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Bureau of Indian Standards

COMPENDIUM OF INDIAN STANDARDS ON

SAFETY AND HAZARDS IN PROCESS INDUSTRIES




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FOREWORD

The International Labour Organization (ILO) emphasizes "Decent Work," recognizing a safe working environment as essential for both human dignity and operational efficiency. Industrial accidents not only result in the loss of skilled manpower but also tarnish an organization's reputation, as seen in the catastrophic Bhopal Gas Tragedy, which underscored the irreversible damage caused by inadequate safety protocols.

The chemical industry plays a pivotal role in India's economy but presents significant hazards, including exposure to neurotoxins, carcinogens, and other harmful substances. Despite stringent regulations from bodies like the Central Pollution Control Board (CPCB), Bureau of Indian Standards (BIS), and the Factories Act (1948), risks persist due to gaps in implementation. Ensuring worker safety demands rigorous risk assessments, strict adherence to protocols such as personal protective equipment (PPE), and safety in handling and transportation of hazardous chemical. Effective enforcement, continuous monitoring, and advanced protective measures are critical for mitigating hazards and ensuring safety in chemical industries

Safety and quality are intrinsically linked, as an unsafe workplace not only endangers lives but also reduces productivity and compromises product integrity. Work authorisation without ensuring appropriate quality of PPEs may expose personnel to toxic fumes and hazardous chemical residues, posing serious health risks. Organizations that prioritize safety attract skilled professionals, enhance operational efficiency, and maintain high product standards. Establishing a strong safety culture across all levels ensures collective responsibility in minimizing workplace incidents, ultimately contributing to a safer and more productive work environment.
Recognizing this need, the Bureau of Indian Standards (BIS) has meticulously compiled this Compendium on Hazards and Safety in the Chemical Industry, integrating Indian Standards into industrial framework to enhance safety in chemical industry alignment.

This compendium is a technical guide to safety norms that should be followed while handling, storing, transportation, and suitable PPEs and hazards risk assessment to be done for chemical industries. BIS has formulated multiple safety standards through two key technical committees, Chemical Hazards Sectional Committee, CHD 7 & Occupational Safety and Health Sectional Committee, CHD 8, ensuring a structured approach to chemical industrial safety.

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CHAPTER 1

CHEMICAL HAZARDS

1.1 HOW UNSAFE IS THE INDIAN CHEMICAL INDUSTRY ?

The latest comprehensive accident statistics, as reported, are:

- Around 45 deaths in chemical industrial accidents were reported last year.
- Government data reports that there are three daily worker deaths in Indian factories due to safety lapses.

850 serious injuries in the last year, 2024.

This alarming situation demands urgent attention from progressive thinkers, compelling a thorough investigation into the underlying causes contributing to the current state of affairs.

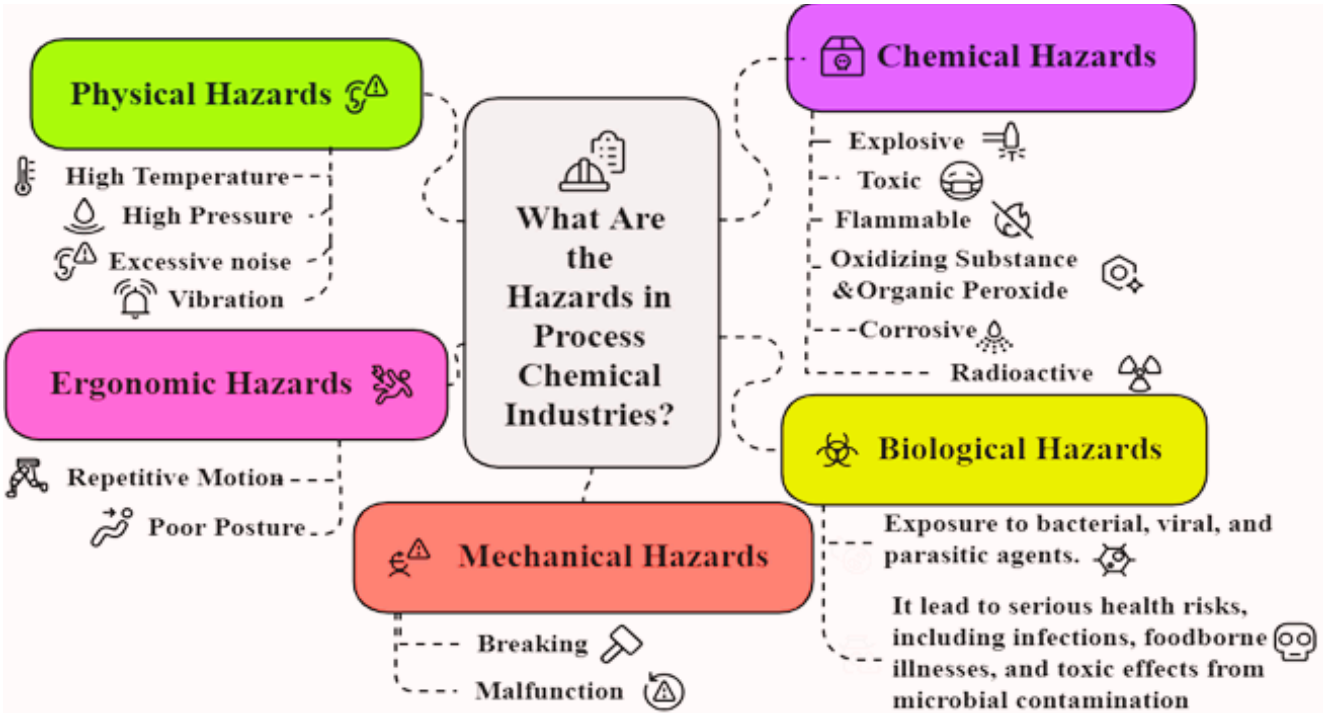
1.2 WHAT ARE HAZARDS ?

A hazard is defined as anything that can be a potential source of harm or something that could have an adverse health effect on those who come into contact with it.

As per **IS/ISO 45001:2018** "Hazards can include sources with the potential to cause harm or hazardous situations, or circumstances with the potential for exposure leading to injury and ill health".

1.3 WHAT ARE THE MAJOR HAZARDS IN CHEMICAL PROCESS INDUSTRIES?

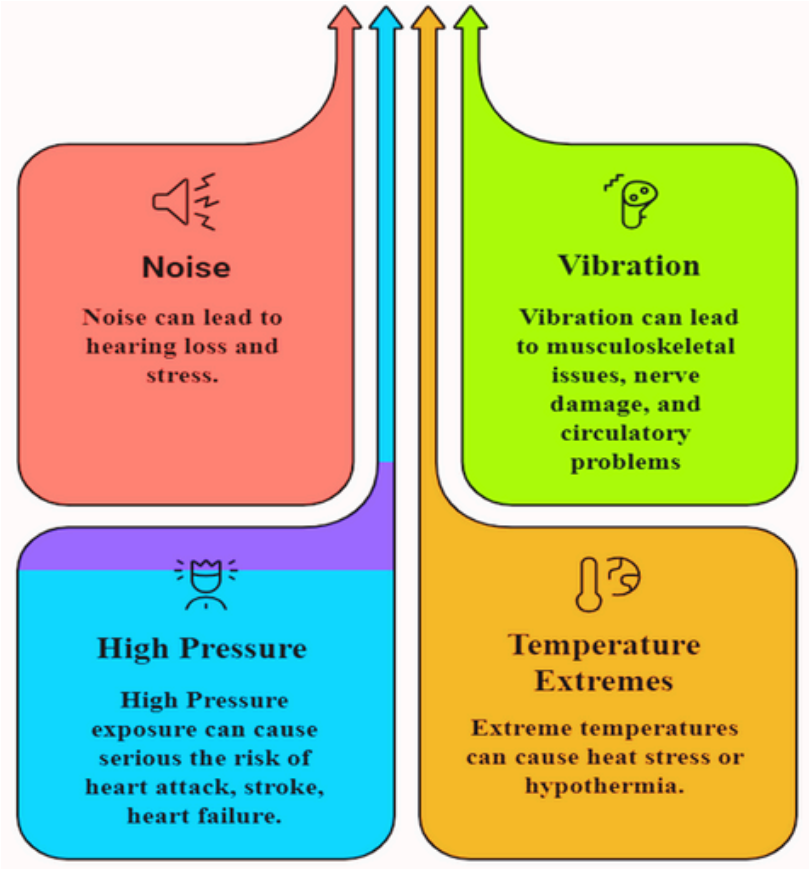
There are different types of hazards associated with chemical industries such as chemical, mechanical, physical, environmental and ergonomic hazards. In the workplace, it is crucial for industries to identify and manage hazards to ensure safety and prevent risks.



Major Hazards in Process Industry

1.4 PHYSICAL HAZARDS

Physical hazards have possible cumulative or immediate effects on the health of employees. Therefore, employers and inspectors should be alert to protect the workers from adverse physical hazards.



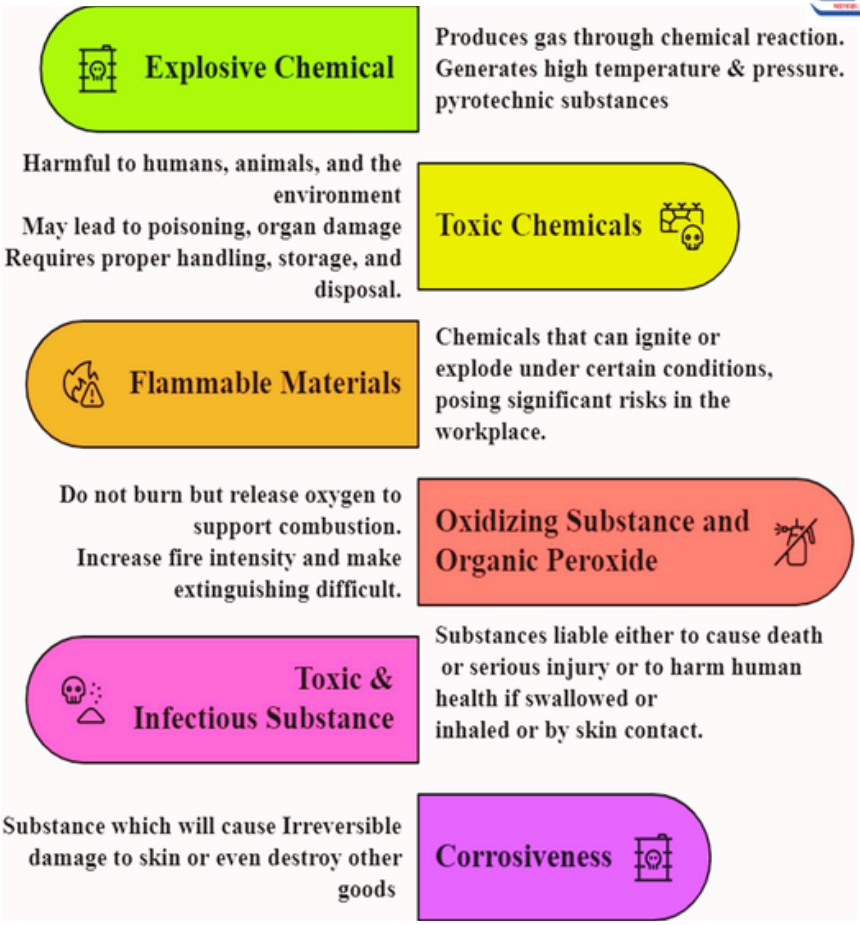
Physical Hazards

1.5 CHEMICAL HAZARDS

Chemical hazards are substances that pose risks to health, safety, and the environment due to their toxic, corrosive, irritant, carcinogenic, flammable, and mutagenic properties.

Chemical hazards are prevalent across industries, with the increasing use of complex and newly developed chemicals. This category includes over 12,000 toxic substances that pose significant risks to human health and safety. Exposure to these chemicals can result in acute effects such as poisoning, severe discomfort, or immediate health deterioration. Additionally, prolonged exposure may lead to chronic diseases, including cancer and pneumoconiosis.

Naturally occurring toxicants like lead and mercury have long been recognized as occupational health risks. With industrial advancements, other hazardous substances such as asbestos, radioactive materials, and petroleum-based compounds have also emerged as major concerns. The widespread use of synthetic chemicals, including plastics, solvents, fertilizers, and pharmaceutical agents, has further heightened occupational and environmental hazards. Ensuring proper handling, storage, and disposal of hazardous chemicals is crucial in mitigating their risks and safeguarding both human health and ecosystems.



Chemical Hazards

1.6 EFFECTS OF CHEMICAL HAZARDS

Chemical agents can have a wide range of effects on human health and the environment, depending on their properties, concentration, duration of exposure, and route of entry into the body. The major effects of chemicals include:

i. Acute Effects
ii. Chronic Effects
iii. Environmental effects

1.6.1 Acute Effects

These effects occur immediately or within a short period after exposure to hazardous chemicals.

a) Irritation and Corrosion

Chemicals such as acids, alkalis, and solvents can cause burns, irritation, or tissue damage on contact with skin, eyes, or mucous membranes.

b)Respiratory Distress

Inhalation of toxic gases, vapors, or particulates (e.g., ammonia, chlorine, sulfur dioxide) can cause breathing difficulties, lung inflammation, or even suffocation.

c) Poisoning

Exposure to highly toxic substances like cyanides, pesticides, or heavy metals can result in nausea, dizziness, organ failure, or death.

1.6.2 Chronic Effects

Long-term exposure to chemical agents may lead to severe, often irreversible health conditions.

a) Carcinogenic Effect

Chemicals like benzene, asbestos, and certain heavy metals can cause cancer after prolonged exposure.

b) Reproductive and Developmental Toxicity

Chemicals such as lead, mercury, and endocrine disruptors may affect fertility, fetal development, and cause birth defects.

c) Neurological Disorders

Long-term exposure to neurotoxins (e.g., mercury, organophosphates) can lead to memory loss, nerve damage, or conditions like Parkinson's disease.

d) Sensitizing and Reprotoxic Substances

Sensitizing substances trigger immune responses and are categorized as skin sensitizers (Sh), causing allergic reactions like dermatitis; airway sensitizers (Sa), leading to respiratory issues such as asthma; and photocontact sensitizers (SP), which cause allergic skin reactions upon UV exposure. Their classification is based on empirical evidence of allergenic or irritant effects.

e) Mutagenic

Mutagenic substances refer to substances giving rise to an enhanced occurrence of genetic mutations that may be transmitted to the offspring, i.e., permanent changes in the amount of the genetic material resulting in a change of the phenotypic characteristics of the organism and its offspring Substances toxic to reproduction refer to substances causing either impaired fertility ("RF") or subsequent developmental effects in the progeny.

