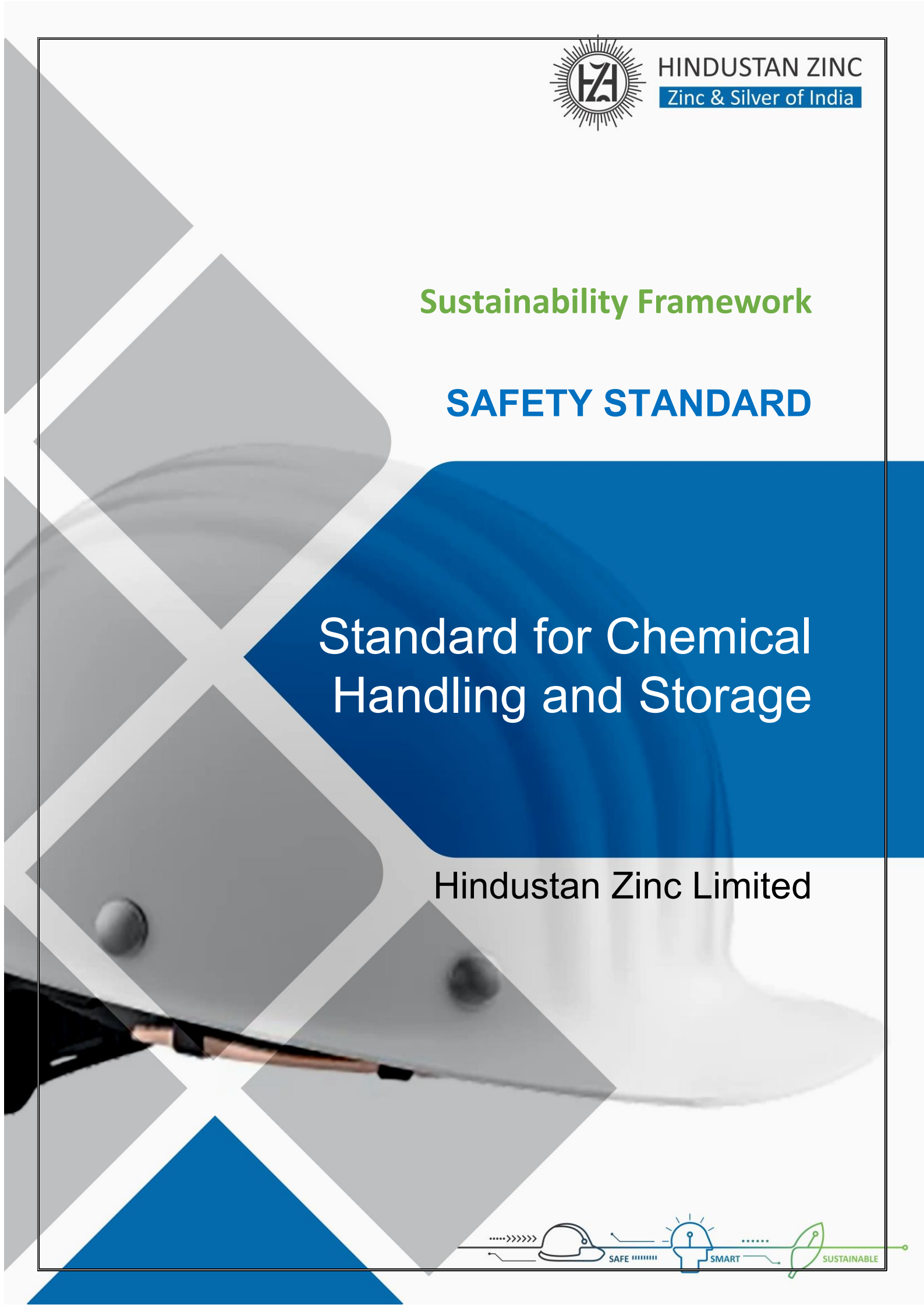
HINDUSTAN ZINC
Zinc & Silver of India

Sustainability Framework

SAFETY STANDARD

Standard for Chemical Handling and Storage

Hindustan Zinc Limited



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02	01.07.2020	01.07.2020	6.4.2, xvi Cleaning Surrounding storage areas.6.10.1, xviii Thickness of high p ressure gas cylinders. 6.10.1, xix Sign boards at gas charging stations.	Risk Chairman
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1. Introduction

A number of hazardous chemicals are required to be stored and handled in appreciable or bulk quantities at HZL sites. These chemicals pose various types of hazards like flammability, toxicity, explosivity, corrosivity etc. Inadequate awareness and risk management about the hazardous properties of these chemicals may lead to serious incidents which will affect the men at work. property and the environment. The risk of an incident is also dramatically increased if sites do not train their employees/contract workers handling hazardous chemicals adequately.

