

Process Safety Management (PSM)


A need for Ammonia Refrigeration Systems

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WHO ARE WE?



We aim to make businesses sustainable by enhancing process safety, driving sustainable development, and improving profitability & reliability. Using advanced tools and techniques, we identify improvement areas and recommend effective solutions.

MISSION
To spread technology, enhance competency and implement best practices across the world, to empower every organization achieve more.

VISION
To contribute in making the world a sustainable place.

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AGENDA

- Basics of Process Safety
- Process Safety Hazards related to ammonia refrigeration facility
- Accident prevention & response
- Handling of Emergency Control Systems


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BASICS OF PROCESS SAFETY

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NEED FOR PSM

Do you agree,
"Accidents can occur with the operation of any process?"

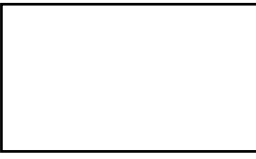
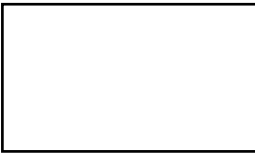


Do we need to learn by experiencing the RISK ?

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INFAMOUS MAJOR INDUSTRIAL DISASTERS

(Changed the way we looked at Safety)

<p>1974 Flixborough, England 28 fatalities, 1,000s of injuries (cause: use of Temporary piping)</p>	<p>1976 Seveso, Italy over 3,000 injuries (cause: improper shutdown)</p>
	

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1984 Bhopal, India
 over 3,000 fatalities,
 Many Injured for life
 (cause: too many negligence,
 cost cutting, poor
 maintenance & poor
 communication)

2005 Texas City, Texas
 15 deaths, 170 injuries
 (cause: faulty instruments,
 overloaded manpower, poor
 communication)

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INFAMOUS ACCIDENTS IN AMMONIA RELATED SYSTEMS

Cloud of Death 24th March, 1992, Senegal in Western Africa

- On March 24, 1992, a catastrophic ammonia tank explosion occurred at a peanut oil processing facility in Dakar, Senegal,
- This was one of the worst industrial accidents involving ammonia, widely known as the "Dakar Ammonia Accident".

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- The incident caused 129 fatalities and 1,150 injuries

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WHAT IS, PROCESS SAFETY...

Process Safety is a blend of engineering and management skills focused on preventing catastrophic accidents, particularly explosions, fires, and toxic releases, associated with the use of chemicals and petroleum products

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MANAGING RISK

Process Safety Incidents	Consequence ↑	LF/HC	There is NO FUTURE here!
		LF/LC	HF/LC
		Occupational, Personal Safety Incidents	
		Frequency →	

Implement Safety Culture and Implement PSM to manage risk

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SAFETY, HEALTH AND ENVIRONMENT MANAGEMENT

The three elements together form the safety management


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WHAT IT IS NOT!

Occupational Safety... tends to be embedded in **INDIVIDUAL BEHAVIOR**

while

Process Safety relies upon a structured set of **PRINCIPLES** and **SYSTEMS** aligned with a **PROACTIVE CULTURE** to assure safe conditions.



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OSHA PSM Elements


Applies to a flammable liquid or gas on site in one location in a quantity greater than 10,000 pounds (**more than 4500Kg**)

As well as certain listed toxic and reactive chemicals in specified amounts

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EMPLOYEE INVOLVEMENT

- Employers shall **develop a written plan of action** regarding the implementation of the employee participation required.
- Employers shall **consult with employees and their representatives on the conduct and development** of process hazards analyses and on the development of the other elements of process safety management.
- Employers shall **provide to employees and their representatives access** to process hazards analyses and to all other information required to be developed.



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PROCESS SAFETY INFORMATION

The employer shall develop and maintain a compilation of **written safety information** to enable to employer and the employees operating the process to identify and understand the hazards posed by processes involving highly hazardous chemicals.