1.6.3 Environmental Impact

Chemical agents also pose significant environmental risks, leading to:

a) Air and Water Pollution

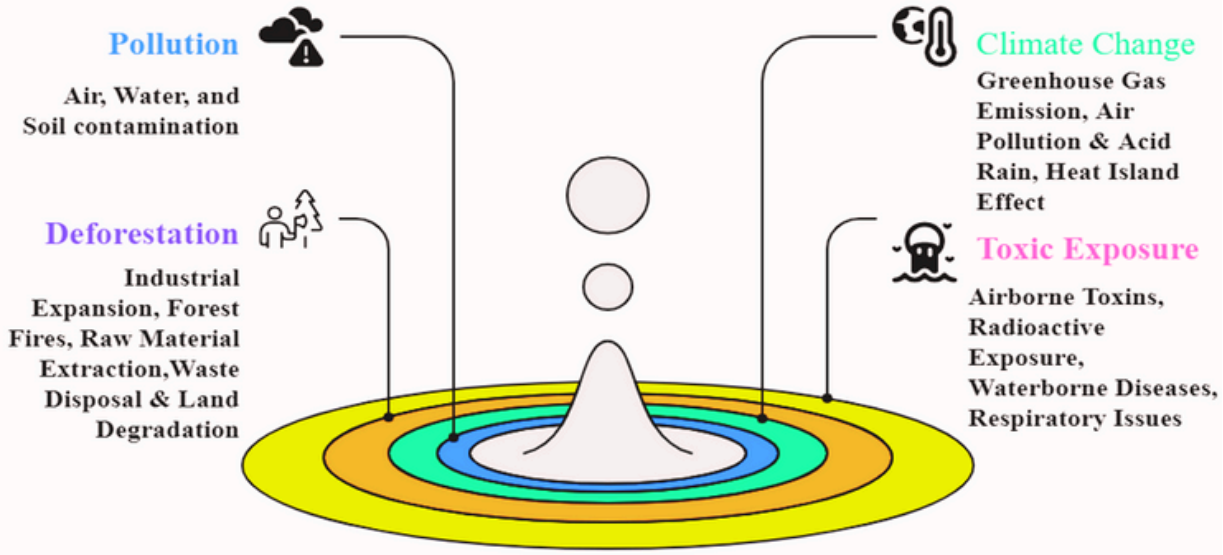
Industrial chemical emissions can contaminate the air and water, leading to ecosystem damage and health hazards

b) Soil Contamination

Heavy metals, pesticides, and hazardous waste disposal can reduce soil fertility and enter the food chain.

c) Bioaccumulation and Bio-magnification

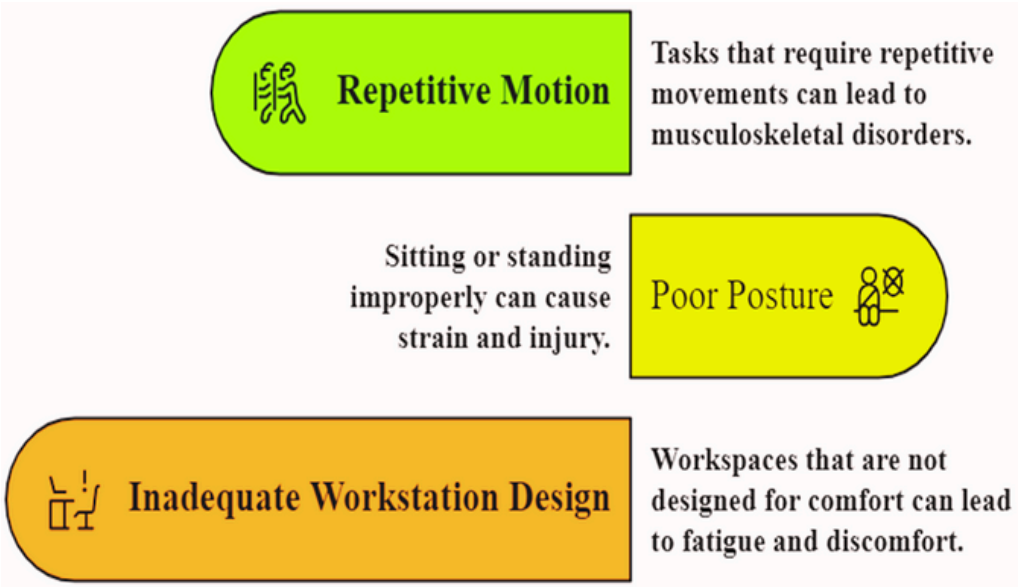
Persistent chemicals (e.g., DDT, PCBs) accumulate in organisms and increase in concentration as they move up the food chain, affecting wildlife and human health.



Environment Impact due to Chemical Hazards

1.7 ERGONOMIC HAZARDS

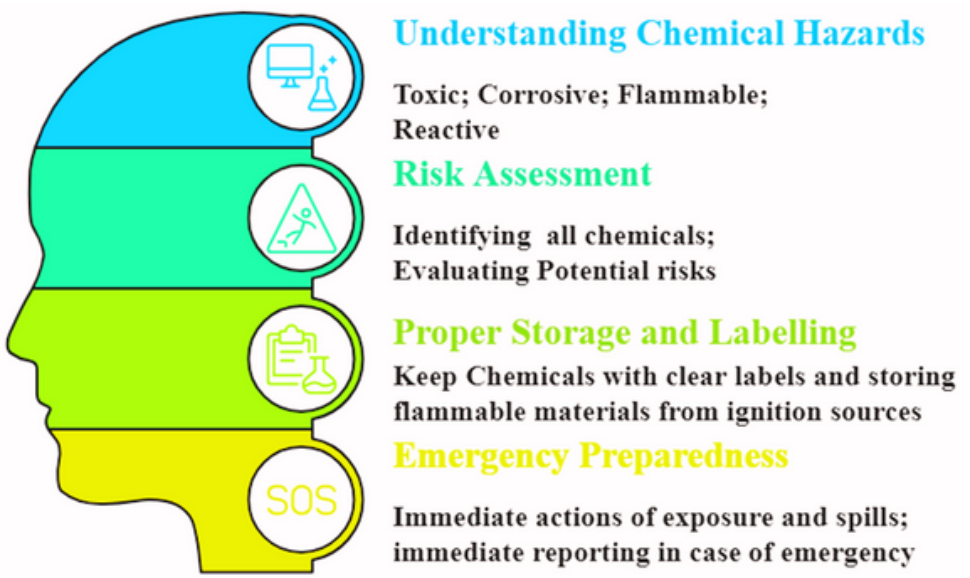
In the chemical industry, ergonomic hazards pose serious risks, particularly musculoskeletal disorders caused by repetitive movements, heavy lifting, and awkward postures. To prevent long-term health issues, industries must adopt ergonomic solutions such as improved workstation design, mechanical lifting aids, and comprehensive worker training, ensuring both safety and productivity.



Ergonomic Hazards

1.8 CHEMICAL SAFETY PROCEDURE: PREVENTING WORKPLACE HAZARDS

Chemical safety in the workplace is essential to protect personnel, prevent environmental damage, and ensure regulatory compliance. Proper safety procedures help mitigate risks associated with hazardous chemicals, including exposure, spills, and accidents. Below are the key steps and measures for ensuring workplace chemical safety.



Chemical Safety Protocols

1.8.1 Establish Written Safety Procedures

- Develop and maintain clear, written operating procedures for handling, storing, and disposing of hazardous chemicals.
- Ensure compliance with national and international safety standards such as the Manufacture, Store, and Import of **Hazardous Chemicals Rule (MSIHC Rules)**, the Central **Motor Vehicle Rule (CMVR Rules)**, the Code **of Safety Standards for Chemicals** published by the Bureau **of Indian Standards (BIS)**, **Central Pollution Control Board norms, and** GHS (Globally Harmonized System of Classification and Labeling of Chemicals).
- Provide personnel with access to **Material Safety Data Sheets (MSDS)** for all hazardous substances.

1.8.2 Risk Assessment & Hazard Control

- Conduct regular risk assessments to identify potential hazards in chemical storage and handling areas.
- Implement a hierarchy of controls to minimize exposure risks.
- Elimination/Substitution—Remove or replace hazardous chemicals with safer alternatives.

- Engineering Controls—Install proper ventilation, fume hoods, and automatic shut-off systems.
- Administrative Controls—Establish strict operating procedures, work permits, and chemical handling protocols.
- Personal Protective Equipment **(PPE)—Provide** necessary protective gear such as gloves, respirators, and eye protection.

1.8.3 Personal Protective Equipment (PPE)

- Ensure all personnel handling chemicals wear appropriate PPE, including:
- Chemical-resistant gloves (nitrile, neoprene, or rubber)
- Safety goggles or face shields
- Protective clothing (lab coats, aprons)
- Respirators for handling volatile or toxic chemicals
- Conduct regular **PPE** inspections and replacements to ensure effectiveness.
- Train employees on the correct usage, storage, and disposal of **PPE**.

1.8.4 Safe Handling & Storage of Chemicals

- Store chemicals in designated, well-ventilated areas with appropriate labeling.
- Separate incompatible substances to prevent dangerous reactions (e.g., acids away from bases, oxidizers away from flammables).
- Use secondary containment systems to prevent leaks and spills.
- Ensure temperature and humidity control in storage areas to prevent decomposition or combustion.
- Implement closed transfer systems to minimize exposure when transferring liquids.

1.8.5 Emergency Preparedness & Response

Install emergency alarms, fire suppression systems, safety showers, and eyewash stations in chemical handling areas.

Develop and train employees on emergency response plans, including:

- Chemical spill containment and cleanup
- Fire-fighting procedures for chemical fires
- First-aid measures for chemical exposure
- Keep spill kits readily available in storage and laboratory areas.

1.8.6 Proper Disposal of Hazardous Waste

- Dispose of chemical waste in compliance with environmental regulations.
- Use designated and labelled containers for hazardous waste collection.
- Segregate different types of waste (flammable, toxic, corrosive, reactive) to prevent dangerous reactions.
- Keep records of waste disposal to track compliance and environmental impact.

1.8.7 Employee Training & Safety Awareness

- Conduct regular safety training programs to educate employees on **chemical hazards**, emergency response, and safe handling procedures.
- Provide instruction on reading and understanding **Material Safety Data Sheets (MSDS)**.
- Encourage a safety-first culture where employees report unsafe conditions and potential hazards.

1.8.8 Incident Reporting & Investigation

- Implement a clear incident reporting system for chemical spills, leaks, and exposure incidents.
- Investigate accidents to determine root causes and take corrective action.
- Maintain detailed records of incidents for future reference and prevention measures.

1.8.9 Routine Inspection & Maintenance

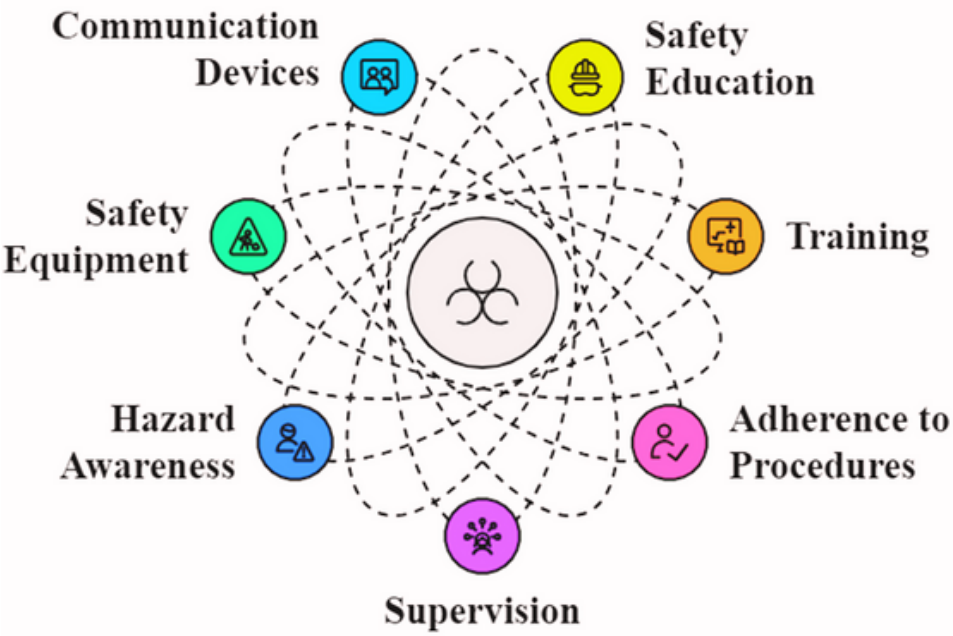
- Conduct regular workplace inspections to identify and correct potential hazards.
- Maintain ventilation systems, fume hoods, and emergency equipment in proper working condition.
- Ensure storage containers, piping, and safety valves are checked regularly for leaks or signs of wear.

CHAPTER 2

STORAGE, HANDLING AND DISPOSAL OF HAZARDOUS CHEMICAL

2.1 WHAT ARE THE GENERAL SAFETY GUIDELINES FOR STORING, HANDLING AND DISPOSAL OF HAZARDOUS CHEMICALS ?

Safety of storage and handling of hazardous chemicals requires comprehensive safety education, rigorous training, strict adherence to established procedures, and vigilant supervision. Personnel must be fully aware of associated hazards and the proper use of safety equipment. The use of standard mobile phones in storage, operation, and handling areas is strictly prohibited; only intrinsically safe communication devices are permitted to mitigate ignition risks.



Safety Protocols

2.2 WHAT ARE THE KEY SAFETY PRECAUTIONS WHEN STORING HAZARDOUS CHEMICALS?

2.3 STORAGE IN BULK

Ensuring a safe and well-maintained storage facility for hazardous chemicals is critical to preventing accidents. The following precautions must be strictly observed:

2.3.1 substituting hazardous chemicals

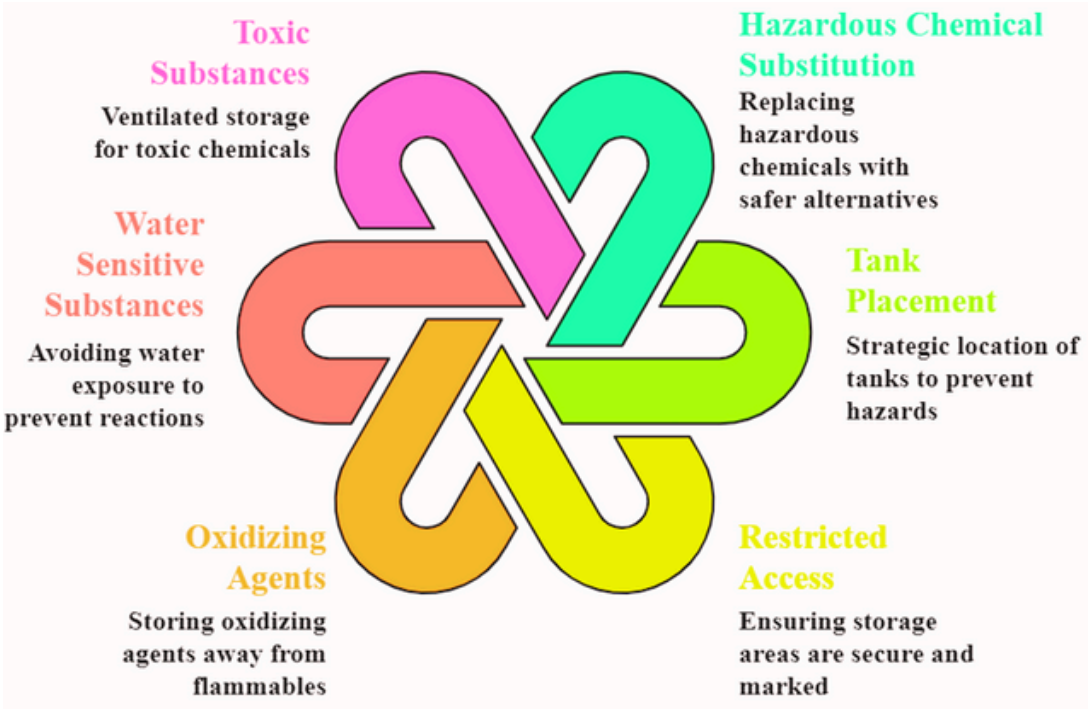
Whenever possible, replace hazardous chemicals with safer alternatives. Maintain the smallest feasible inventory of hazardous substances to minimize risks.

2.3.2 Proper Tank Placement

Storage tanks must be strategically located to prevent safety hazards arising from leaks or chemical reactions with adjacent substances. The surrounding environment should be suitable for the specific chemicals stored.

2.3.3 Restricted Access And Signage

The storage area should be designated as a restricted zone for the following types of chemicals with secure fencing and at least two exit points. Clear warning signs, such as "**No Smoking**" and "**Prohibited Area**," should be prominently displayed to ensure compliance with safety protocols.



Restricted Areas and signage

2.3.3.1 Oxidising Agents

Oxidizing substances must be stored away from all flammable materials even if they are only slightly flammable. Oxidizing material must be kept away from substance which are reducing agents.

2.3.3.2 Water Sensitive Substances

These substances react with water or steam to produce flammable or explosive gases and evolve heat, example concentrated acids like **sulphuric acid, glacial ethanoic acid** etc. **Conc. Alkali like sodium hydroxide** react with **water later to evolve heat**. Such materials must not be stored in areas where water flooding from pipe leakages or leaky roofs can happen.

2.3.3.3 Toxic Substances

These substances must be stored in well ventilated areas, preferably cool and certainly away from direct sun rays. Periodic checks should be organized for all parts of storage areas. Extremely toxic substances like **TEL (Tetra Ethyl Lead)** must be stored separately under strict security.

2.3.3.4 Incompatible Chemicals

Incompatible chemicals should not be stored near each other.

2.3.3.5 Corrosive Chemicals

The flooring of the area where corrosive chemicals are stored, shall be impervious and made of corrosion resistant materials.

2.3.4 Corrosion Prevention

Storage tanks and their foundations should be constructed from corrosion-resistant materials to ensure long-term durability.