1.1 What are hazardous chemicals?

Under international regulations / best practices, a hazardous chemical is any pure substance and its dilute solution, mixture or article which, by reason of its chemical or physio-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plants, micro-organisms, property or the environment. They are also referred as hazardous substances or hazardous materials.

In relation to chemicals, a hazard is a set of inherent properties of the substance, mixture, or article that may cause adverse effects to organisms or the environment. There are two broad types of hazards associated with hazardous chemicals which may present an immediate or long term injury or illness to people. These are:

Health hazards – These are properties of a chemical that have the potential to cause adverse health effects. Exposure usually occurs through inhalation, skin contact or ingestion. Adverse health effects can be acute (short term) or chronic (long term). Typical acute health effects include headaches, nausea or vomiting and skin corrosion, while chronic health effects include asthma, dermatitis, nerve damage or cancer.

Physio-chemical hazards – These are physical or chemical properties of the substance, mixture or article that pose risks to workers other than health risks, as they do not occur as a consequence of the biological interaction of the chemical with people. They arise through inappropriate handling or use and can often result in injury to people and/or damage to property as a result of the intrinsic physical hazard. Examples of physicochemical hazards include flammable, corrosive, explosive, chemically reactive and oxidising chemicals.

Many chemicals have both health and physicochemical hazards.

When a hazardous material is no longer usable for its original purpose and is intended for disposal, but still has hazardous properties, it is considered to be a hazardous waste. Accordingly, all hazardous waste are also hazardous chemicals.

For the purpose of this standard, any chemical that satisfies the criteria of one or more *Globally Harmonised System of Classification and Labelling of Chemicals* (GHS) hazard classes shall be considered a hazardous chemical. In addition, Radioactive Sources which are not covered under GHS shall be classified as hazardous chemicals.

Most substances and mixtures that are listed as dangerous goods under “United Nations

Recommendations for Transport of Dangerous Goods" are hazardous chemicals.

For definition of "hazardous chemical / goods" under Indian regulations, refer

- Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989
- The Central Motor Vehicles Rules, 1989
- Hazardous wastes Rules 2016

1.2 Purpose

The present standard covers good practices that should be used to facilitate safe storing and handling of hazardous chemicals in order to prevent incidents and occupational diseases arising out of unsafe handling and storage of hazardous chemicals.

This standard also stipulates the procedures that need to be developed by the HZL sites for safe storage and handling of hazardous chemicals, and information and training on safe storage and handling of hazardous chemicals to be provided to company and contracted employees.

This standard will help provide a new impetus towards achieving the best in class safety standards at HZL.

2. Scope and field of application

2.1 Scope

This standard provides general requirements and guidance pertaining to the management and control of handling & storage of all hazardous chemicals, and the prevention of exposure at HZL sites / plants.

Sites should be aware that local regulations may impose requirements not reflected in this standard. In case of conflict, the most stringent requirement shall apply. Additional information on regulations comes from a number of sources, including Statutory/Regulatory Documents.

While the intent of this Standard is to bring in homogeneity across all HZL plants / sites with regard to safe handling and storage of hazardous chemicals, certain provisions are kept to allow some latitude to the implementing sites / plants. However, those requirements in this standard which are noted in "shall', "must" or "requires" are mandatory and must be complied with. The word "should" is used in this standard to indicate a recommended course of action, while "may" is used to indicate an optional course of action.

2.2 Exclusions

This standard does not cover the followings:

a) Transport of hazardous materials*

b) Storage and handling of hazardous chemicals in Laboratory or in Office buildings*

c) Storage and handling of Asbestos-containing materials (ACMs)*

d) Mining, handling or storage of ore mineral or other material from which one or more Radioactive Materials can be extracted

e) Disposal of hazardous wastes. *However, this standard is applicable for handling and storage of hazardous wastes.*

f) Gaseous substances emitted from chimney stacks, fumes and mists

g) Biological agents (such as legionella, leptospirosis), or hazardous geological materials and flora & fauna

h) Prescription medicines and drugs

**It is to be noted that general guidance and certain specific requirements contained in this standard are equally applicable for these activities. However, additional considerations and precautions are required to address all safety and health concerns associated with these activities.*

2.3 Field of application

The requirements and practices which have been identified in this standard are equally applicable across all the HZL units / plants and facilities in Smelters and Mines including existing and expansion projects with regard to chemical handling & storage and exposure control.