- A simplified process flow diagram
- Process chemistry
- Toxicity information like MSDS
- Maximum intended inventory
- Safe upper and lower limits
- Piping and Instrument diagrams (P&ID's)
- Operating Procedures
- System design and design codes
- Relief system design and design basis,
- Material and energy balances for processes
- Safety systems (such as interlocks, detection, and suppression systems, etc.),
- Electrical area classification
- Mechanical Procedures for Repair

All documents must be Most recent, Readily Available

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PROCESS HAZARDS ANALYSIS

- The employer shall **perform an initial process hazard analysis** (hazards evaluation) on processes covered by the PSM regulation.
- The process hazard analysis shall be **appropriate to the complexity of the process and shall identify, evaluate, and control** the hazards involved in the process.
- These process hazard analyses shall be **updated and revalidated**, based on their completion date, every five years.

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PROCESS HAZARDS ANALYSIS

The employer shall perform a hazard analysis for identifying, evaluating, and controlling hazards involved in the process, using at least one of the following methodologies:

- Checklists,
- What-If? / Checklist,
- Hazard and Operability Study (HAZOP),
- Failure Mode and Effects Analysis (FMEA),
- Fault Tree Analysis,
- An appropriate equivalent methodology.

- HAZOP is one of the widely used techniques, recent software make it quite easy to record and track

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PROCESS HAZARDS ANALYSIS

The process hazards analysis shall address:

- The hazards of the process,
- The identification of any previous incident,
- Engineering and administrative controls applicable to the hazards),
- Consequences of failure of engineering and administrative controls,
- Facility siting,
- Human factors.

The process hazard analysis shall be performed by a team with expertise in engineering and process operations.

OPERATING PROCEDURES

The employer shall develop and implement written operating procedures that provide clear instructions for safely conducting activities involved in each process consistent with the process safety information and shall address at least the following steps for each operating phase:

- Initial Startup,
- Normal Operation,
- Temporary operations as the need arises,
- Emergency operations,
- Normal shutdown,
- Startup following a turnaround, or after an emergency shutdown,
- Operating limits,
- Safety and health considerations,
- Safety systems and their functions.

OPERATING PROCEDURE

- The employer shall develop and implement **safe work practices (work permit system)** to provide for the control of hazards during operations such as lockout/tag out, confined space entry, opening process equipment or piping, and control over entrance into a facility by maintenance, contractor, laboratory, or other personnel.
- These safe work practices **shall apply to all employees**, Company and contractor.



Operating procedures shall be **readily accessible** to employees who work in or maintain a process

The operating procedures **shall be reviewed** as often as necessary.

The employer shall **annually certify** that these operating procedures are current and accurate.

TRAINING

- Each employee presently involved in operating a process and each employee, before being involved in operating a newly assigned process, **shall be trained in an overview of the process and in the operating procedures.**
- The training shall include **emphasis on the specific safety and health hazards, emergency operations** including shutdown, and safe work practices applicable to the employee's job tasks.

TRAINING

REFRESHER TRAINING


- Refresher training shall be provided at least every three years, and more often, if necessary, to each employee involved in operating a process to assure that the employee understands and adheres to the current operating procedures of the process.
- The employer, in consultation with the employees involved in operating the process, shall determine the appropriate frequency of refresher training.



TRAINING

TRAINING DOCUMENTATION

- The employer shall ascertain that **each employee involved in operating a process has received** and understood the training required by this paragraph.
- The employer shall **prepare and maintain record** which contains the identity of the employee, the date of training, and the means used to verify that the employee understood the training.



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CONTRACTORS

APPLICATION

- This application **applies to contractors performing maintenance or repair, turnaround, major renovation, or specialty work on or adjacent to a covered process.**
- It **does not apply to contractors** providing incidental services **which do not influence process safety**, such as janitorial work, food and drink services, laundry, delivery or other supply services.

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CONTRACTORS

EMPLOYER RESPONSIBILITIES

- The employer, when selecting a contractor, shall obtain and evaluate information regarding the **contract employer's safety performance and programs.**
- The employer shall **inform contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process.**
- The employer shall **explain to contract employers the applicable provisions** of the emergency action plan required by paragraph EMERGENCY PLANNING AND RESPONSE of this section.