2.3.5 Minimal Connections And Openings

Tanks should have the fewest possible openings to reduce the risk of leaks and maintenance-related hazards.

2.3.6 Ventilation And Pressure Relief

Tanks must be equipped with adequately sized vents or relief systems that discharge vapors at a safe height. For chemicals prone to high vapor evolution due to external heating, relief capacity should be assessed accordingly. Where atmospheric release is unsafe, vapors should be routed through a neutralizing system. Flame arrestors must be installed on vents of atmospheric storage tanks containing **Class A chemicals (flash point < 23°C)** and should be easily accessible for routine inspection.

2.3.7 Emergency Evacuation Provisions

Tanks should have a dedicated emergency drainage system to transfer contents to a safe location during incidents such as fire or structural failure. A double isolation valve system (gate and globe valve in series) is recommended on drain lines.

2.3.8 Monitoring And Leak Detection

Storage tanks must be equipped with instruments to monitor level, pressure, and temperature, with remote indications in control rooms or field operator cabins. Any abnormal rise in these parameters should trigger an alarm. Level gauges must be guarded, illuminated, and designed for in-situ cleaning to prevent leakage hazards. Advanced leak detection systems should be in place to promptly identify and alert control rooms of any chemical leaks.

2.3.9 storage tank dyke containment:

The tank should have a dyke of suitable material (compatible with the chemical) of volume equal to the volume of the larger storage tank. The dyke should have facility to:

a) drain off rain water into storm water channel ;
b) route high volume spillage / leakage to suitable neutralizing pit nearby ;
c) discharge safe effluent to oily water system, as applicable.
The isolation valves on dyke drains should be located outside the dyke.

2.3.9.1 Fire Safety

Fire access roads must be provided around storage areas for quick emergency response. Storage tanks should be equipped with suitable fire protection and firefighting systems.

2.3.9.2 Communication Facility

A reliable communication system, such as a public address system or telephones, must be available for coordination with the control room, fire stations, and medical units.

2.3.9.3 Signage & Hazard Identification

Each storage tank should have clear signage displaying the chemical name, hazard type, emergency procedures, antidotes, and first aid instructions.

2.3.9.4 Electrical Safety

All electrical cables and fittings must be properly designed, installed, protected, operated, and maintained to prevent the risk of sparking.

2.4 STORAGE OF CHEMICALS IN DRUMS / OTHER CONTAINER

This section should be read in conjunction with as most of the guidelines for bulk storage also apply to the storage of drums and other containers. In fact, the storage of hazardous chemical liquids in drums presents a greater potential hazard compared to bulk storage due to the following reasons:

(a) Each drum of a cluster of drum can become a source of leakage;

(b) The drums normally being less resistant to fire would collapse faster escalating and spreading of fire to other drums of the stack.

Drums should never be completely filled with liquid chemicals; adequate ullage must be maintained to accommodate thermal expansion.

- Drums should preferably be stored in a well-ventilated shed, ideally away from process units, with an impermeable floor sloping away from the storage area.
- Proper provisions must be in place for the collection and safe disposal of accidental spills.
- Drums should be stacked in a single tier, with the lid positioned as per the manufacturer's recommendations to ensure safe storage.
- Empty drums should be thoroughly cleaned and free of residual contents before being stored in a designated safe area.
- Regular site inspections should be conducted to detect and prevent any leakage from the drums.
- In areas where combustible solid materials are stored, the dust concentration in the air must be maintained below the lower explosive limit. An efficient dust collection system and proper housekeeping practices should be ensured.

2.5 STORAGE OF COMPRESSED GAS CYLINDERS

Apart from the inherent nature of the **chemical gas**, the high-pressure storage of gas cylinders significantly increases the associated hazards. The following guidelines are recommended for the safe storage of gas cylinders:

- Cylinders should be adequately protected from temperature variations and stored in a cool, dry, well-ventilated, and covered area. They must be kept away from steam pipes, furnaces, boilers, or any other heat sources. Cylinders should not be placed near gangways or elevators to prevent impact from hard objects.
- Cylinders containing **flammable gases** and **toxic gases** must be stored separately from each other and from other types of gas cylinders, either by maintaining a safe distance or by using a suitable partition wall.
- Cylinders should be securely stacked to prevent accidental knocking, dropping, or rolling.
- Cylinder nozzles should be adequately protected against damage. Oil or similar lubricants must not be used on valves or other fittings of gas cylinders.
- Cylinders containing liquefied gases, such as liquid nitrogen, should be stored in an upright position to ensure that, in case of a faulty regulator, only gas escapes rather than liquid.
- Cylinder valves must be equipped with security caps on the outlets as an additional safety measure. If a valve leak cannot be rectified by tightening the gland nut or spindle, the affected cylinder should be moved to an open area where it poses minimal risk to life and property, and appropriate remedial actions should be taken.

- Each cylinder should be clearly labelled with: a) The name of the chemical b) The state of the chemical (gas or liquid) c) The pressure of the contents d) The date of filling e) The name and address of the manufacturer or supplier

- The due date for the cylinder's periodic testing must be marked on a metal ring placed between the valve and the cylinder neck. Cylinders with an expired test date must not be used.

- For flammable gases, the storage area should be constructed using non-combustible materials, and all electrical fittings should be flameproof.

- The storage area floor should be elevated above ground level to prevent waterlogging and corrosion. The flooring must remain dry and free from mud.

- Filled and empty cylinders should be properly tagged and stored separately.

- The storage area must be fenced and designated as a Prohibited Area, with NO SMOKING warnings displayed. It should have at least two emergency exits.

- Regular inspections should be conducted to detect leaks in cylinders. Where applicable, automatic gas detectors should be installed at strategic points to trigger an alarm in case of a leak.

- An emergency kit, along with necessary safety protective equipment and clothing, should be readily available near the storage area.

- Adequate and appropriate fire extinguishers must be installed at the site.

- To ensure proper identification, all cylinders must be painted in accordance with Rule 8 of The Gas Cylinders Rules, 1981.

2.6 WHAT ARE THE KEY SAFETY PRECAUTIONS WHEN HANDLING HAZARDOUS CHEMICALS?

2.6.1 Unloading of Tank Trucks / Tank Wagons

a) Before a tanker enters the industry premises, it must be inspected for authorized entry and assessed for its overall condition, including the integrity of the tanker, its contents, and the prime mover. Tankers entering the plant must be equipped with flame arresters on their exhaust systems.

b) The quality of the chemical in the tanker must be verified before unloading to prevent contamination of the chemicals already in storage.

c) For flammable chemicals, the prime mover (engine) must be switched off, and the tanker must be securely immobilized before making any unloading connections.

d) The unloading point for flammable chemicals must be located at a safe distance outside the storage dyke.

e) Pressurizing with air or inert gas for unloading should be avoided. Instead, pumps or vacuum systems should be used. Pumps should preferably be seal-less, and valves should be glandless. Bulk solid chemicals should be handled using lifting machines and conveyors.

f) The coupling used to connect the hose to the tanker must be leak-proof. Flange connections are preferred, and if threaded connections are used, they must be protected against corrosion and wear. Thorough inspection should be conducted before making any connections.

g) The unloading hose must be free from cracks and blisters and capable of withstanding the pressure developed during unloading. It should be hydro-tested at appropriate intervals based on experience, with proper records maintained.

h) The same hose must not be used for unloading different chemicals. Hoses designated for different chemicals should be marked with distinct color stripes for easy identification.

i) For flammable chemicals, both the tanker and the hose must be properly earthed and bonded before commencing the unloading operation.

j) The unloading process must be carried out under the direct supervision of responsible staff authorized by the management.

k) Operating personnel must wear appropriate personal protective clothing and equipment. Suitable breathing canisters and a first aid kit must be readily available at the site in case of an emergency.

l) An ample supply of water or a suitable neutralizing medium must be available to manage any leaks or spills. Additionally, steam and inert gas hose stations must be provided at the unloading point.

m) The unloading site must be well-illuminated, with flame-proof fittings used wherever necessary.

n) The unloading system must include a facility to vent or drain any residual chemicals in the hose to a safe disposal point. When not in use, the hose should be properly blinded. A thermal safety valve discharging to a safe disposal or handling facility should also be installed.

o) Before initiating unloading, the ullage of the receiving tank must be checked to prevent overflow. Gas or chemical leak detection systems should be installed to trigger an alarm at the control room or site, allowing for quick remedial action. Wherever necessary, quick-acting or remote isolation valves should be installed.

p) Fire alarms and firefighting facilities, as specified in the data sheet, must be available at the unloading point and must align with the nature of the chemical being handled.

q) An effective communication system, such as a public address system, telephone, or other means, must be available for immediate contact with the control room, fire station, and health unit.

Safe Unloading

2.6.2 Unloading of Drums / Containers

a) Manual handling of drums / containers should be minimized. It is preferable fork-lifters and suitable cradles are used to handle drums.

b) Carboys containing hazardous chemicals should not be subjected to impact.

c) Suitable protective clothing should be used while handling drums / containers and the operators should position himself such that he is in the upwind direction so that even in case of accidental release of chemical, he is safe.

2.6.3 Handling of Cylinders:

a) The cylinder should be checked for proper markings as listed below, if not in order the cylinder should be returned to the supplier.

a. Owner's / manufacturer's name.
b. Specification to which cylinder has been made.
c. Date of last hydrostatic test and due date for next test
d. Working pressure and test pressure.
e. Tare weight.
f. Water capacity and proper identification colour of the chemical.

b) Cylinders should be unloaded using appropriate mechanical equipment such as a forklift or hoist. Manual handling is not recommended. Valve hoods must not be used as support while unloading.

c) Ensure that the cylinder is free from leaks at the valve or body. It must not be dropped, bumped against another cylinder, or struck against a hard surface.

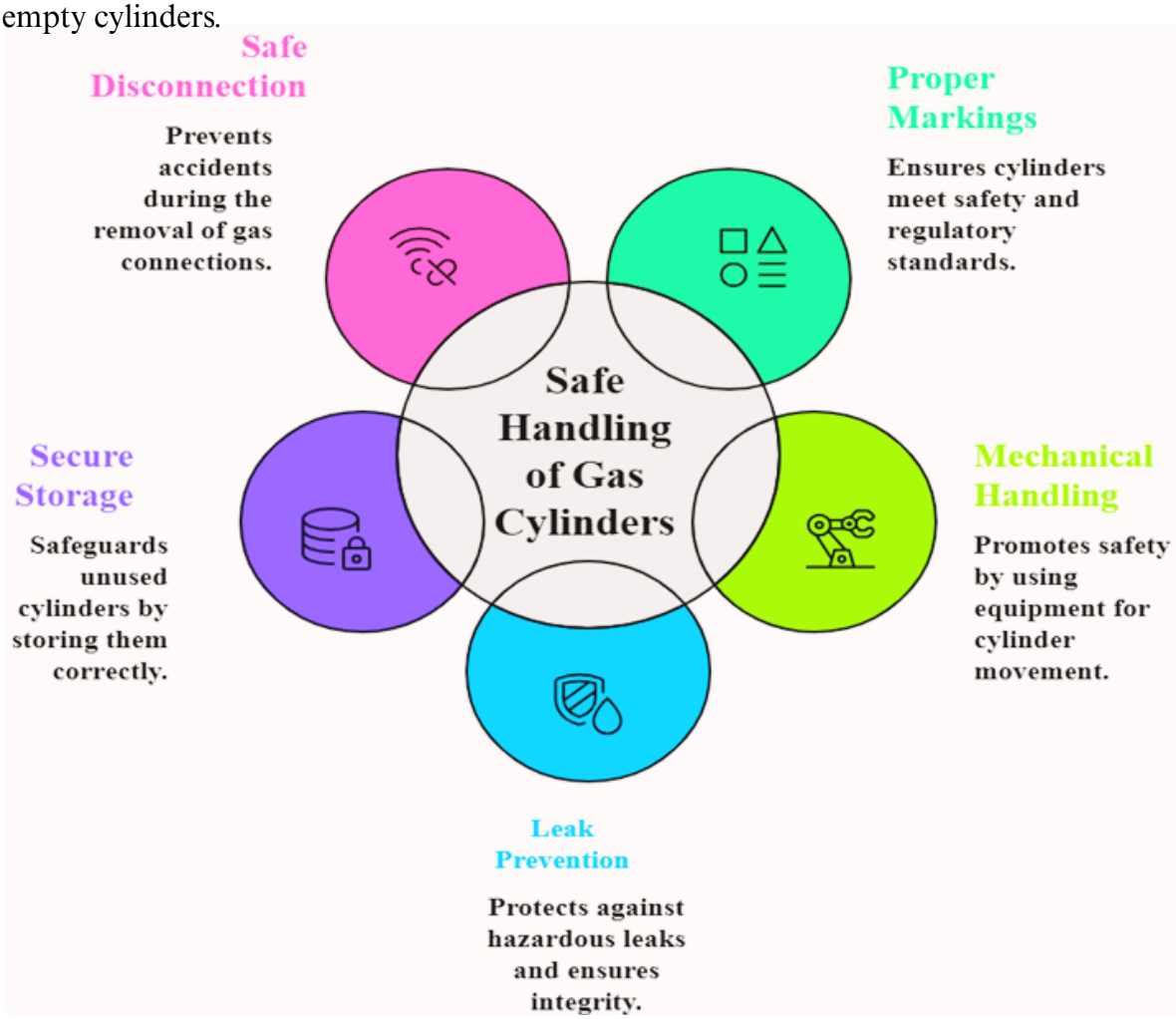
d) If an increased gas flow rate is required, a suitable vaporizer should be used. Direct heating of the cylinder using steam or an open flame is strictly prohibited.

e) A pressure gauge and a flow-measuring device should be used to monitor gas flow accurately.

f) A non-return valve must be installed to prevent backflow of process fluids into a partially empty or empty cylinder.

g) If a cylinder is not required for an extended period, it should be disconnected from the process, completely closed, properly stored, and marked accordingly.

h) Once a cylinder is fully consumed, first close the cylinder valve completely, followed by the process valve. Carefully disconnect the connection, label the cylinder as "Empty," and store it in the designated area for empty cylinders.



Safe Handling of Gas cylinders

2.6.4 Safe Disposal practices for empty hazardous chemical containers

Safe disposal of empty containers of hazardous chemicals should be done based on guidelines given by the manufacturers.

2.7 HOW TO SAFELY DISPOSED EXPIRED HAZARDOUS CHEMICALS ?

The safe disposal of hazardous chemicals with expired shelf life should be carried out in accordance with the manufacturer's guidelines. As a preventive measure, the **First-In, First-Out (FIFO)** approach should be implemented to ensure that chemicals are used before reaching their expiration date.