These requirements and practices are intended to be used by own employees and contract personnel involved in aforesaid works inside the premises of HZL plants / sites.

3. References

Corporate Policy

- HZL SHE Policies

Corporate Standards/ Guidelines

- HZL PSM Standard
- HZL PHA Standard
- HZL MOC Procedure
- HZL PT Standard / Guidelines
- HZL PPE Standard /Guidelines

Vedanta Sustainability Governance System Guidance Notes

- GN02- Hazardous Materials Management
- GN 07- Risk Assessment
- GN 10 - Personal Protective Equipment

Regulations

- Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989

- The Central Motor Vehicles Rules, 1989
- Explosive Rules, 2008
- Gas Cylinders Rules 2004
- The Factories Act, 1948
- The Chemical Accidents (Emergency, Planning, Preparedness and Response) Rules 1986
- The Hazardous substances (Classification, packaging, and Labelling) ***Draft*** Rules, 2011 (These rules have been framed considering UN GHS System. However, these are draft rules and final rules are yet to be notified)
- Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016
- Petroleum Rules, 2002
- Atomic Energy (Radiation Protection) Rules, 2004
- Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987
- Factories Act, 1948 and the rules made thereunder
- Environment Protection Act, 1986 and the rules made thereunder
- Water (Prevention and Control of Pollution) Act, 1974 and the rules made thereunder
- Air (Prevention and Control of Pollution) Act, 1981 and the rules made thereunder
- Atomic Energy Act, 1962 and the rules made thereunder

External References

- United Nations Economic Commission for Europe (UNECE) Purple Book, A Guide to the Globally Harmonised System of Classification and Labelling of Chemicals (GHS)
- United Nations Recommendations for Transport of Dangerous Goods (Orange Book)
- Safe Work Australia - Managing risks of hazardous chemicals in the workplace Code of Practice
- Safe Work Australia - Labelling of workplace hazardous chemicals Code of Practice
- Dust Explosion and Fire Prevention Handbook, A Guide to Good Industry Practices, Nicholas P. Cheremisinoff, John Wiley & Sons, 2014
- OHSA 29 CFR 1910.1200 OSHA Hazard Communication
- OSHA 1910.169 - Compressed Gas and Compressed Air Equipment
- 29 CFR 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories
- OSHA Hazard Communication Web Site
- ISO 11014-1 Safety Data Sheet for Chemical Products

- American National Standards Institute (ANSI) Z129.1-2010 Hazardous Industrial Chemicals – Precautionary Labeling
- U.S. Nuclear Regulatory Commission (NRC) 10 CFR Part 20 – Standards for Protection Against Radiation
- Occupational Safety and Health Association (OSHA) 29 CFR 1910.1096 – Ionizing Radiation International Commission on Radiation Protection
- International Radiation Protection Association

4. Definitions and Acronyms

Item	Definition
Adequate Ventilation	Ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentration above 25 % of their lower flammable (explosive) limit, LFL (LEL)
Article	Means a manufactured item, other than a fluid or particle, that is formed into a particular shape or design during manufacture and has hazard properties and a function that are wholly or partly dependent on the shape or design
Auto Ignition Temperature	The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element. For the purpose calculating AIT, the definition can be read as the lowest temperature at which ignition occurs in a mixture of explosive gas and air when the method specified in IS: 7820-1975 is followed.
Biological Hazards	Enzymes, micro-organisms, viruses, or substances derived from living organisms that may present a hazard to human health
Bulk Storage Tanks	Fixed storage tanks (Above ground, underground or partially buried) usually with a capacity of greater than approximately 55 gallons (approx. 208 litres)
Bulk Transportation Equipment	Container sizes greater than 119 gallons (450 liters) liquid or 1,000 pounds (454 kilograms) solid (e.g., rail cars, International Organization for Standardization (ISO) containers, barges, tank trailers, one ton tanks, and intermediate bulk containers [IBCs]) and any equipment required to transport bulk containers (e.g., chassis, trailer, and rail flat car).