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PRE - STARTUP SAFETY REVIEWS

The pre-start up safety review shall confirm that prior to the introduction of highly hazardous chemicals to a process:


- Construction and equipment** is in accordance with design specifications.
- Safety, operating, maintenance, and emergency procedures are in place and are adequate.
- For new facilities, **a process hazard analysis has been performed, and recommendations have been resolved or implemented before startup;** and modified facilities meet the requirements contained in the paragraph **MANAGEMENT OF CHANGE.**
- Training of each employee** involved in operating a process has been completed.

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MECHANICAL INTEGRITY

This section applies to the following process equipment:

- Pressure vessels** and storage tanks,
- Piping systems** (including piping components such as valves),
- Relief and vent systems and devices,**
- Emergency shutdown systems,**
- Controls** (including monitoring devices and sensors, alarms, and interlocks),
- Pumps**



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MECHANICAL INTEGRITY

INSPECTION AND TESTING

- Inspections and tests shall be performed **on all process equipment,**
- Inspection and testing procedures shall **follow recognized and generally accepted good engineering practices,**
- The **frequency of inspections and tests of process equipment shall be consistent with applicable manufacturer's recommendations** and good engineering practices, and more frequently if determined to be necessary by prior operating experience,
- The employer shall **document each inspection and test and maintain record** that has been performed on process equipment.

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QUALITY ASSURANCE

- In the construction of new plans and equipment, the employer shall **assure that equipment, as it is fabricated, is suitable for the process application for which it will be used.**
- **Appropriate checks and inspections shall be performed to assure** that equipment is installed properly and consistent with design specifications and the manufacturer's instructions.
- The employer shall **assure that maintenance materials, spare parts, and equipment are suitable for the process application for which they will be used.**

HOT WORK PERMITS

- The employer shall **issue a hot work permit for hot work operations conducted** on or near a covered process.
- The permit shall document that the **fire prevention and protection requirements:**
 - Have been implemented prior to beginning the hot work operation
 - Shall indicate the date(s) authorized for hot work
 - Shall identify the object on which hot work is to be performed.
- The permit shall **be kept on file until completion** of the hot work operations.

MANAGEMENT OF CHANGE

The employer shall **establish and implement written procedures to manage changes** (except for "replacements in kind") to process chemicals, technology, equipment, and procedures, and changes to facilities that affect a covered process. The procedures shall **assure that the following considerations** are addressed prior to any change:

- The **technical basis** for the proposed change,
- **Impact of change** on safety and health,
- **Modifications to operating** procedures,
- **Necessary time period** for the change,
- **Authorization requirements** for the proposed change.



INCIDENT INVESTIGATION

- The employer shall investigate each incident which resulted in or could reasonably have resulted in a catastrophic release of highly hazardous chemical in the workplace.
- An incident investigation shall **be initiated** as promptly as possible, but not later than **48 hours** following the incident.
- An incident investigation team shall be established and consist of at least one person knowledgeable in the process involved.



INCIDENT INVESTIGATION

- A report shall be prepared at the conclusion of the investigation which includes, at a minimum:
 - date of the incident,
 - date the investigation began,
 - description of the incident,
 - factors that contributed to the incident,
 - any recommendations resulting from the investigation.
- The employer shall **establish a system to promptly address and resolve the incident report findings and recommendations**
- Incident investigation reports shall be retained for five years.

EMERGENCY PLANNING AND RESPONSE

- The employer shall establish and implement an emergency action plan for the entire plant in accordance with the provisions of the regulation.
- In addition, the emergency action plan shall include procedures for handling small releases / spillages.



COMPLIANCE SAFETY AUDITS

- If your company handles anhydrous ammonia in quantities ≥ 10 MT, **safety audits, emergency plans, and risk assessments become mandatory**. For quantities ≥ 500 MT, stricter compliance measures like MAH classification and off-site emergency planning are required.
- Frequency - Every year, as per Rule 10 of MSIHC-1989 Rules
- The compliance audit shall be conducted by at least one person knowledgeable in the process.
- A report of the audit findings shall be developed.
- The employer shall promptly determine and **document an appropriate response to each of the findings of the compliance audit**, and document that deficiencies have been corrected.
- Employers shall retain the two (2) most recent compliance audit reports.
- **IS-14489 is Indian standard of safety audit** recommended to improve safety systems in any company