The following Indian Standards lay down general properties of different **chemical**, the properties of various **chemicals, associated hazards, and essential safety measures, including storage, handling, labelling, transportation, waste disposal, protective equipment, employee training, and first aid**:

SI.No	IS Number	IS Tittle
1	IS 10870 :1984	Code of safety of Hexane
2	IS 10871 : 1984	Code of safety for Hydrzine and Hydrazine hydrate
3	IS 10872 : 2023	Malathion code of safety (first revision)
4	IS 10920 : 1984	Code of safety for Phosphorus Trichloride
5	IS 11141 : 1984	Code of safety for Acrylonitrile
6	IS 12033 : 1986	Code of safety for Dinitrotoluene (dnt)
7	IS 12034 : 1986	Code of safety for methyl bromide
8	IS 12141 : 1987	Code of safety for methyl ethyl ketone
9	IS 12142 : 1987	Code of safety for 1,1,1 - trichloro ethane
10	IS 12143 : 1987	Code of safety for tetrachloroethane
11	IS 13440 : 1992	Methyl chloride - code of safety
12	IS 13441 : 1992	Ethyl ether - code of safety
13	IS 13442 : 1992	Trichloro ethylene - code of safety
14	IS 13447 : 1992	P - nitro aniline - code of safety
15	IS 13910 : 1993	Sulphur dioxide - code of safety
16	IS 13911 : 1993	Sulphur - code of safety
17	IS 13914 : 1993	Perchlorates of ammonium, potassium and sodium - code of safety
18	IS 14165 : 1995	Handling Carcinogenic substances - code of safety
19	IS 14200 : 1994	Hydrogen peroxide - code of safety
20	IS 14518 : 2023	Acetaldehyde - code of safety (first revision)

21	IS 14572 : 2022	Chloroform code of safety (first revision)
22	IS 14631 : 1999	Styrene - code of safety
23	IS 14814 : 2023	Acetylene - code of safety (first revision)
24	IS 14983 : 2022	Phosphorous (white or yellow) - code of safety (first revision)
25	IS 14984 : 2001	1,3 - butadiene - code of safety
26	IS 14985 : 2001	Methyl acrylate and ethyl acrylate - code of safety
27	IS 15200 : 2024	Hydrogen sulphide code of safety (first revision)
28	IS 15201 : 2022	Hydrogen- code of safety (first revision)
29	IS 15548 : 2005	Hydrofluorocarbon - code of safety
30	IS 18099 : 2022	Sodium hypochlorite - code of safety
31	IS 19083 : 2025	Nitrous oxide-code of safety
32	IS 5184 : 1969	Code of safety for hydrofluoric acid
33	IS 5208 : 2024	Acetic acid - code of safety (first revision)
34	IS 5302 : 1969	Code of safety for acetic anhydride
35	IS 5311 : 1969	Code of safety for carbon tetrachloride
36	IS 5685 : 1970	Code of safety for carbon disulphide (carbon bisulphide)
37	IS 5931 (part 5) : 2025	Cryogenic liquid - code of safety part 5 liquid hydrogen (first revision)
38	IS 5931 (part 2) : 2025	Cryogenic liquid - code of safety part 2 liquid nitrogen (first revision)
39	IS 5931 (part 6) : 2025	Cryogenic liquid - code of safety part 6 liquid krypton (first revision)
40	IS 5931 (part 1) : 2025	Cryogenic liquid - code of safety part 1 liquid oxygen (first revision)
41	IS 5931 (part 7) : 2025	Cryogenic liquid - code of safety part 7 liquid neon (first revision)
42	IS 5931 (part 3) : 2025	Cryogenic liquid - code of safety part 3 liquid argon (first revision)

43	IS 5931 (part 4) : 2025	Cryogenic liquid - code of safety part 4 liquid helium (first revision)
44	IS 5931 (part 5) : 1970	Code of safety for handling cryogenic liquids
45	IS 6156 : 1971	Code of safety for Chlorosulphonic acid
46	IS 6164 : 2023	Hydrochloric acid code of safety (first revision)
47	IS 6269 : 1971	Code of safety for Ethylene oxide
48	IS 6270 : 2024	Phenol code of safety (first revision)
49	IS 6818 : 1973	Code of safety for Phosphoric acid
50	IS 6819 : 1973	Code of safety for Calcium carbide
51	IS 6953 : 1973	Code of safety for Bromine
52	IS 6954 : 1973	Code of safety for Caustic Potash
53	IS 7415 : 1974	Code of safety for Aniline
54	IS 7420 : 1974	Code of safety for Phthalic Anhydride
55	IS 7444 : 1974	Code of safety for Methanol
56	IS 7445 : 2022	Acetone code of safety (first revision)
57	IS 7812 : 1975	Code of safety for mercury
58	IS 8185 : 1976	Code of safety for phosgene
59	IS 8388 : 1977	Code of safety for nitrobenzene
60	IS 9052 : 1978	Code of safety for aluminium chloride, anhydrous
61	IS 9053 : 1978	Code of safety for m - dinitrobenzene
62	IS 9277 : 1979	Code of safety for monochlorobenzene
63	IS 9278 : 1979	Code of safety for zinc phosphide
64	IS 9279 : 2023	Aluminium phosphide - code of safety (first revision)
65	IS 9744 : 1981	Code of safety for thionyl chloride
66	IS 9785 : 1981	Code of safety for aluminium alkyls
67	IS 9786 : 1981	Code of safety for vinyl chloride (vcm)
68	IS 9787 : 1981	Code of safety for phosphoryl chloride

CHAPTER 3

LABORATORY SAFETY IN THE CHEMICAL INDUSTRY: BEST PRACTICES AND PROTOCOLS

3.1 RULE OF CONDUCT FOR LABORATORY

Laboratory safety requires strict adherence to rules prohibiting smoking, intoxication, and unsafe activities, while ensuring proper hygiene, housekeeping, and emergency preparedness. Safe handling of chemicals, gas cylinders, and waste, along with clear **SOPs** and regular safety checks, is essential to prevent accidents and maintain a secure working environment.

Rule of Conduct for Laboratory

3.1.1 Prohibited activities and Personal Conduct

- Smoking is strictly prohibited in all laboratory areas except those specifically designated for it. This prevents fire hazards and contamination risks.
- Intoxication at work is forbidden and is considered a serious violation of workplace safety protocols. Individuals reporting to work under the influence of alcohol or drugs will face disciplinary action.
- Unsafe activities that compromise safety should be strictly avoided. This includes reckless behavior, horseplay, or unauthorized experimentation that may put individuals or equipment at risk.

3.1.2 Working Conditions and Personal Safety

- Working alone in a laboratory should be avoided. A second person must always be within calling distance in case of emergencies.
- Handling or consuming food or drinks in the laboratory is not permitted. This helps prevent chemical contamination and accidental ingestion of hazardous substances.
- Maintaining good personal hygiene is crucial. This includes washing hands thoroughly before eating, drinking, or leaving the lab. In cases where chemicals may linger on the skin, a full-body wash at the end of the shift is advisable.

3.1.3 Housekeeping and Organization

- Good housekeeping is a key component of laboratory safety. Proper organization helps reduce the risk of spills, contamination, and accidents. Best practices include:
    - Storing equipment and materials in their designated locations.
    - Clearly labeling all chemicals to prevent mix-ups.
    - Keeping laboratory floors free of obstructions and trip hazards.

3.1.4 Fire Safety and Emergency Preparedness

- Fire extinguishers must be installed near every laboratory. These should be checked periodically to ensure they are functional and accessible.
- All laboratory personnel should be familiar with the location and operation of fire extinguishers.
- Emergency procedures should be prominently displayed, including contact numbers for:
    - Fire brigade
    - Ambulance services
    - Laboratory supervisor/safety coordinator
    - Nearest hospital
- In case of fire, the use of lifts is strictly prohibited. Stairs must be used for evacuation.

3.1.5 Handling of Hazardous Substances

- All substances should be treated as potential hazards and handled with care to prevent exposure and contamination.
- Spills must be cleaned immediately and thoroughly to avoid accidents and chemical reactions. The appropriate spill response procedure should be followed based on the nature of the spilled substance.
- Glass or plastic containers of two liters or more must be transported in safety carriers.
- Incompatible chemicals should never be transported together. Separate carriers should be used to prevent dangerous reactions.

3.1.6 Gas Cylinder Storage and Handling

- Gas cylinders must never be dragged while being transported. They should be moved using appropriate trolleys and always kept upright.
- Cylinders should be securely chained or fastened to prevent tipping over.
- When stored, the valve cap should always be in place. This prevents accidental gas leaks.
- Pressure regulators specific to the gas must be used. Improper regulators can cause leaks or dangerous pressure build-ups.
- Liquid oxygen must never be used as a substitute for liquid nitrogen. This is due to differences in boiling points and chemical reactivity, which could lead to hazardous situations.
- A designated material lift must be used for transporting dry ice and liquid nitrogen.

3.1.7 Accident Reporting and Investigation

- All injuries, regardless of severity, must be reported to the supervisor and safety coordinator. Prompt first aid should be provided.
- All accidents and near-misses must be documented and investigated. This ensures preventive measures can be implemented to avoid recurrence.
- Unsafe conditions and unsafe acts by personnel should be immediately reported to the supervisor. This proactive approach enhances workplace safety.

3.1.8 Waste Management and Disposal

- Broken glass should be disposed of in separate containers. Mixing it with other waste like paper or rubber can cause injuries during disposal.
- Chemical waste must be segregated and disposed of according to approved protocols. Each laboratory should maintain a waste management plan to ensure safe disposal practices.

3.1.9 Standard Operating Procedures (SOPs) and Safety Documentation

- A comprehensive laboratory safety manual must be available. This should outline all safety protocols, emergency procedures, and best practices.
- Standard Operating Procedures (SOPs) must be documented and followed for all laboratory activities. This ensures consistency in safety and operational efficiency.
- Regular inspections of laboratory equipment and emergency facilities (such as fire extinguishers, safety showers, eyewash stations, and first-aid kits) should be conducted, and records of these inspections should be maintained.

3.1.10 Emergency Protocols

- All exits must be kept clear of obstructions to facilitate quick evacuation in case of an emergency.
- During fire emergencies, the designated emergency procedures must be followed, and the safety coordinator must be notified.
- In the event of a chemical exposure, the affected person should be taken to the nearest safety shower or eyewash station immediately, and medical assistance should be sought.

3.2 WORKING WITH CHEMICALS

Proper handling and storage of chemicals are essential to prevent hazards such as explosions, corrosion, or poisoning. Safety measures include using protective equipment, ensuring proper labeling, preventing spills, and following handling precautions. Chemicals should be stored based on compatibility, and volatile substances must be handled with care. Additionally, transferring chemicals requires proper labeling and secure handling to maintain safety.

List of working with Chemicals

3.2.1 Most of the chemicals could be regarded as hazardous and could be explosive, corrosive, flammable or a poison under certain circumstances.

3.2.2 Always use the safety appliances recommended while handling chemicals and avoid skin contact with chemical substances.

3.2.3 Chemicals should only be used when the drums, sacks, containers or pipelines containing them are clearly labelled and their identity confirmed. In case of doubt, or when a mix-up has actually occurred, inform supervisor immediately.

3.2.4 Avoid spillage of chemicals by careful handling. Keep suitable materials to chemically treat spillage, or physically containing if necessary.

3.2.5 Ensure that the clips/clamps are properly fixed while transferring chemicals through rubber, PVC or teflon hoses.

3.2.6 It is advisable to keep a water hose close by, whenever a chemical's transfer through drums, carboys, etc, is being performed (not in case of water sensitive chemicals).

3.2.7 Chemicals storage must always be done after considering their compatibility. Once a place for storing a particular chemical is fixed, it should not be altered without purpose.

3.2.8 Observe precautions concerning handling of chemicals as given in 3.2 and use safety equipment.

3.2.9 The containers of chemicals that are highly volatile or decompose or are moisture sensitive should be carefully opened and isolated from the surrounding.

3.2.10 whenever chemicals are transferred from old containers to new containers, all relevant details should be transferred to labels on new containers.

3.2.11 Low temperature (cryogenic) liquids like liquid nitrogen, liquid oxygen, dry ice, etc, are also commonly used in laboratories. The hazards associated with the handling of cryogenic liquids are,

a) Cold 'burns' to the person;
b) Explosions due to the vapourization of liquefied gas into an enclosed space;
c) Explosions due to chemical reaction or condensation of air;
d) Asphyxiation due to exclusion of oxygen/air; and
e) Oxygen enrichment of the surrounding atmosphere in case of liquid oxygen.

Always handle low temperature **(cryogenic) liquids** in **well-ventilated areas** to prevent excessive concentration of gas. Excessive amounts of liquid cryogens except liquid oxygen reduce the concentration of oxygen and can cause suffocation/ asphyxiation in a confined space. Portable oxygen detectors should be available with personnel associated with handling of **cryogenic liquids**. Personnel, including rescue workers, should not enter areas where oxygen concentration is below **19.5 per cent**, unless provided with self-contained breathing apparatus or airline respirator. No oil and grease shall be present on clothing or equipment when working with or around liquid cryogens especially liquid oxygen.

Skin contact with cryogenic liquids should be avoided as serious cold burns may occur. Care must be taken with gloves, wristbands or bracelets, which may trap liquid cryogen close to the skin. Do not carry liquid cryogens in an open Dewar on any elevator.

3.3 GENERAL LABORATORY TECHNIQUES

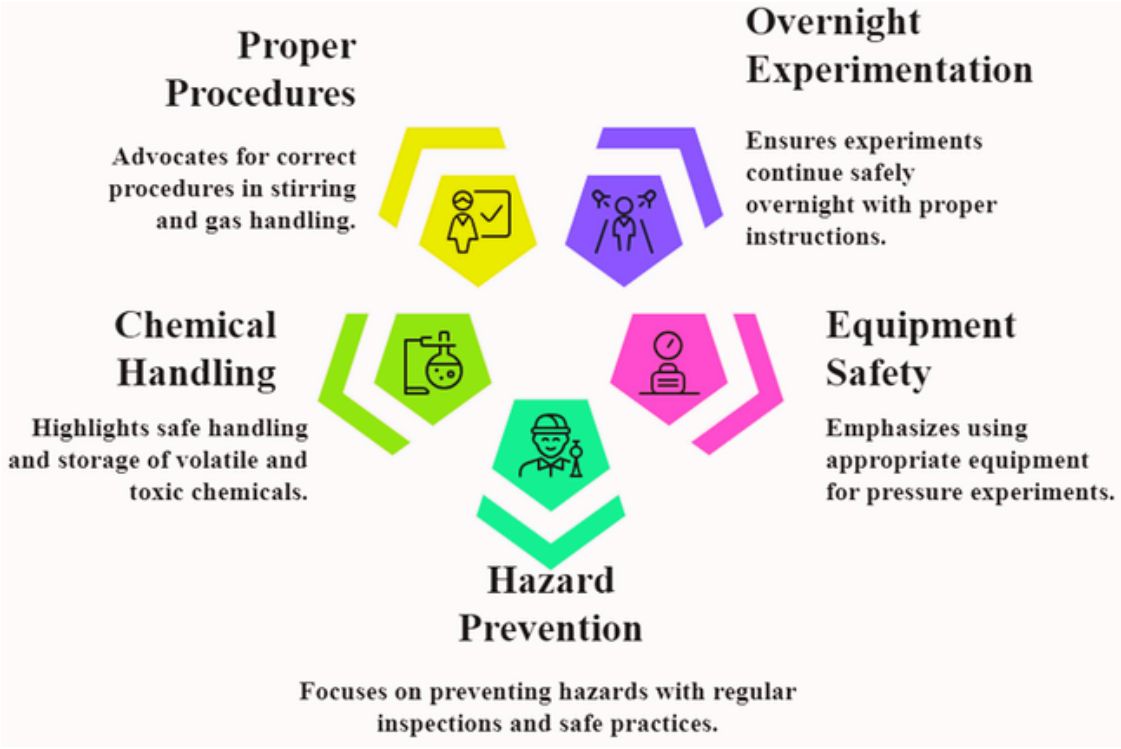
3.3.1 If it is necessary to continue an experiment overnight, leave precise and adequate information to night shift assistants or security staff.

3.3.2 Use proper equipment for experiments carried out under reduced or elevated pressure.

3.3.3 Vacuum flasks and desiccators should be regularly checked for signs of damage.

3.3.4 All experiments involving use of toxic chemicals should be carried out in a fume cupboard.

3.3.5 Use a cloth for protection when inserting glass tubing, rods or thermometers into bungs or tubing. Use a lubricant, wherever necessary.



Laboratory Techniques

3.3.6 Compressed gas cylinders, when standing upright, should always be properly supported. Never connect a gas cylinder directly to the apparatus, always interpose a system of traps. Always turn off a gas cylinder at the main valve after use and release any excess pressure in the regulator.

3.3.7 It is to be ensured that condenser tubing does not become trapped. Make sure that all rubber connections to a condenser are well secured.

3.3.8 Highly volatile/inflammable chemicals should not be stored indefinitely inside refrigerator, unless suitably modified by removing the bulb and the thermostat outside the refrigerator cabinet. On no account must any food or drink be kept in laboratory refrigerators.

3.3.9 Labels on reagent bottles should not be altered or tampered with.

3.3.10 Nitrogen should be preferred to air on all capillary bleeds as a large number of organic substances oxidize at high temperatures.

3.3.11 Use proper stirring system after taking the volume of the flask into account.

The following **Indian Standards** provide guidelines for testing laboratories to **ensure safety, compliance, and risk management** in **chemical, Radioactive and Microbiological labs**. Adhering to these standards helps identify hazards, enforce safety protocols, and implement preventive measures effectively.