Carcinogen	A substance capable of producing cancer, mutations of genes resulting in irregular, uncontrollable growth of abnormal cells in humans
Cargo transport unit (CTU)	An article of transport equipment that is of permanent character and accordingly strong enough to be suitable for repeated use; commonly referred to as freight containers, swap-body vehicles, railway wagons, cargo tanks, or other similar names.
CAS NO.	Chemical Abstracts Service Registry Number is a numeric designation assigned by American Chemical Society's Chemical Abstracts Service and uniquely identifies a specific chemical compound. This entry allows one to conclusively identify a material regardless of the name or naming system used. A CAS registry number is separated by hyphens into three parts, the first consisting of up to 6 digits, the second consisting of two digits, and the third consisting of a single digit serving as a check digit. The numbers are assigned in increasing order and do not have any inherent meaning. For example, the CAS number of water is 7732-18-5, Ethyl Mercaptan 75-08-1, Liquefied Petroleum Gas 68476-85-7.
Chemical Hazards	Chemical substances (e.g., liquids [including solutions], solids, dusts, gases, vapors, or fumes) that may present a hazard to human health and/or to the environment
Container (also called Primary container)	A vessel of any size used to contain hazardous materials. This includes process vessels, sampling and draining containers, portable mixing vessels, and any bag, barrel, bottle, box, can, cylinder, drum, reactions vessel, storage tank, or the like that contains a hazardous material. For purposes of this section, pipes or piping systems, and engines, fuel tanks, or other operating systems in a vehicle are not considered to be containers
Dangerous Goods	A substance or material that a local competent authority has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The term may include hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, and materials designated as dangerous in classes 1-9 as provided in the United Nations Model Regulations on the transport of dangerous goods. Also called Hazardous Goods.
Environment	Surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation

Environmental Hazard	A single substance or mixture of substances that, based on its inherent ecotoxicity and/or potential to bioaccumulate or biodegrade, may cause adverse effects to living organisms or their habitats.
Flash Point	Means the lowest temperature (corrected to a standard pressure of 101.3 kPa) at which the application of an ignition source causes the vapours of a liquid to ignite under specified test conditions
Gas Cylinder	"Gas Cylinder" or "Cylinder" means any closed metal container having a volume exceeding 500 ml but not exceeding 1000 liters intended for the storage and transport of compressed gas,
GHS	Means the 'Globally Harmonized System of Classification and Labelling of Chemicals, 6th Revised Edition', published by the United Nations
Hazard	A set of inherent properties of the substance, mixture, or article that may cause adverse effects to organisms or the environment. There are two broad types of hazards associated with hazardous chemicals which may present an immediate or long term injury or illness to people
Hazard Pictogram	Means a graphical composition, including a symbol plus other graphical elements, that is assigned in the GHS to a hazard class or hazard category
Hazard Warning	Any words, pictures, symbols, or combination thereof appearing on a container label or other form of warning that convey the specific physical, health, and/or environmental hazard(s) including target organ effects of the material(s) in the container(s)
Hazardous Atmosphere	A hazardous atmosphere is one in which: ♦ there is not a safe oxygen level for breathing; or ♦ concentrations of hazardous gases, vapours, mists, fumes and dusts are at or above relevant exposure standards; or ♦ the concentration of flammable gases, vapours, mists, fumes and dusts is at or above 5 per cent of the lower explosion limit.
Hazardous Chemicals	Any pure substance and its dilute solution, mixture or article which, by reason of its chemical or physio-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plants, micro-organisms, property or the environment. Also called hazardous substances or hazardous materials.