Legal Requirements in India

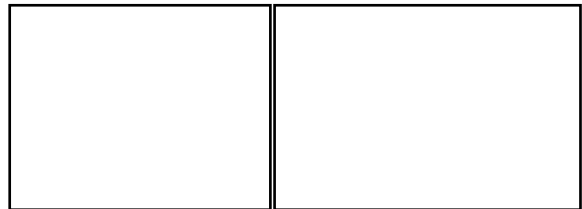
Major legal frameworks affecting industries in India:
Companies Act, 2013: Governing company formation, governance, and financial reporting.
Factories Act, 1948: Ensuring worker safety, health, and welfare within factories.
Industries (Development and Regulation) Act, 1951: Providing a legal framework for industrial development and regulation.
Payment of Wages Act, 1936: Guaranteeing timely wage payments to workers.
The Environment (Protection) Act, 1986 was enacted with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities [under section 3(3)] charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country.

Regulatory Compliance for PSM:
 In India, process safety management (PSM) requirements are primarily governed by the **Factories Act, 1948, specifically Section 41B(4)**, which mandates the identification and management of major accident hazards in facilities handling hazardous chemicals, requiring companies to develop and implement safety procedures, inform employees and the public about potential risks, and take necessary safety measures in case of accidents; additionally, the "Major Incident Control Rules" under the Manufacture, Storage and Import of Hazardous Chemicals Rules (MSIHC) also play a key role in defining PSM practices within the country.

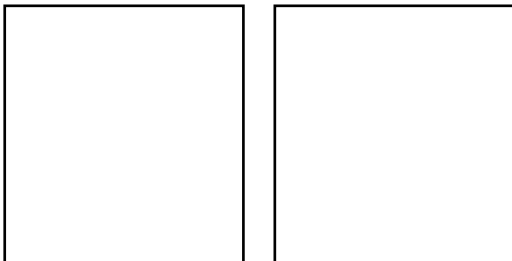
COMPANIES LEADING PSM IMPLEMENTATION IN INDIA

- Reliance Industries,
 - Indian Oil Corporation (IOCL),
 - Bharat Petroleum Corporation Limited (BPCL),
 - Hindustan Petroleum Corporation Limited (HPCL)
 - Tata Chemicals, and
 - Major chemical manufacturing units
- are prominent examples of companies actively implementing Process Safety Management (PSM) practices due to the hazardous nature of their operations and regulatory requirements.

EXAMPLE OF HAZID REPORT



EXAMPLE OF HAOP REPORT



EXAMPLE OF HAZOP WORKSHEET

1.1 Node Name : Boiler Feed Water Pump Discharge to Boiler Design Intent : To feed water to boiler consistently to make steam and avoid boiler overheating											
Deviation	Causes	Consequences	S	L	Risk Rating = Severity x Likelihood	Existing Safeguards in Design	S	L	Risk Rating = Severity x Likelihood	Recommendations, if any	Action by & Target Date
No-flow	Discharge Isolation Valve Closed	Line Pressurize & Rupture	4	3	12	1) Fuel trip on low flow 2) SOP	4	1	4		Name : XYZ Date : ABC

Risk Assessment

Level	Severity (SI)	People	Assets	Environment	Severity (E)
5	Disastrous	One or more death outside community	Extensive damage, > 1 MS	Important external pollution	5
4	Catastrophic	One or more death inside plant	Major damage, > 50 k\$	Important internal pollution	4
3	Serious	Permanent injury, Hospitalization	Localized damage, > 5 k\$	Moderate internal pollution	3
2	Moderate	Days off	Minor damage, < 50 k\$	Off spec declaration	2
1	Minor	Low injury - No day off	Slight damage < 5k\$	Off spec without declaration	1