S.No	IS Number	IS Tittle
1	IS 4209 : 2013	Chemical laboratories - Code of safety (Second Revision)
2	IS 12035 : 1986	Code of Safety in Microbiological Laboratories
3	IS 4906: 2017	Radiochemical Laboratory - Code of Safety (First Revision)

मानकः पथप्रदर्शकः

CHAPTER 4

PERSONNEL PROTECTIVE EQUIPMENTS

4.1 WHAT ARE PERSONNEL PROTECTIVE EQUIPMENTS ?

Personal protective equipment (PPE) is essential for minimizing exposure to workplace hazards that can cause serious injuries or illnesses. These hazards may arise from chemical, radiological, physical, electrical, or mechanical sources. Common PPE includes gloves, safety glasses, protective footwear, ear protection, hard hats, respirators, and full-body suits.

4.2 OPTIMIZING WORKPLACE SAFETY: EFFECTIVE USE OF PPE AND PROTECTIVE MEASURES

To maximize safety, PPE should be well-designed, durable, and maintained in a clean and reliable condition. Proper fit is crucial, as ill-fitting equipment can compromise protection and discourage usage. When engineering, administrative, or work practice controls are insufficient to eliminate risks, employers must provide appropriate PPE and ensure its correct usage. Additionally, comprehensive training must be given to workers on the proper selection, use, and maintenance of PPE to enhance workplace safety.

Personnel working in environments with high levels of dust exposure should wear protective goggles to safeguard their eyes and use appropriate respiratory equipment, such as dust masks, to prevent inhalation of harmful particles. In hot weather conditions, the application of protective creams or water-repellent ointments can help minimize skin irritation, particularly for individuals prone to such reactions. These protective measures are especially beneficial around areas like the neck and wrists, where friction and moisture can worsen irritation when exposed to substances like calcium carbide dust. However, it is important to note that while these creams or ointments provide some relief, they should not be considered a replacement for maintaining proper personal hygiene and following safety protocols.

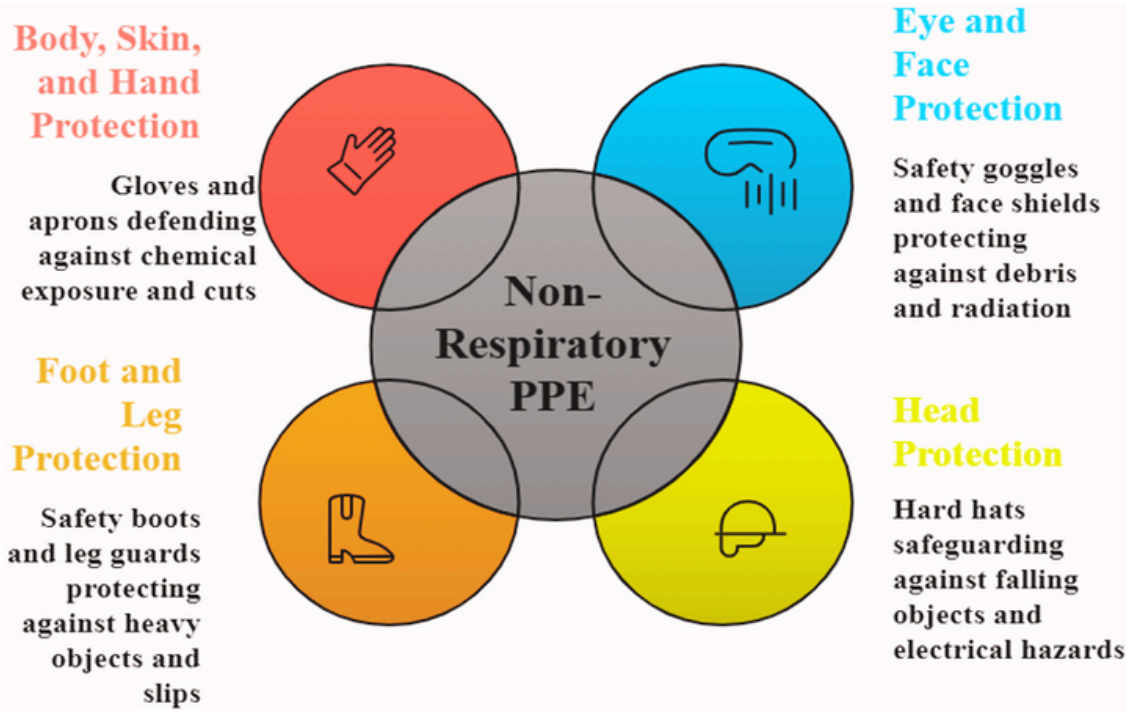
4.3 ESSENTIAL CATEGORIES OF PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal Protective Equipment (PPE) is broadly classified into two categories:

Personal Protective Equipment (PPEs)

4.4 NON-RESPIRATORY EQUIPMENT

This includes eye and face protection, head protection, foot and leg protection, body, skin and hand protection, which safeguard against physical, chemical, mechanical, and electrical hazards.



Major Non-Respiratory Equipment

4.4.1 Head Personnel Protective Equipment

Ensuring **proper head protection** is essential in the chemical process industry to prevent injuries caused by **falling objects, impact hazards, electrical risks, and chemical exposure**. As per the Bureau of Indian Standards (BIS), **IS 2925:1984** governs industrial safety helmets, ensuring they meet safety criteria such as impact **resistance, penetration resistance, flame retardancy, and electrical insulation.**

Types of Safety Helmets as per Indian Standards

- **Industrial Safety Helmets (IS 2925)**
  - Designed for impact and penetration protection in hazardous work environments.
- **Electrical Safety Helmets (IS 8521 (Part 1) & (Part 2))**
  - Protect against electrical hazards, with insulation properties up to 20,000V for high-voltage applications.
- **Firefighter Helmets (IS 2745)**
  - Heat-resistant helmets suitable for fire-related emergencies in chemical plants.
- **Bump Caps**
  - Suitable for workplaces with minor head injury risks but not compliant with **IS 2925** for impact protection.

By adhering to **Indian Standards**, employers in the chemical process industry can ensure **worker safety**, reducing risks from **falling objects, chemical splashes, and electrical hazards.**

Head Personnel Protective Equipment

4.4.2 Eyes and Ears Protective Equipment

Workers in the chemical process industry face significant risks to their eyes and ears due to exposure to **toxic gases, corrosive chemicals, splashes, radiation, and high noise levels**. According to **Indian safety regulations**, including **BIS (Bureau of Indian Standards) IS 5983 and IS 8520**, employers must provide appropriate **Personal Protective Equipment (PPE)** to mitigate these risks.

4.4.3 Eye Protection

Proper eye protection is critical to prevent injuries from chemical splashes, fumes, and hazardous light radiation. Workers must use **chemical-resistant safety goggles, face shields, or safety spectacles** based on the nature of their work. Key considerations include:

- **Chemical-Resistant Goggles (IS 5983)**
  - For protection against liquid splashes and gas exposure.
- **Face Shields (IS 8521)**
  - For comprehensive protection against corrosive chemical splashes.
- **Welding Shields With Appropriate Filter Lenses (IS 1179)**
  - For protection against radiant energy in high-temperature operations.
- **Laser Safety Goggles**
  - For workplaces using laser-based processes.

Prescription lens users should wear specially designed **safety goggles or over-the-glass (OTG) protection** to ensure clear vision without compromising safety.

Eye Personnel Protective Equipment

4.4.4 Ear Protection

High noise levels in chemical plants, caused by machinery, pumps, compressors, and reactors, can lead to hearing loss and long-term health issues. As per **IS 6229**, hearing protection must be provided in areas where noise levels exceed **85 dB(A)**. Options include:

- **Earplugs (IS 9167)**
  - Disposable or reusable, suitable for moderate noise exposure.
- **Earmuffs (IS 6229)**
  - Ideal for high-noise areas with continuous exposure.
- **Helmet-mounted hearing protectors**
  - For integrated head and ear safety.

All protective equipment should be durable, comfortable, resistant to chemical degradation, and compliant with **BIS standards**. Regular maintenance, fit testing, and worker training ensure optimal protection and long-term safety compliance in the chemical process industry.

Ears Personnel Protective Equipment

4.4.5 Foot and Leg Protective Equipment

In the chemical process industry, foot and leg protection is essential to safeguard workers from chemical exposure, heavy objects, molten metal splashes, and electrical hazards. According to **Indian Standards (IS 15298: 2016** - Personal Protective Equipment for Foot Protection), safety footwear must meet stringent impact resistance, anti-slip, chemical resistance, and electrical safety requirements.

Key Protective Footwear for Chemical Industries

- **IS 15298 (PART 1-4)**
  - Covers general and specialized safety footwear standards
- **Reinforced Safety Shoes**
  - Protect against heavy objects, punctures, and compression
- **Chemical-Resistant Boots**
  - Made from **PVC, rubber**, or specialized materials to prevent chemical penetration.
- **Heat-Resistant Footwear**
  - Suitable for high-temperature environments like refineries and metal processing plants.
- **Electrical Safety Shoes (IS 15298-4)**
  - Designed for protection against electrical hazards.
- **Anti-Static & Conductive Footwear**
  - Prevents static charge buildup in environments with flammable chemicals.

By adhering to **IS 15298**, employers in chemical industries can significantly reduce risks associated with chemical exposure, impact hazards, and electrical accidents, ensuring a safe working environment for employees.

Foot and Leg Personnel Protective Equipment

4.4.6 Gloves

Workers in the chemical process industry are exposed to chemical burns, abrasions, cuts, punctures, and electrical hazards. To ensure safety, protective hand and arm equipment must comply with Indian Standards such as **IS 4770:1991 (Rubber Gloves for Electrical Purposes)** and **IS 15331:2003 (Protective Gloves for Industrial Use)**.

Types Of Protective Gloves As Per Indian Standards

- **Chemical-Resistant Gloves (IS 15331:2003)**
  - Made from nitrile, neoprene, butyl, or latex, providing protection against corrosive chemicals, acids, and solvents.
- **Heat-Resistant Gloves**
  - Aluminized and aramid fiber gloves protect against extreme heat, making them essential for chemical reactors, refineries, and furnace operations.
- **Cut and Abrasion-Resistant Gloves**
  - Leather, metal mesh, and reinforced fabric gloves protect against sharp objects, mechanical hazards, and rough materials.
- **Electrical Insulating Gloves (IS 4770)**
  - Required for handling electrical equipment in chemical plants, preventing electrical shocks.
- **Anti-Static Gloves**
  - Designed for static-sensitive environments, reducing the risk of electrostatic discharge in volatile chemical handling.

By adhering to **IS 4770, IS 15331**, and other Indian safety regulations, the chemical process industry can ensure worker safety, regulatory compliance, and improved workplace hazard management.

Gloves

4.4.7 Body Protective Equipment

Body protective equipment is essential in the chemical process industry to safeguard workers from hazardous chemical exposure, extreme temperatures, and mechanical risks. Protective clothing must comply with **BIS (Bureau of Indian Standards)** guidelines to ensure resistance against chemical splashes, thermal hazards, and toxic substances.

- **Chemical-Resistant Protective Clothing**

Designed for handling corrosive substances, toxic chemicals, and hazardous liquids, ensuring impermeability, durability, and comfort. Materials such as **neoprene, rubber-coated fabrics, and PVC-coated textiles** provide superior resistance to chemical penetration and degradation.

- **Heat and Flame-Resistant Workwear**

Essential for environments where workers face high temperatures, fire hazards, or molten chemical splashes. **IS 15748:2022** specifies requirements for flame-resistant protective clothing used in industries involving chemical processing, petrochemicals, and hazardous material handling.

- **High-Visibility and Anti-Static Clothing**

Critical in chemical plants and explosive atmospheres, ensuring workers are visible in low-light conditions and preventing electrostatic discharge, which could ignite volatile chemicals. **IS 15744:2021** outlines standards for high-visibility warning garments.

Ensuring proper selection, maintenance, and adherence to **Indian safety standards** enhances worker **protection, regulatory compliance, and operational safety in the chemical process industry.**

Body Protective Equipment

The following **Indian Standards** lay down test methods evaluate non-respiratory protective devices, excluding escape and diving apparatus, for occupational use in environments with low risk. Compliance is verified through rigorous laboratory and practical performance testing.

S.No	IS Number	IS Tittle
1	IS 8940 : 1978	Code of practice for maintenance and care of industrial safety equipment for eye and face protection
2	IS 8521 (Part 2) : 2022	Eye and face protection for occupational use : Part 2 Additional requirements for mesh protectors (First Revision)
3	IS 2925 : 1984	Specification for industrial safety helmets
4	IS 8521 (Part 3) : 2025	Eye and Face Protection for Occupational Use Part 3 Additional Requirements for Protectors Used During Welding and Related Techniques
5	IS 7524 (Part 2) : 2021	Eye and face protection - Test methods : Part 2 Physical optical properties (Second Revision)
6	IS 7524 (Part 1) : 2021	Eye and face protection - Test methods : Part 1 Geometrical optical properties (Second Revision)
7	IS 8521 (Part 1) : 2022	Eye and face protection for occupational use : Part 1 General requirements (First Revision)
8	IS 8520 : 2023	Eye and face protection Guidance on selection, use, and maintenance (First Revision)
9	IS 7524 (Part 4) : 2021	Eye and face protection - Test methods : Part 4 Headforms
10	IS 7524 (Part 3) : 2021	Eye and face protection Test methods Part 3 Physical and mechanical properties
11	IS 10592 : 2018	Industrial Emergency Showers, Eye and Face Fountains and Combination Units - Specification (First Revision)
12	IS 6229 : 1980	Method for Measurement of Real - Ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs (First Revision)
13	IS 9167 : 1979	Specification for ear protectors
14	IS 10667 : 2025	Selection of Industrial Safety Equipment for Protection of Foot and Leg - Guide (First Revision)

15	IS 8519 : 2024	Guide for Selection of Occupational Protective Clothing Body Protection (Selection, Care, and Maintenance) (First Revision)
16	IS 6994 (Part 1) : 2021	Protection of Arms and Hands Part 1 Protective Gloves against Dangerous Chemicals and Micro-organisms-Terminology and performance requirements for chemical risks (First revision)
17	IS 6994 (Part 2) : 2021	Protection of Arms and Hands Part 2 Protective Gloves against Dangerous Chemicals and Micro-organisms- Determination of resistance to penetration
18	IS 6994 (Part 4) : 2021	Protection of Arms and Hands Part 4 Protective Gloves against Dangerous Chemicals and Micro-organisms- Determination of resistance to degradation by chemicals
19	IS 6994 (Part 5) : 2021	Protection of Arms and Hands Part 5 Protective Gloves against Dangerous Chemicals and Micro-organisms - Terminology and performance requirements for micro-organisms risks
20	IS 6994 (Part 6) : 2021	Protection of Arms and Hands Part 6 Protective gloves against mechanical risks
21	IS 6994 (Part 7) : 2021	Protection of Arms and Hands Part 7 Protective Gloves – General requirements and test methods
22	IS 15748 : 2022	Protective clothing - Clothing to protect against heat and flame - Minimum performance requirements (first revision)
23	IS 16890 : 2024	Textiles - Protective Clothing for Firefighters - Specification (First revision)
24	IS 16874 : 2018	Textiles - Protective gloves for firefighters - Specification
25	IS 15809 : 2017	High visibility warning clothes – Specification (first revision)
26	IS 18849 : 2024	Textiles - Workwear for cement workers - Specification
27	IS 16655 : 2017	Textiles - Protective clothing for use in welding and allied processes
28	IS 15298 (Part 1) : 2024	Personal protective equipment part 1 test methods for footwear (third revision)
29	IS 15298 (Part 2) : 2024	Personal protective equipment part 2 safety footwear (ISO 20345 : 2021, mod) (third revision)

30	IS 15298 (Part 3) : 2024	Personal protective equipment part 3 protective footwear (ISO 20346 : 2021, mod) (third revision)
31	IS 15298 (Part 4) : 2024	Personal protective equipment part 4 occupational footwear (ISO 20347 : 2021, mod) (third revision)
32	IS 15298 (Part 5) : 2004	Safety, protective and occupational footwear for professional use: Part 5 additional requirements and test methods
33	IS 15298 (Part 6) : 2004	Safety, protective and occupational footwear for professional use: Part 6 additional specifications for safety footwear
34	IS 15298 (Part 7) : 2004	Safety, protective and occupational footwear for professional use: Part 7 additional specifications for protective footwear
35	IS 15298 (Part 8) : 2004	Safety, protective and occupational footwear for professional use: Part 8 additional specification for occupational footwear
36	IS 1989 (Part 2) : 1986	Specification for leather safety boots and shoes: Part 2 for heavy metal industries (Fourth Revision)
37	IS 11226 : 1993	Leather safety footwear having direct moulded rubber sole specification (First Revision)
38	IS 14544 : 2022	Leather safety and protective footwear with direct moulded polyvinyl chloride pvc sole - specification first revision
39	IS 5557 (Part 1) : 2024	All Rubber Gum Boots and Ankle Boots Part 1 Safety and Protective (Fifth Revision)
40	IS 5557 (Part 2) : 2018	All rubber gum boots and ankle boots: Part 2 occupational purposes
41	IS 12254 : 2021	Polyvinylchloride (p v c) industrial boots - specification (second revision)

4.5 WHAT IS RESPIRATORS?

A respirator is a protective device designed to shield the wearer from hazardous atmospheres by covering the nose and mouth or the entire face or head. Based on their fit, respirators can be tight-fitting, such as half masks that cover the mouth and nose or full face pieces that extend from the hairline to below the chin, or loose-fitting, like hoods or helmets that fully enclose the head. They are also categorized into two major types based on function: air-purifying respirators, which filter contaminants from the surrounding air, and atmosphere-supplying respirators, which provide clean, breathable air from an uncontaminated source. Generally, atmosphere-supplying respirators are used in more hazardous environments where air-purifying respirators may not offer sufficient protection.