Health Hazard	a material for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed personnel. The term “health hazard” includes materials that are carcinogens, mutagens, toxic or highly toxic agents, reproductive toxins, developmental toxins, irritants, corrosives, sensitizers, hepatoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that may damage the lungs, skin, eyes, mucous membranes, or other target organs
Incompatible Chemicals	These are chemical substances which in contact with each other cause hazardous reactions which may be violent or produce toxic materials
Intermediate Bulk Containers (IBCs)	An intermediate bulk container (IBC), IBC tote (jumbo bag), or pallet tank, is a reusable industrial container designed for the transport and storage of bulk liquid and granulated substances, such as chemicals, food ingredients, solvents, pharmaceuticals, etc. These containers are not directly connected as an input, outflow from a process (up to 1,000 litres or 1 MT)
Label	means written, printed or graphical information elements concerning a hazardous chemical that is affixed to, printed on, or attached to the container of a hazardous chemical
LC_{50} (Median Lethal Concentration)	LC50 (Lethal Concentration 50) is the concentration of a chemical in air or of a chemical in water that when administered by inhalation over a specified period of time, is expected to cause the death of 50% of a defined animal population (test group).
LD_{50} (Median Lethal Dose)	LD50 (Lethal Dose 50) is the amount of substance that when administered by a defined route of entry (e.g., oral or dermal) over a specified period of time, is expected to cause the death of 50% of a defined animal population (test group). LD50s are usually expressed as the weight of the chemical per unit of body weight (mg/kg).
Line Management	Managers and supervisors who are in the line of command of a primary function of their organization, business, location or site such as the Site / Unit Head or President or the Head of an operations department or Sectional Head or front line supervisors at a manufacturing site or a Manager / Engineer in the maintenance department at a manufacturing site
Local Regulations	Regulations or legislation from Central or State Government of India
Mixture	Means a combination of, or a solution composed of, two or more substances that do not react with each other
MOC	Management of change

Mutagen	A substance capable of inducing genetic change which when transmitted to an offspring can result in heritable variation
Odorous	Any material that has an immediate and obvious effect on the respiratory and olfactory systems of an individual when exposed to the unpacked material in a confined, unventilated space
Outage	Sufficient interior vacant space in a tank car, tank truck, portable/ISO tank, or IBC to prevent leakage or distortion of the container due to content expansion caused by temperature and/or pressure changes
Personnel	includes DuPont employees and contractor employees who receive day-to-day direction from DuPont employees
Physical hazard	A material for which there is scientifically valid evidence that it is a combustible liquid or dust; a gas under pressure (e.g., compressed, liquefied, refrigerated, and dissolved); explosive; a flammable gas, liquid, or solid; an organic peroxide; an oxidizer; pyrophoric; unstable (reactive); or water-reactive
Placard	Means a sign or notice: a) displayed or intended for display in a prominent place, or next to a container or storage area for hazardous chemicals at a workplace b) that contains information about the hazardous chemical stored in the container or storage area
Portable Containers	Small containers (drums, barrels, carboy etc.) up to 205 litres, or 45 gallon) and totes, bags, sacks etc. (up to 200 Kg)
PPE Grid	A PPE grid is a document that tells employees which PPE is required to be worn while entering inside and plant area or section.
Preparation	Means mixtures or solutions of two or more chemical substances
Regulations or Legislation	Describe the legally binding statutory general duties to comply with to assure an acceptable risk to the environment and occupation. Contravention is punishable through the judiciary
Reprotoxic Substances	Are capable of producing irregularities in the reproductive system of either gender, the growth of a foetus (teratogenic) and children. This includes the lactic period
Sensitisers	Substances which can induce changes in the respiratory system or on the skin. Once these changes have taken place, further exposure to the substance, sometimes to very small quantities cause the symptoms to return. Some persons are more susceptible to sensitisers than others

STEL (Short Term Exposure Limit)	It is defined as a 15 minutes time weighted average exposure, which should not be exceeded at any time during a workday even if the 8 hours time weighted average is within the TLV. Exposure at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes interval between successive exposures at the STEL. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.
Storage Containers	Same as containers
Substance	Means a chemical element or compound in its natural state or obtained or generated by a process: • including any additive necessary to preserve the stability of the element or compound and any impurities deriving from the process, but • excluding any solvent that may be separated without affecting the stability of the element or compound, or changing its composition
Surroundings	In this context includes both local and global system
Synonyms	For common chemicals, several chemical names and numerous trade names may be applied to describe the chemical in question. In synonyms field, many of these names are identified to aid users on the range of names which have been used to describe each substance.
Teratogen	A substance that can induce non-heredity genetic damage in a developing foetus
Threshold limit value (TLV)	Occupational exposure limit recommended by the American Conference of Governmental Industrial Hygienists that refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. Normally, it is the time weighted average concentration in ppm or gm/m3 for a normal 8-hour work day or 40 hour workweek. Excursions above this limit may occur if they are compensated during the workday, by equivalent excursion below the limit.
Transfer	Includes the pumping, dispensing or decanting from one container into another or from one place to another
UN NUMBER	The united nations number is a four figure code that identify dangerous goods, hazardous substances and articles (such as explosives, flammable liquids, toxic substances, etc.) in the framework of international transport by road, rail and by air; e.g. flammable liquid, not otherwise specified, have UN IDs as UN1993. UN numbers range from UN0001 to about UN3500 and are assigned by the United Nations Committee of Experts on the Transport of Dangerous Goods.