Level	Likelihood	Description	Frequency estimate	Risk Ranking Level	Risk Acceptance / Control Criteria
5	Frequent event	Current event, Event could appear many times during plant life	Multiple times in 1 year	1 to 5	LOW - No mitigation required
4	Possible event	Event possible during operation	Once in 1 year	6 to 10	ACCEPTABLE - Should be acceptable with current safeguards in place
3	Probable event	Event seen in industry	Once in 10 years	11 to 25	UNACCEPTABLE - Should be mitigated with engineering and/or administrative controls to a risk ranking of 6 or less immediately
2	Rare event	Very improbable event, never seen in similar industry	Once in 100 years		
1	Extremely rare event	Extremely improbable event, never seen in industry	Once in 1000 years		

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PROCESS SAFETY HAZARDS related to AMMONIA REFRIGERATION FACILITY

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AMMONIA SAFETY Hazards, Risks and Threats

Threats

- Fire
- Overpressure
- Releases
- Reactivity
- Other (Natural, Terrorism, etc.)

Keys to Ammonia Safety

- Understand the Hazards
- Manage the Risks
- Control the Threats

Hazards (Properties)

- Chemical
- Physical
- Thermodynamic

Risks

- Life
- Environment
- Product, Equipment, Processes

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WHERE DO I FIND ALL INFORMATION ABOUT CHEMICAL?

MSDS Ammonia

IS MY FACILITY A SAFETY RISK?

**Indian Standard;
AMMONIA - CODE OF SAFETY REQUIREMENTS
(ICS 71.060 ; 13.300 © BIS 2000)**

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CHEMICAL HAZARDS

- Can form **unstable or explosive compounds** by reacting with halogens, hypochlorite, mercury, nitric acid, or oxides of nitrogen.
- Copper, zinc, cadmium, and their alloys** are attacked by ammonia in the presence of small quantity of water.

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FIRE HAZARDS

- Oxy acetylene** burning or welding operation on ammonia systems can constitute a serious explosion risk and strict precautions must be taken.

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HEALTH HAZARDS

- Low concentration can cause **eye irritation**, conjunctivitis, swelling of the eye lids or **dry lips, red mouth & tongue** burning of throat.
- Inhalation of high concentration gives sensation of **suffocation, burning of Respiratory tract** and may lead to **fatality**.
- **Liquid** splashes will cause **burns** on contact with skin.

ENGINEERING HAZARDS

- Failure of joints and gasket materials,
- Corrosion of external surface of the pipe,
- Non condensable gases sometimes air build up in ref. system leading to high Discharge pressures,
- Ammonia stress corrosion cracking,
- Failure of safeties and controls.



EXPOSURE SYMPTOMS

EFFECT ON HUMAN BODY

BREATHING

Irritation and inflammation of mucous membrane of the lung. The most dangerous aspect of this is **rapid swelling of the vocal cords** which may completely interrupt the air supply.

DEHYDRATION

Is the result of ammonia's great attraction for water. Anhydrous ammonia will **extract water from body tissue**.

BURNING

Is the result of the strong base formed when ammonia combines **with water** from body tissue. Once **ammonia extracts water from body tissue** it forms ammonium hydroxide that can chemically burn tissue.

FREEZING

As liquid ammonia vaporizes it **pulls heat away from body tissue** causing frostbite in an instant. Released liquid anhydrous ammonia has a temperature of **-33°C**.

TYPE OF RELEASE OF AMMONIA

MAJOR RELEASE

- Major **Ammonia Gas Leak > Greater than 250 ppm constantly maintained for 10 mins** (Factory Area):
 - If any of the ammonia sensors is in an alarm condition of 250 ppm or greater for a time of **10 mins constantly maintained the refrigeration plant should totally shut down**, turning off all compressors, pumps, and vessel liquid emergency valves unless overridden by the operator.
 - A leak of this size **would affect a much greater area and is usually the result of equipment failure or pipework rupture**. Short term exposure can be harmful and may cause long term damage to body tissue.