4.6 WHY RESPIRATORS PROTECTION MATTER ?

In India, workplace exposure to harmful airborne contaminants, toxic chemicals, and oxygen-deficient environments poses significant health risks, including respiratory diseases, lung impairment, cancer, and even death. According to occupational health data, a substantial number of workers across various industries are vulnerable to respiratory hazards, making it essential to implement effective protective measures. While engineering and administrative controls, such as exhaust ventilation and substitution of toxic materials, play a crucial role in minimizing exposure, they are not always sufficient. In such cases, respirators become necessary to safeguard worker health.

Employers must provide appropriate respiratory protection based on workplace hazards and the Permissible Exposure Limit **(PEL)** of contaminants. Selecting the right type of respirator—whether Disposable Respirators, reusable Air-Purifying Respirators **(APR)**, Powered Air-Purifying Respirators **(PAPR)**, Supplied Air Respirators **(SAR)**, or Self-Contained Breathing Apparatus **(SCBA)**—is crucial for ensuring worker safety. Additionally, atmosphere-supplying respirators are essential in oxygen-deficient environments to prevent symptoms such as increased breathing rates, elevated heart rates, and impaired cognitive function, which can be particularly dangerous during high-risk tasks like operating machinery or working at heights.

With millions of workers' lives at stake, safety managers must ensure that respirators are not only effective but also comfortable for prolonged use. Compliance with **Indian occupational health and safety standards** is vital to ensuring workers receive the highest level of protection. Understanding the different types of respirators, their configurations, and the appropriate situations for their use can help employers create safer work environments, especially when engineering and administrative controls alone are inadequate.

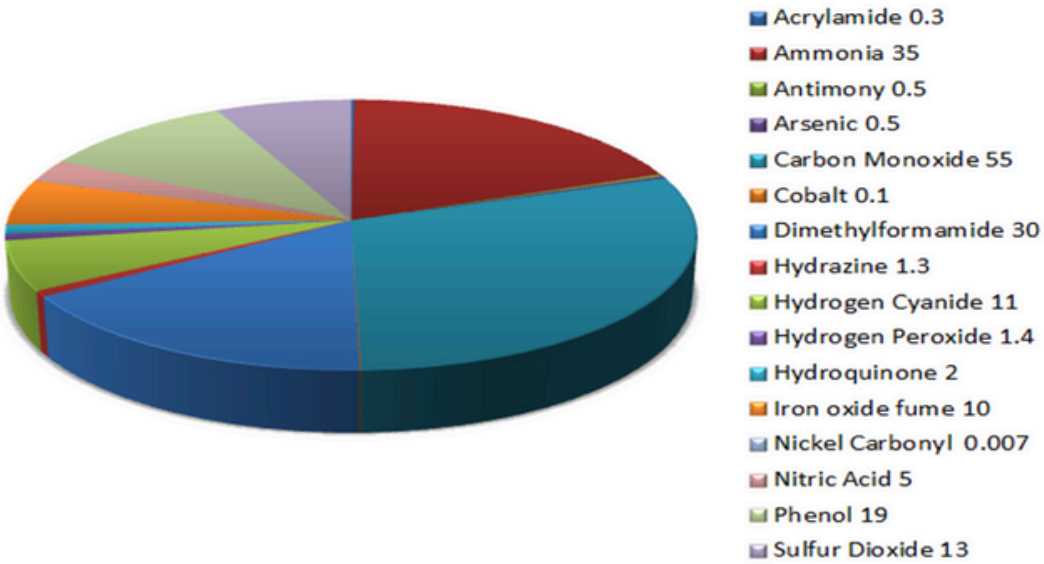
4.7 WHAT ARE THE CONCENTRATION LEVELS FOR RESPIRATORY PROTECTION?

Respiratory protection begins with identifying workplace contaminants through air sampling. If exposure exceeds the **Permissible Exposure Limit (PEL)**, workers must use a respirator with a suitable **Assigned Protection Factor (APF)**. The **Maximum Use Concentration (MUC)** is the highest level of a hazardous substance a respirator can protect against, determined by multiplying its Assigned Protection Factor **(APF)** by the Permissible Exposure Limit **(PEL)** or other exposure limits., but if it exceeds Immediately Dangerous to Life or Health **(IDLH)** levels, a Self-Contained Breathing Apparatus **(SCBA)** or a Pressure-Demand Supplied Air Respirator **(PD-SAR)** with an escape option is required.

Permissible Exposure limit (PEL) **X** **Assigned protection Factor (APF)** **=** **Maximum Use Concentration (MUC)**

S.No	Type of Respirator	Quarter Mask	Half Mask	Full Face Piece	Helmet/Hood	Loose-Fitting Face Piece
1	Air-Purifying Respirator	5	10[3]	50		
2	Powered Air-Purifying Respirator (PAPR)		50	1000	25/1000[4]	25
3	Supplied- Air Respirator (SAR) or Airline Respirator					
	• Demand Mode		10	50		
	• Continuous Flow Mode		50	1000	25/1000[4]	25
	• Pressure-demand or other positive-pressure mode		50	1000		

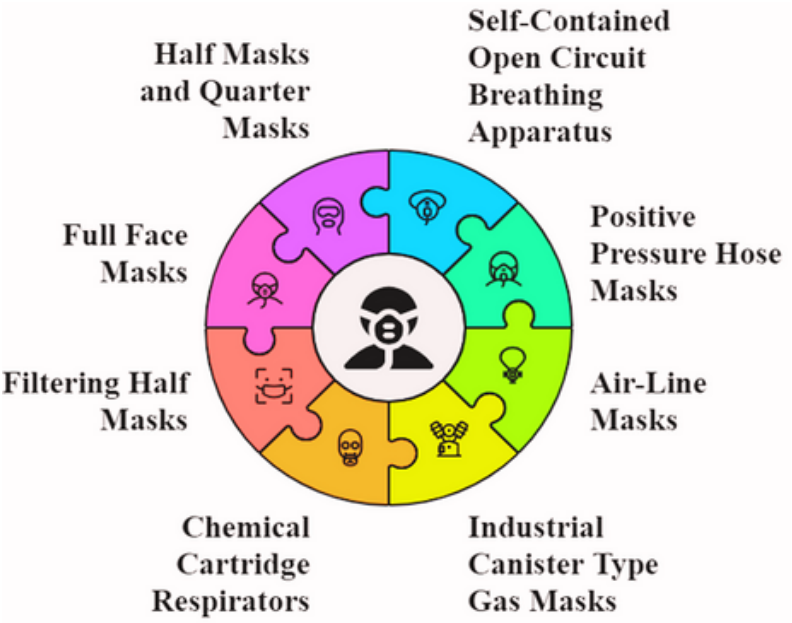
4	Self-Contained Breathing Apparatus (SCBA)					
	• Demand Mode		10	50	50	
	• Pressure-demand or other positive-pressure mode			10,000	10,000	



OSHA PEL Concentration (mg/m3)

4.8 RESPIRATORY EQUIPMENT

This category comprises dust masks respirators, self-contained breathing apparatus **(SCBA)**, Positive pressure hose masks, **Airline masks, Industrial canister type gas masks, Chemical Cartridge Respirators**, designed to protect against airborne contaminants, toxic gases, and insufficient oxygen environments.



Major Respiratory Equipment

4.8.1 Self-Contained Open Circuit Breathing

A **Self-Contained Open Circuit Breathing Apparatus (SCBA)** is a vital lifesaving device used in hazardous environments where the risk of cylinder over-pressurization due to high temperatures is minimal. It is classified into two types: **Class 1**, designed for industrial use, and **Class 2**, intended for firefighting. The performance of **SCBA** is assessed based on its design, materials, cleaning and disinfection procedures, weight, water immersion resistance, strength of harness connections, and practical usability. Additionally, it must meet stringent requirements for **temperature resistance, flammability, pressure regulation, warning devices, leak tightness, and breathing hose durability to ensure safety and reliability**. These parameters, along with their testing methods, are specified in **IS 10245 (Part 2): 2023**, which also outlines the required inspection and maintenance frequency to maintain operational standards.

Self-Contained Open Circuit Breathing

4.8.2 Positive Pressure Hose Masks

Breathing apparatus enables individuals to function effectively in irrespirable or toxic environments while maintaining full physical and mental capacity. Also referred to as a rescue **apparatus, anti-gas apparatus, respirator, smoke helmet, or gas mask**, it is essential for use in **mines, gas works, chemical factories, steel plants, oil refineries, and similar industries**. It is also widely utilized by fire brigades, municipalities, defense forces, and mountaineers. The apparatus must offer high efficiency and reliability to ensure safety in conditions involving **toxic gases, oxygen deficiency, extreme heat, high humidity, structural wreckage, and falls during emergencies**. Therefore, its design must incorporate **leak protection, high-quality materials, durability, and safety under adverse conditions**, while also ensuring the purity of inhaled air. It must undergo rigorous physiological, physical, chemical, and mechanical testing.

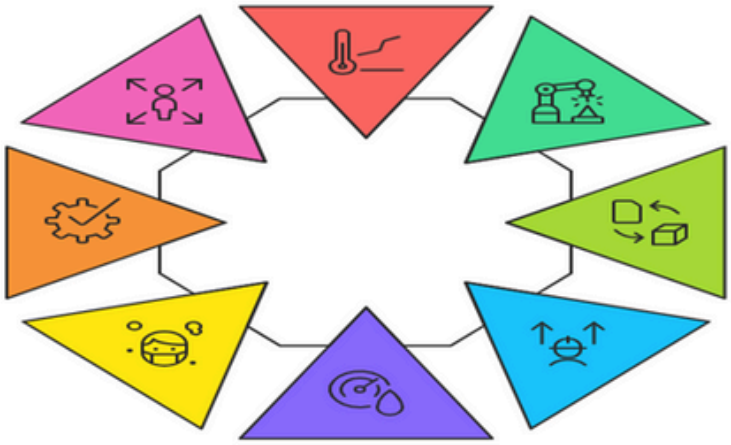
Additionally, comfortable wearability, secure and adjustable harness design, and a flexible, well-fitted mouthpiece are crucial for user safety. In recognition of these requirements, **BIS** has established the Indian Standard **IS 10245 (Part 3): 1999**, which classifies breathing apparatus into three types: **Type 1 – Fresh air hose apparatus without a blower**, **Type 2 – Fresh air hose apparatus with a hand- or motor-operated blower, and Type 3 – Compressed air line apparatus supplying air from a compressed source**. This standard specifies the design, construction, and performance requirements for breathing apparatus, along with testing methods, ensuring that materials used possess adequate mechanical strength, durability, corrosion resistance, and heat, fire, and water resistance. Furthermore, the design must allow for **comfortable wear, complete head and neck coverage, and prevent leakage**, while a harness or belt should prevent strain on the breathing tube or mouthpiece. Importantly, the standard also regulates the carbon dioxide content in inhaled air, ensuring that the breathing apparatus meets stringent quality parameters for safe and reliable use in its intended applications.

Positive Pressure Hose Masks

4.8.3 Airline Masks

The design, construction, and performance requirements for breathing apparatus used in irrespirable and toxic environments, ensuring wearers maintain full physical and mental capacity. Essential in industries like **mining, gas works, chemical plants, and steel production**, as well as for **fire brigades, military personnel, and mountaineers**, this standard covers three types of apparatus: **Type 1 (Fresh air hose without blower)**, **Type 2 (Fresh air hose with hand/motor-operated blower)**, and **Type 3 (Compressed air line apparatus)**. The standard mandates mechanical strength, durability, corrosion resistance, and resistance to heat, fire, and water, ensuring comfort, proper sealing, and prevention of air leaks. It also regulates harness design for stability and tests for CO_2 content in inhaled air, guaranteeing safe, efficient, and reliable respiratory protection in hazardous conditions..

Airline Masks



Material Durability
Ensures the apparatus can withstand physical stress and rough use.

Component Separation
Allows for easy disassembly for cleaning and maintenance.

Adjustability
Provides secure and accessible adjustments to prevent accidental changes.

Leak Tightness
Prevents external atmosphere from entering except at designated inlets.

Cleaning & Decontamination
Maintains hygiene and functionality without material deterioration.

Compliance with Standards
Ensures proper fit and protection for facepieces and masks.

User Comfort
Minimizes discomfort during prolonged use, especially in confined spaces.

Temperature Resistance
Ensures reliable function in low-temperature environments.

Major list for Respirator

4.8.3.1 General Requirements for Respirators

4.8.3.1.1 Materials

Must be durable, corrosion-resistant, anti-static, fire-resistant, and resistant to organic vapors (e.g., benzene, toluene). Exposed parts should not be made of metals that generate sparks.

4.8.3.1.2 Strength

The apparatus should withstand rough use and physical stress.

4.8.3.1.3 Component Separation

Must allow easy disassembly for cleaning, maintenance, and testing.

4.8.3.1.4 Adjustability

All adjustable parts should be secure, easily accessible, and not prone to accidental alteration.

4.8.3.1.5 Leak Tightness

Should prevent external atmosphere from entering except at the designated fresh air inlet.

4.8.3.1.6 Cleaning & Decontamination

Must allow thorough cleaning without deterioration.

4.8.3.1.7 Facepieces & Masks

Facepieces must conform to **IS 14166**, and half masks/mouthpieces to **IS 14746.**

4.8.3.1.8 Nose Clip

If a mouthpiece is used, a secure and comfortable nose clip must be provided.

4.8.3.1.9 Head Harness

Should hold the facepiece securely, be adjustable, durable, and resistant to shrinkage.

4.8.3.1.10 Harness/Belt

Prevents strain on breathing tubes and must withstand a 1,000 N pull test for 30 minutes.

4.8.3.1.11 Comfort

Should not cause undue discomfort or strain during prolonged use, including in confined spaces.

4.8.3.1.12 Temperature Resistance

Apparatus should function reliably in low-temperature environments.

4.8.4 Filtering Half Masks

It defines respiratory protective devices, specifically filtering half masks designed to protect the wearer from airborne particles such as **solid aerosols, liquid aerosols, and water-based aerosols**. These masks are widely used in industries like **construction, mining, and chemical processing, where exposure to dust, fumes, and other particulates is commo**n. The standard categorizes masks into **FFP1, FFP2, and FFP3**, based on increasing levels of filtration efficiency to ensure protection against harmful particles. It also specifies breathing resistance limits to maintain wearer comfort, ensuring that inhalation and exhalation are not overly restrictive. Proper fit and seal are essential to prevent leakage, ensuring that air passes through the filter rather than escaping around the edges. The materials used must be **durable, resistant to deformation, and skin-friendly to prevent irritation during prolonged use**. Testing methods include sodium chloride and paraffin oil tests to evaluate filtration efficiency against solid and liquid aerosols, as well as breathing resistance and total inward leakage assessments to confirm performance under real-world conditions. By establishing these rigorous requirements, **IS 9473** ensures that filtering half masks provide effective, reliable, and comfortable protection against airborne particulate hazards.

