in fire box

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Ammonia Cylinder Handling Safety

- Do NOT carry out welding or hot work near ammonia cylinders
- Do NOT weld or cut an empty container — residual product is dangerous
- Secure cylinders in upright position at all times
- Use appropriate pressure regulator for cylinder pressure
- Use hand truck — never drag, roll, slide, or drop cylinders
- Keep containers tightly closed when not in use or empty
- Prepare a written ammonia charging procedure and train all operators before any charging activity

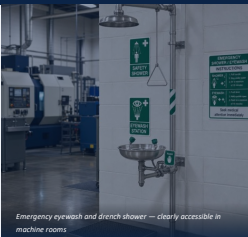
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First Aid — General Decontamination

Decontaminate as QUICKLY as Possible

- Start with the eyes — irrigate immediately
- Flush whole body with generous amounts of water
- Include hair, ears, under chin, and armpits
- Water sources: showers, hoses, eyewash stations, stock tanks
- Do NOT delay decontamination to seek medical help first



Emergency eyewash and drench shower — clearly accessible in machine rooms

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First Aid — Eye Contact with Ammonia

15 Minutes
Minimum irrigation time — even for small exposures

- Irrigate eyes with abundant water for MINIMUM 15 minutes
- Eyes close involuntarily — hold eyelids OPEN to flush
- Flush both eyes even if only one appears affected
- Continuously flush entire eye surface AND inner lining of eyelids
- Remove contact lenses if possible during flushing
- After flushing — seek immediate medical attention

Do NOT rub eyes
Rubbing spreads contamination and causes further damage

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First Aid — Skin Contact with Ammonia

IMMEDIATE ACTIONS

- Remove ammonia from skin IMMEDIATELY and move victim to safety
- Liquid ammonia may freeze clothing to skin — do NOT forcibly remove
- With clothing on — get immediately under shower or any water source
- Remove clothes ONLY AFTER they are thawed and can be freely removed

Critical Warning
If clothing is removed incorrectly, whole sections of skin can be torn off

Do NOT apply for 24 hours
Salves, creams, ointments, or jellies — prevents natural elimination of ammonia from skin after 24 hours — treat as thermal burns medically

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First Aid — Inhalation & Ingestion

For Inhalation

- Take exposed worker immediately to clean, uncontaminated area
- For mild exposure at low concentration: monitor, usually no treatment needed
- For severe exposure: call physician immediately
- Administer oxygen by trained/authorized person
- Begin artificial respiration if patient is not breathing; keep warm and rested

For Ingestion

- Call a physician immediately
- If conscious: give large amounts of water
- Do NOT induce vomiting if victim is in shock, severe pain, or unconscious
- If vomiting begins: position face down, head lower than hips

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Mock Drill — Purpose & Planning

PURPOSE OF MOCK DRILLS

- Check reaction of occupants and employees during emergencies
- Test workability of emergency plan and leak detection system
- Identify deficiencies and implement improvement plans
- Avoid life and property loss in real emergencies

PLANNING

- Plan with external experts and internal team
- Frequency: minimum twice per year
- Simulate realistic ammonia leak scenario with observers

Mock drill in progress — employees evacuating ammonia plant

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Mock Drill Report — Contents

1	Date of onsite ammonia gas leakage mock drill	9	Name of deputized observers
2	Aim and Objective	10	Event schedule and timeline
3	Extended scope of mock drill	11	Number of head count at assembly points
4	Need and rationale for conducting the drill	12	Details of first aid given
5	Steps and framework of mock drill	13	Hospital treatment details and doctor feedback
6	Pre-mock drill planning details	14	Post mock drill activities
7	Emergency situation simulated	15	Observations and corrective actions
8	Area covered and location of occurrence	16	Learning for the future

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Training Checklist — What Every Employee Must Know

• How will you know if there has been an ammonia leak?	• How do you don and use the SCBA and escape respirator?
• In the event of a leak, what is the first action you will take?	• Where is the nearest PPE station and fire box?
• Where are the indoor and outdoor assembly points?	• Who is your emergency warden for your section?
• What must you NOT do until given a clear instruction?	• What are the symptoms of ammonia exposure?

Employee sign-off on training is mandatory — keep records on file

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Key Takeaways & Call to Action

CLOSING THOUGHTS

- Ammonia is an excellent refrigerant — but demands respect and discipline
- SOPs, maintenance, and training are non-negotiable
- Regular mock drills save lives — treat every drill as a real emergency
- WILLINGNESS is the most important element — AIARI is committed to safe, responsible ammonia refrigeration in India
- Invest in PPE and ensure it is accessible and functional at all times
- Never compromise cost over human safety
- External safety evaluation every 2-5 years is essential

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