FIRST AID

- People exposed to ammonia vapors should be **de-contaminated** immediately.
- First **eyes must be flushed** with water after opening the eye lids.
- Contaminated clothing should be removed, and skin must be flushed with plenty of water.
- Mouth should be rinsed, and victim should be kept in fresh air.
- Cardiopulmonary Resuscitation (**CPR**) should be given if there is any sign of cardiac or respiratory arrest



PPE FOR HANDLING AMMONIA



- **Face mask with ammonia canister:**
Panorama nova full mask with 5000 PPM canister gives ammonia free air for respiration for 6 min. This can be useful for minor ammonia leak. Jumbo canisters are also available for 15 min cover.
- **Self-contained breathing apparatus (SCBA):**
PA 91 unit consist of face mask and Compressed air cylinder which gives continuous supply of air for breathing up to 30 min.
- Safety goggles:**
LPS 800 goggles protect eyes from acid, alkali, and solvents.
- Full body suit:**
This can be used along with SCBA and covers the entire body against any spillage of ammonia.
- Hand gloves:**
Hand protection against acid, alkali, and solvents.

WHAT'S THE BIG EMERGENCY in a Ammonia Refrigeration facility?

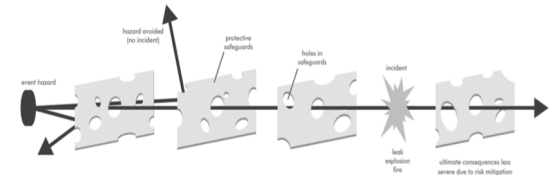
• **ACCIDENTAL AMMONIA RELEASES**

Ammonia causes injuries and death to employees, emergency response personnel, and people in surrounding communities.

- Around **322 hazardous chemical incidents** in the U.S. in 2023,
- 72% of all reported chemical accidents involve **anhydrous ammonia**.
- Up to 96% of them are preventable through increased operator training, improved procedures, and better communication of lessons learned.

(Based on chemical accidents required by EPA to be reported by industry)

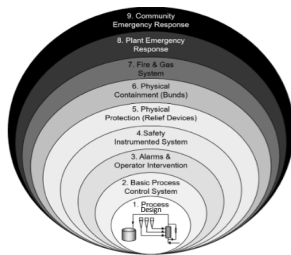
The Swiss Cheese Model of Hazard Mitigation



LAYERS OF PROTECTION ANALYSIS

Layers of Defense against a Possible Accident

- The LOPA reveals the layers of protection available in case one of those possibilities becomes reality, identifying any weaknesses that exist so they can be addressed



PREVENTING ACCIDENTS

System Periodic Inspections

Conduct Visual Testing

Conduct Leak Testing

Conduct Vibration Testing

Conduct Thermal Imaging

Security of the Hazardous

Area Training

WHAT TO DO WHEN THERE IS AN ACCIDENT?

- Always Be Prepared..... **Never be complacent** towards the HAZARDS of the Ammonia.
- Immediately **Report** the Accident to the Incident Controller.
- If feasible to isolate leak, use safe **PPEs** (Mask, SCBA, Chemical Suit).
- **Call emergency services.**
- Non-responders should **evacuate** the affected area.
- Follow instructions from emergency responders.
- Post accident perform proper **investigations** and take Corrective actions to avoid repetition
- **Train Employees** in advance on Ammonia Safety & Emergency Response

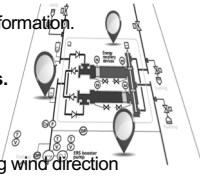


EMERGENCY PLANNING

- A facility shall have one plan as long as it meets all of the OSHA and EPA Emergency plan requirements:
 - As per Indian FACTORIES ACT, 1948, Section 41-B (4) every occupier shall with the approval of the Chief Inspector of Factories draw up an On-site Emergency Plan and detailed disaster control measures Emergency Response Program refresher training to all employees

EMERGENCY PLANNING

- Follow Procedures for inspecting, testing, and maintaining emergency response equipment.
- Establish and update Emergency Contact Information.
- Identify and remember Chain of Command.
- **Follow Emergency Shutdown Procedures.**
- Follow Mitigation Procedures.
- Establish Public Communication Plan.
- Follow to move to Assembly point in watching wind direction
- Use wind Socks to know direction
- **Practice Your Plan / Mock-drills** to identify and strengthen the plan.
- Include Local Emergency Response and Medical Services Personnel in your Planning and Practice.



THANK YOU