Filtering Half Masks

4.8.5 Full Face Mask

Full face masks used in respiratory protective devices, excluding escape and diving apparatus. These masks play a crucial role in occupational safety, protecting wearers from hazardous environments by covering the eyes, nose, mouth, and chin, while ensuring an effective seal during movement and speech. This first revision aligns with **EN 136:1998** and introduces three classes—**Class 1 (light duty), Class 2 (general use), and Class 3** (special use)—tailored to different applications. The standard mandates rigorous testing to ensure leak tightness, flammability resistance, temperature durability, inward leakage control, and carbon dioxide safety. Additionally, it assesses head harness strength, connector durability, impact resistance of visors, and proper valve function under various conditions. Breathing resistance tests ensure comfort, while thermal radiation resistance is specifically tested for **Class 3 masks**. Practical performance tests validate usability under real-world conditions. The standardization ensures consistent quality, safety, and compatibility with other protective equipment. Manufacturers must provide comprehensive usage guidelines, and **Class 3** masks feature replaceable components for cost efficiency. Compliance with **IS 14166:2024** allows products to be certified under the **Bureau of Indian Standards Act, 2016**, offering additional consumer assurance and ensuring reliable respiratory protection in hazardous environments.

Full Face Mask

4.8.6 Half Masks And Quarter Masks

Half masks and quarter masks designed to cover the nose and mouth or the area below the nose, providing **filtration and protection** against airborne contaminants such as particulates, gases, and vapors, depending on the filter type. This standard sets material, construction, performance, and testing requirements to ensure masks meet **filtration efficiency, breathability, and durability criteria**. It also emphasizes face seal, fit, comfort, and stability to prevent contaminated air from bypassing the filter. Testing includes inhalation and exhalation resistance, filtration efficiency, and fit assessment to validate mask performance. Commonly used in construction, mining, and chemical industries, these masks provide essential respiratory protection in hazardous environments. **IS 14746:1999** serves as a critical guideline for manufacturers and users, ensuring that respiratory protective devices offer effective and reliable protection under Indian industrial conditions.

Half Masks And Quarter Masks

4.8.7 Self-Contained Closed Circuit

Self-contained closed-circuit breathing apparatus of the **chemical oxygen (KO_2) type,** specifically self-rescuers, which are vital for survival in irrespirable atmospheres. These devices, increasingly replacing filter **self-rescuers, are primarily used by miners and workers to escape hazardous environments** after explosions or toxic gas leaks. The standard ensures that these **self-contained systems** effectively absorb carbon dioxide and humidity while releasing oxygen for re-breathing. To guarantee reliability, rigorous laboratory and practical performance tests assess oxygen and CO_2 levels, breathing resistance, surface temperature, and leak tightness under extreme conditions **(-30°C to 70°C)**. Additional tests verify flammability resistance, mechanical strength, and durability under impact and vibration. The standard mandates clear user instructions, safe material composition, and proper marking for traceability, ensuring that these life-saving devices meet high safety standards. Compliance with **IS 15803:2008** provides consumers' confidence in the effectiveness, durability, and safety of chemical oxygen self-rescuers for emergency escape situations.

Self-Contained Closed Circuit

4.8.8 Closed Circuit Breathing Apparatus

Closed-circuit breathing apparatus that utilize compressed oxygen cylinders, essential for individuals working in **irrespirable or toxic environments.** These devices play a crucial role in rescue operations, hazardous industrial processes, fire services, and military applications, ensuring wearers can operate safely while maintaining full physical and mental capacity. The standard mandates rigorous design, efficiency, and safety testing, including **leak tightness, breathing resistance, durability, and gas purity**. Performance evaluations involve practical exercises under different work conditions, such as **treadmill tests, restricted movement simulations, and exposure to extreme temperatures**, ensuring the apparatus functions reliably in real-world scenarios. Additionally, lung simulator tests assess breathing resistance and carbon dioxide removal efficiency, while material durability tests confirm resistance to wear, decontamination, and environmental factors. Standardization ensures that all certified products meet consistent **safety benchmarks, reducing the risk of equipment failure and providing confidence to users, manufacturers, and procurers. Aligning with EN 145, this standard enhances interoperability, reliability, and safety, making** it a critical guideline for life-support equipment in hazardous environments.

Closed Circuit Breathing Apparatus

The following Indian Standards lay down test methods evaluate respiratory protective devices, excluding escape and diving apparatus, for occupational use in environments with low risk. Compliance is verified through rigorous laboratory and practical performance testing.

S.No	IS Number	IS Tittle
1	IS 10245 (Part 1) : 1996	Breathing Apparatus: Part 1 closed circuit breathing apparatus (Compressed Oxygen Cylinder) - Specification (First Revision)
2	IS 10245 (Part 2) : 2023	Respiratory Protective Devices - Specification : Part 2 self-contained open circuit breathing apparatus (Second Revision)
3	IS 10245 (Part 3) : 1999	Breathing Apparatus: Part 3 fresh air hose and compressed air line breathing apparatus - Specification (First Revision)
4	IS 10245 (Part 4) : 1982	Specification for breathing apparatus: Part 4 escape breathing apparatus (Short Duration Self - Contained Type)
5	IS 14138 (Part 1) : 2024	Respiratory Protective Devices - Threads for Face pieces - Specification : Part 1 standard thread connection (First Revision)
6	IS 14138 (Part 2) : 2024	Respiratory Protective Devices - Threads for Face pieces - Specification : Part 2 centre thread connection (First Revision)

7	IS 14166 : 2024	Respiratory protective devices full - Face masks - Specification (First Revision)
8	IS 14170 : 2024	Respiratory protective devices - mouthpiece assemblies - specification (first revision)
9	IS 14746 : 2025	Respiratory protective devices - Half masks and quarter masks - Specification (First Revision)
10	IS 15322 : 2003	Particle Filters used in Respiratory Protective Equipment - Specification
11	IS 15323 : 2003	Gas Filters and Combined Filters used in Respiratory Protective Equipment - Specification
12	IS 15803 : 2008	Respiratory protective devices - self-contained closed circuit breathing apparatus chemical oxygen (ko2) type, self-generating, self-rescuers - specification
13	IS 17274 (Part 1) : 2023	Respiratory protective devices Methods of test and test equipment : Part 1 Determination of inward leakage (First Revision)
14	IS 17274 (Part 2) : 2019	Respiratory Protective Devices —Methods of Test and Test Equipment Part 2 Determination of Breathing Resistance
15	IS 17274 (Part 3) : 2019	Respiratory Protective Devices - Methods of Test and Test Equipment : Part 3 Determination of Particle Filter Penetration
16	IS 17274 (Part 5) : 2019	Respiratory Protective Devices - Methods of test and test equipment : Part 5 Breathing machine, metabolic simulator, RPD head forms and torso, tools and verification tools
17	IS 17274 (Part 6) : 2023	Respiratory protective devices Methods of test and test equipment : Part 6 Mechanical resistance strength of components and connections (First Revision)
18	IS 17274 (Part 7) : 2023	Respiratory protective devices Methods of test and test equipment : Part 7 Practical performance test methods (First Revision)

19	IS 17274 (Part 8) : 2019	Respiratory Protective Devices — Methods of Test and Test Equipment : Part 8 Measurement of RPD Air Flow Rates of Assisted Filtering RPD
20	IS 17274 (Part 9) : 2019	Respiratory Protective Devices - Methods of Test and Test Equipment : Part 9 Determination of Carbon Dioxide Content of the Inhaled Gas
21	IS 17274 (Part 10) : 2019	Respiratory Protective Devices - Methods of Test and Test Equipment : Part 10 Resistance to Ignition, Flame, Radiant Heat and Heat
22	IS 17274 (Part 11) : 2019	Respiratory Protective Devices - Methods of Test and Test Equipment : Part 11 Determination of Field of Vision
23	IS 17274 (Part 12) : 2019	Respiratory Protective Devices - Methods of Test and test Equipment : Part 12 Determination of Volume-Averaged Work of Breathing and Peak Respiratory Pressures
24	IS 17274 (Part 13) : 2019	Respiratory Protective Devices - Methods of Test and Test Equipment : Part 13 RPD Using Regenerated Breathable Gas and Special Application Mining Escape RPD: Consolidated Test for Gas Concentration, Temperature, Humidity, Work of Breathing, Breathing Resistance, Elastance and Duration
25	IS 19089 : 2025	Respiratory protective devices- powered filtering devices incorporating a helmet or hood- specification
26	IS 8347 : 2024	Respiratory protective devices — definitions, classification and nomenclature of components (second revision)
27	IS 9473 : 2002	Respiratory protective devices - Filtering half masks to protect against particles - Specification (First Revision)
28	IS 9623 : 2008	Selection, use and maintenance of respiratory protective devices - Code of practice (First Revision)

CHAPTER 5

SAFETY DOCUMENTATION, TRAINING, AND RISK MANAGEMENT

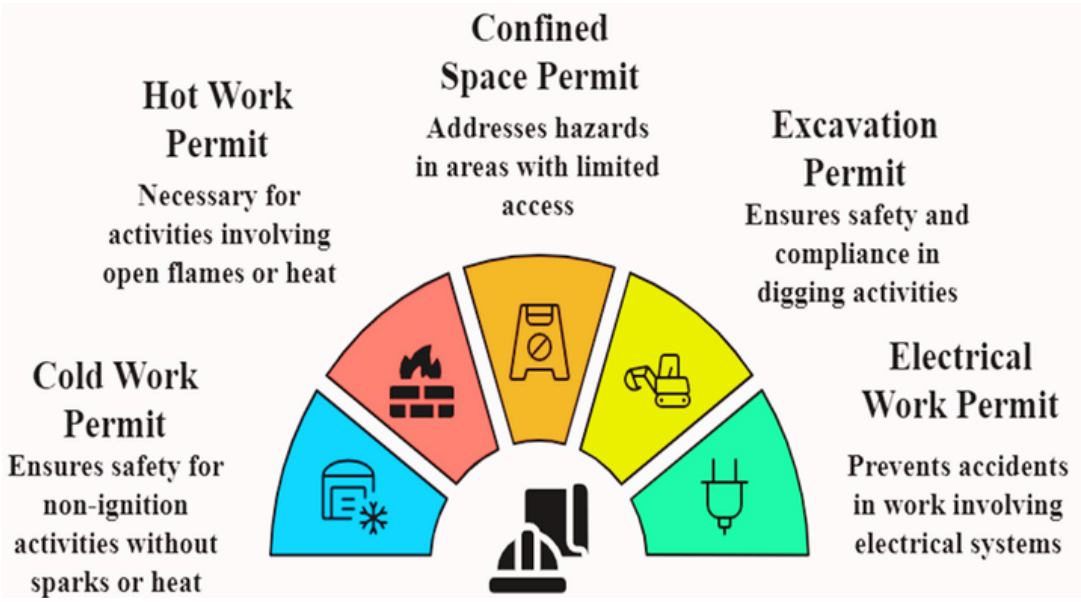
5.1 GENERAL

Proper training of personnel is essential for ensuring safety, operational efficiency, and regulatory compliance in the process chemical industry. Training programs focus on equipping workers with the necessary skills, knowledge, and awareness to handle hazardous chemicals and industrial processes safely.

This is to mitigate risks and prevent human and property losses in the operation and management of process plants. It provides a structured approach for systematically identifying hazards and quantifying the associated risks, enabling a comprehensive understanding of potential threats within an installation. When applied with expertise and diligence, the prescribed methodology aids in assessing hazard levels and prioritizing risk mitigation strategies. This, in turn, enhances plant safety, minimizes accident occurrences, and reduces potential losses. The risk analysis process follows a systematic sequence of steps to ensure effective hazard management and accident prevention these steps are as follows:

5.2 PERMIT TO WORK IN PROCESS CHEMICAL INDUSTRIES

The work permit process involves issuing, complying with specified conditions, and closing the permit upon job completion. Various personnel, including the issuer, acceptor, area in-charge, and technicians, are involved. The issuer oversees the entire process, and permits are issued in triplicate for record-keeping and safety compliance. The issuer, usually the shift in-charge, and the acceptor, responsible for execution, conduct a joint risk assessment before work begins, ensuring adherence to procedures, necessary preparations, and use of protective equipment. Work beyond specified hours requires approval, and operations can be halted if conditions become unsafe. Employees must be trained in work permit procedures to fulfil their designated roles effectively **IS 17893:2023**.



Major list for Work Permits

5.2.1 Types Of Work Permits

5.2.1.1 Cold Work Permit

For non-sparking activities that do not generate heat.

5.2.1.2 Hot Work Permit

Required for tasks involving open flames, sparks, or high temperatures.

5.2.1.3 Confined Space/Vessel Entry Permit

Necessary for working inside tanks, vessels, or enclosed spaces.

5.2.1.4 Excavation Permit

Required for digging activities to prevent damage to underground utilities.

5.2.1.5 Electrical Work Permit

Ensures safe handling of electrical equipment and installations.

5.2.1.6 Work At Height Permit

For tasks performed at elevated locations to prevent falls.

5.2.1.7 Radiography Permit

Required for work involving radiation sources.

5.2.2 Exemptions From Work Permit Requirements

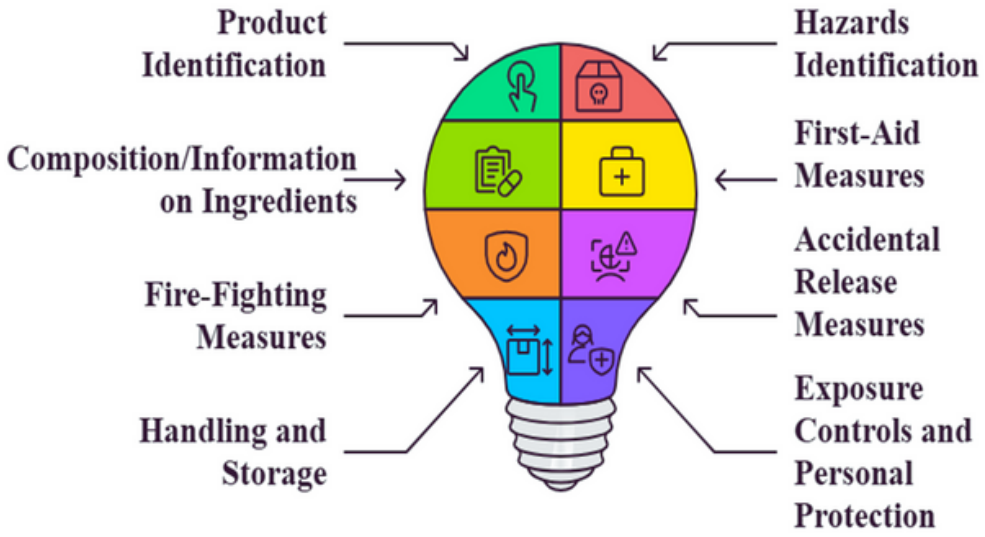
A work permit is not required for specific routine activities, including:

- Welding, cutting, and fabrication within approved workshop areas.
- Routine sampling for laboratory analysis.
- Cooking and food preparation in designated canteens.
- Use of torches, furnaces, and sparking equipment in designated laboratory areas.
- Garbage collection from designated safe locations.
- Routine cold work in office buildings, except electrical isolation, height work, and excavation.
- Visual inspections by maintenance personnel of plant equipment.
- Replacement of tube lights inside buildings (verbal permission required).
- Manual gardening tasks unless electrical tools, height work, or deep excavation is involved.
- Any other routine activities authorized by the facility in-charge.

Work Permission Requirements

5.3 MATERIAL SAFETY DATA SHEETS

An **MATERIAL SAFETY DATA SHEETS (MSDS)** applies to a chemical product as a whole and provides non-confidential information regarding its composition and ingredients. Suppliers are required to provide a complete, up-to-date **MSDS** that contains relevant **safety, health**, and situations that may arise in the workplace. The responsibility lies with the user to assess risks based on the specific conditions under which the chemical product is used and ensure that workers are appropriately informed about the relevant hazards in their environment. The **MSDS**, therefore, forms only a part of the information needed to establish a comprehensive safety program. While a single **MSDS** may be produced for a mixture, detailing individual ingredients may not be necessary unless it is useful for the workplace. In such cases, information on each ingredient should be provided. An **MSDS** shall provide the relevant information about a chemical product, in following **16** section headings. Text of the section headings, numbering and sequence shall not be altered. The section headings are given:



Material Safety Data Sheets (MSDS) Protocols

5.3.1 Chemical Product And Company Identification

This section includes the **product identification, supplier details (name, address, telephone number, emergency contacts), product code, and recommended uses or restrictions**.

5.3.2 Hazards Identification

It provides a summary of the product's potential hazards to human health and the environment, including **physical and chemical hazards**. If the product is classified under the **GHS** system, it includes the relevant hazard classes, pictograms, and precautionary statements. It may also list **non-GHS** hazards and symptoms of exposure.

5.3.3 Composition/Information on Ingredients

This section identifies whether the product is a substance or mixture, providing **chemical names, CAS numbers, and concentrations of hazardous ingredients. For mixtures**, the full composition is not required unless specific hazardous ingredients are present above threshold levels.

5.3.4 First-Aid Measures

Details the first-aid measures for various exposure routes **(inhalation, skin contact, eye contact, ingestion)**, what actions to avoid, and the anticipated acute or delayed effects. Information for first responders and any specific antidotes is also included.

5.3.5 Fire-Fighting Measures

This section identifies suitable extinguishing media, specific hazards from the product during combustion, and any special protective equipment required for fire-fighting.

5.3.6 Accidental Release Measures

Includes information on **personal precautions, protective equipment, emergency procedures, environmental precautions**, and methods for containment and cleanup.

5.3.7 Handling and Storage

Covers safe handling precautions, including prevention of **exposure, fire, and explosion risks**, and details about safe storage conditions, including separation from incompatible substances.

5.3.8 Exposure Controls and Personal Protection

Lists permissible exposure limits, engineering controls, and the necessary personal protective equipment, such as **respiratory protection, gloves, eye protection, and clothing**. It also addresses specific conditions that require special precautions.

5.3.9 Physical and Chemical Properties

Provides key physical properties of the chemical, such as **appearance, odor, pH, boiling and melting points, flash point, solubility**, and other relevant data for safe use.

5.3.10 Stability and Reactivity

Describes the chemical stability of the product, conditions to avoid, incompatible materials, and potential hazardous decomposition products.

5.3.11 Toxicological Information

Provides detailed health effects, including acute toxicity, skin/eye irritation, carcinogenicity, reproductive toxicity, and other adverse health effects based on different exposure routes.

5.3.12 Ecological Information

Describes the product's environmental impact, including its behavior, persistence, biodegradability, bioaccumulation, and mobility in soil.

5.3.13 Disposal Considerations

Outlines safe and environmentally preferable disposal methods for the chemical product and any contaminated containers, as well as any local disposal regulations.

5.3.14 Transport Information

Includes information about transport classifications, including **UN numbers, proper shipping names, transport hazard classes**, and special precautions for handling during transport.

5.3.15 Regulatory Information

Lists relevant laws and regulations for the chemical product, including labeling requirements, and points out any local regulatory information that may apply.

5.3.16 Other Information

Provides any additional safety information that may not fit into the previous sections, such as required training or recommended uses and restrictions.

5.4 RISK ASSESSMENT

Risk assessment is the process of **Goal (Planning, Statutory), Location, Layout, Hazard identifying, Quantification of hazard, analysing, and evaluating potential risks that could negatively impact people, assets, or operations**. It is commonly used in industries such as environmental management, chemical processing, wastewater treatment, and occupational health and safety.

5.4.1 Goal

Goal for carrying out risk analysis is required as a part of statutory requirement, emergency planning, etc. depending on the nature of industry

5.4.2 Location, Layout, and Process Parameters

The plant location, equipment layout, and process conditions is essential for conducting a comprehensive risk analysis.

5.4.3 Hazard Identification

Hazard identification is carried out using comparative and/or fundamental methods, yielding qualitative or quantitative results.

5.4.4 Quantification of Hazards

The indices method is used to assess the hazard potential of identified scenarios and serves as a screening tool in risk evaluation.

5.4.5 Selection of the Most Credible Scenario

Among various major and minor scenarios, the most credible scenario is one that could realistically lead to an accident due to material or energy release is selected.

5.4.6 Selection of the Worst-Case Scenario

The scenario with the highest potential for causing maximum damage is identified for detailed analysis.

5.4.7 Consequence Estimation

The potential consequences of identified scenarios—such as **fire, explosion, or toxic exposure**—are evaluated and documented.

5.4.8 Estimation of Frequency of Occurrence

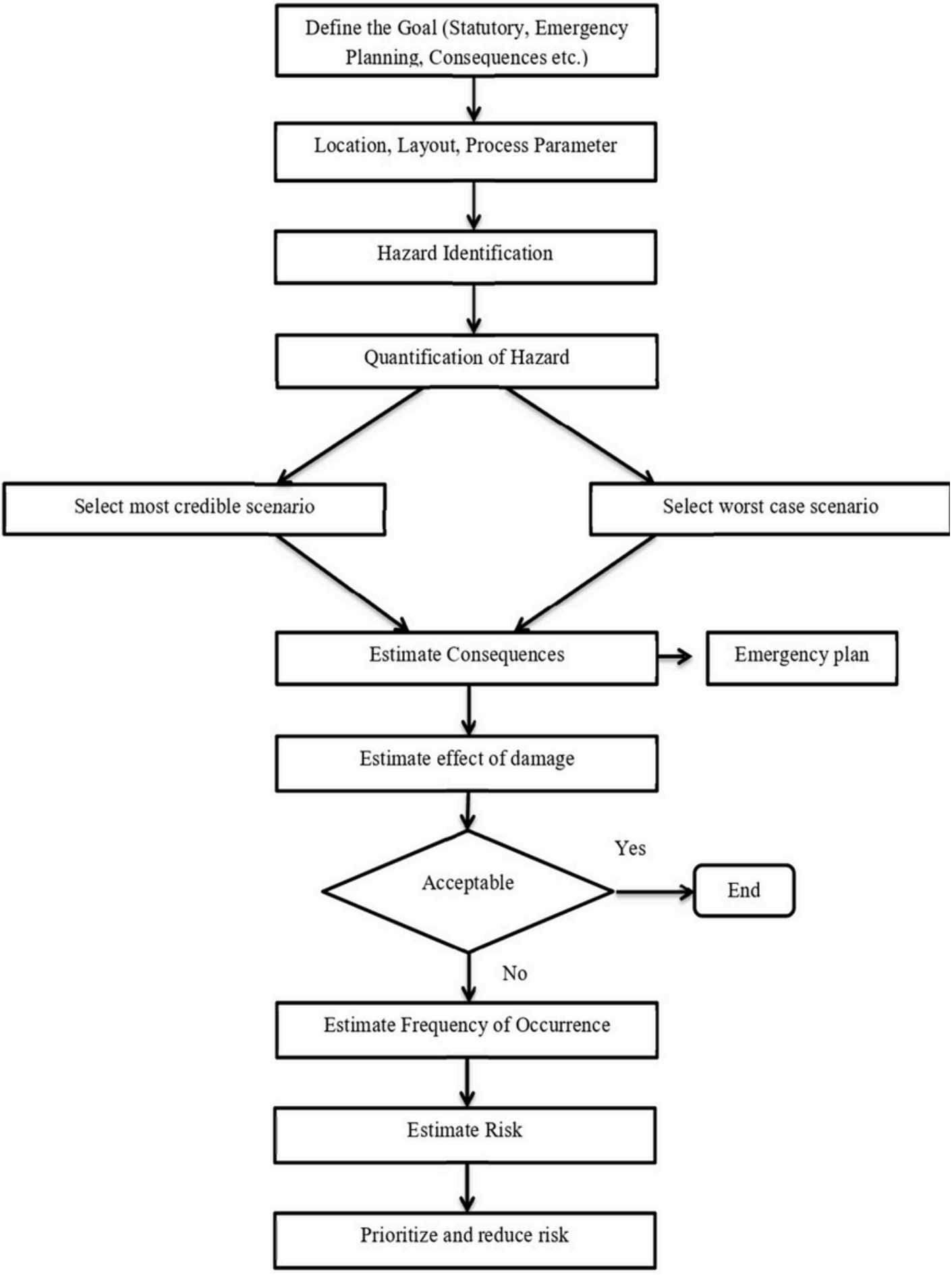
The likelihood or frequency of an incident is determined using reliability analysis techniques, such as fault tree and event tree analysis.

5.4.9 Risk Estimation

Risk is quantified as the product of an event's frequency and the severity of its consequences. The calculated risk is then compared against national or international standards.

5.4.10 Risk Prioritization and Mitigation

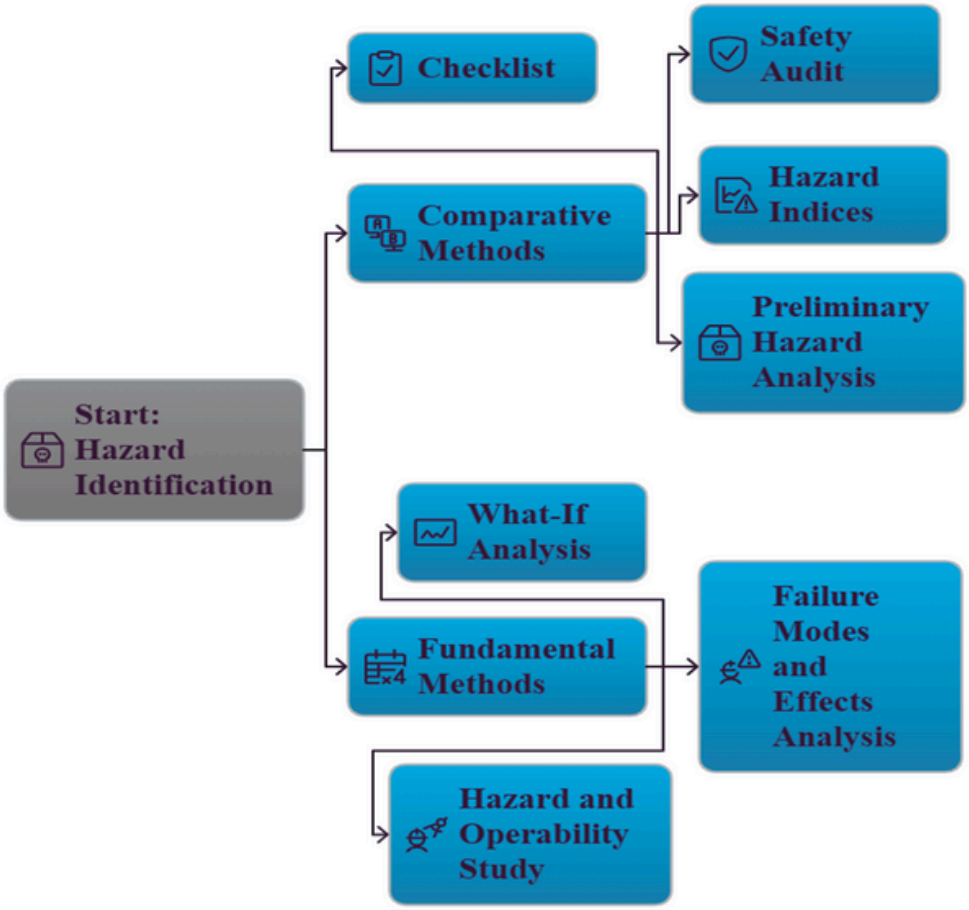
Based on the estimated risk, contributing factors leading to potential incidents are analysed, prioritized, and addressed through risk reduction strategies.



Risk Assessment

5.5 HAZARD IDENTIFICATION AND HAZARD ANALYSIS

A hazard typically manifests as the loss of containment of a hazardous material. This loss can occur through various routes, such as leaks from pipe fittings carrying liquids or gases, releases from vents and relief systems, or vessel ruptures. While adherence to good engineering practices is essential, it may not be sufficient to fully control plant hazards. Therefore, a range of hazard identification techniques and probability assessment methods have been developed to analyse processes, systems, and operations.
The primary objective of hazard identification is to recognize and assess potential hazards and unintended events that could lead to accidents. The initial step involves identifying hazards inherent to the process or plant, followed by evaluating possible events associated with these hazards. In hazard identification and probability quantification, it is assumed that the plant will function as designed, provided there are no unintended events such as component or material failures, human errors, external disturbances, or unknown process variables that may impact plant or process behaviour.



Hazards Analysis

5.5.1 Hazard Identification

Formal hazard identification studies produce a comprehensive list of potential failure scenarios. This list is typically derived by considering: (a) the form in which chemicals are stored or processed, (b) the nature of the hazards they present, and (c) the quantity of material contained. Hazard identification methods are broadly classified into comparative methods and fundamental methods.

5.5.1.1 Comparative Methods

These methods compare existing systems with established standards to identify hazards.

5.5.1.1.1 Checklist

A quick, qualitative tool that assesses compliance with safety standards. It's used at any stage of a project and provides a "yes-or-no" answer regarding safety compliance.

5.5.1.1.2 Safety Audit

An intensive plant inspection that ensures safety procedures align with design intent. It helps identify hazards and suggests improvements.

5.5.1.1.3 Hazard Indices

Used to rank hazards based on the risk of fire or explosion. It provides a quantitative ranking of plant processes to prioritize risk management.

5.5.1.1.4 Preliminary Hazard Analysis (PHA)

Conducted in the early design phase to identify hazards and recommend design changes to mitigate risks.

5.5.1.1.5 Fundamental Methods

These methods involve structured brainstorming and foresight to identify hazards, often without relying on existing standards.

5.5.1.2.1 What-If Analysis

A creative approach used during plant changes or pre-startup to simulate accident scenarios and their consequences.

5.5.1.2.2 Failure Modes and Effects Analysis (FMEA)

Focuses on identifying equipment failures and their impact on the process. It helps prioritize failure modes based on severity and likelihood.

The following Indian Standards lay down techniques for Personnel trainings, assessing risks, and implementing safety measures in process plants to prevent accidents and minimize losses.

S.No	IS Number	IS Tittle
1	IS 17889 : 2022	Material safety data sheets — guidelines
2	IS 17893 : 2023	Work permit system — code of practice
3	IS 15656:2006	Hazard identification and Risk analysis — code of practice

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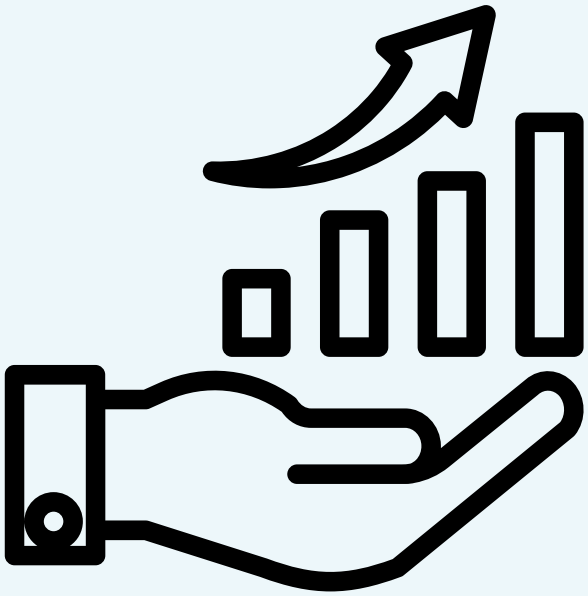

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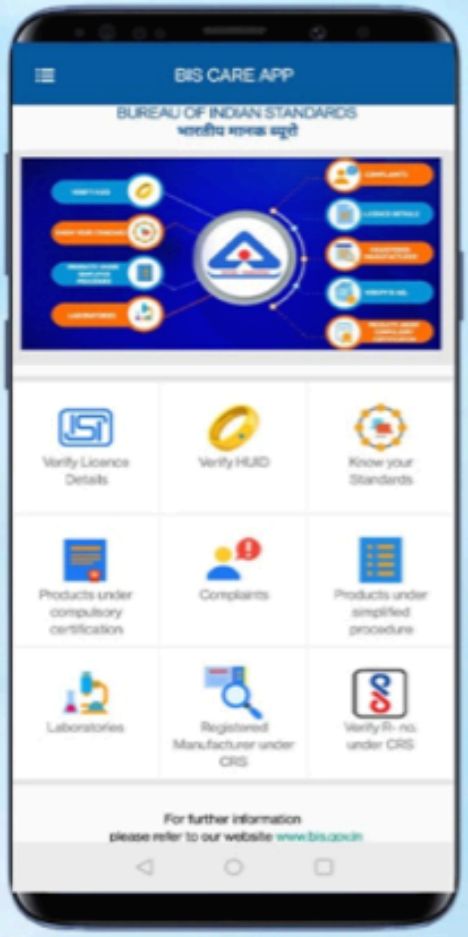

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