Note - *For definitions related to classification or division of hazardous chemicals, please refer Annexure-1.*

4.1 Definitions Pertaining to Radioactive Sources

Item	Definition
Alpha emitter	an atom that upon radioactive decay emits an alpha particle (two protons and two neutrons bound together in a particle identical to a helium atom) and transforms (or "decays") into an atom with a mass number 4 less and atomic number 2 less. Americium-241 (found in smoke detectors) and Krypton-85 are examples of alpha emitters.
Absorbed dose of radiation	the measure of the energy deposited in matter by ionizing radiation, measured in units of gray (Gy) in the International System of Units (SI system). The Gy is the absorbed dose of radiation when the energy per unit mass is one joule per kilogram. The traditional symbol name is rad and conversion factor is 1 rad = 0.01 Gy.
Accident	any unintended event, including operating error, equipment failure or other mishap, the consequences or potential consequences of which are not negligible from the radiation protection point of view
Activity	the average number of spontaneous nuclear transformations taking place per unit time in a radioactive substance or material
AERB	Atomic Energy Regulatory Board
As Low As Reasonably Achievable (ALARA)	a concept with the basic tenet that all radiation exposures to area personnel, the environment, and the public are maintained As Low As Reasonably Achievable. This concept serves as the basis of most site or facility radiation safety programs.
Becquerel (Bq)	an International System (SI) of unit of radioactivity. 1 Bq = 2.7 x 10^{-11} Ci; 2.7 x 10^{-8} mCi; 2.7 x 10^{-5} µCi
Contamination	the presence of a radioactive substance in or on a material or in the human body or other place in excess of quantities specified in the relevant safety codes by the regulatory authority
Controlled area	any area in which specific protection measures and safety provisions are or could be required for: (a) controlling exposures or preventing the spread of contamination during normal working conditions; and (b) preventing or limiting the extent of potential exposures

Curie (Ci)	The activity of a quantity of radioactive material in which 3.7 x 10^{10} atoms are transformed, or decayed, per second. Although used as a unit of quantity, the curie does not relate to the mass or volume of radioactive material; it is a measure of activity. When considering human protection from radiation produced by radiographic activities, a single curie is considered a large amount of activity. 1 Ci = 3.7 x 10^{10} Bq.
Dose equivalent	the absorbed dose, taking into account its effect on body tissues, measured in units of sievert (Sv) in the SI system. The Sv is the dose equivalent when the absorbed dose (Gy) multiplied by dimensionless factors related to biological effects equals one joule per kilogram (1000 millisieverts [mSv] = 1 Sv). The traditional symbol name is rem and conversion factor is 1 rem = 0.01 Sv = 10 mSv.
Exposure to X-rays	measured in units of coulomb per kilogram (C/kg). The C/kg is the exposure when X- or gamma rays produce one coulomb of electrical charge per kilogram of dry air. The traditional symbol name is roentgen (R) and conversion factor is 1 R = 2.58 x 10^{-4} C/kg
Gamma emitter	an atom that after a decay reaction emits energy in the form of a very high-energy electromagnetic radiation pulse (gamma ray). Cesium-137, used in nuclear gauges, is an example of a gamma emitter.
Half-life	the amount of time for a radioisotope to decay to one-half its original amount. For example, tritium (H-3) has a half-life of approximately 12.3 years. If one starts with 100 units of H-3, in one half-life (or 12.3 yrs) 50 units remain; in two half-lives (24.6 yrs) 25 units remain
High radiation area	an area where a major portion of the body could receive a dose equivalent to an excess of 1 mSv (100 millirem [mrem]) in any one hour at 30 cm (1 ft) from the radiation source or from any surface that the radiation penetrates
Industrial radiography	sometimes called field radiography, refers to radiography conducted on materials of construction to identify potential internal flaws (e.g., metal castings or welds)
Leak test	the process of assessing a sealed source to determine if the source housing is intact and no leakage of the source material has occurred.
Loose or unsealed source	any radioactive material that is not a sealed source
Millicuries (mCi)	a unit of radioactivity where 1 millicurie = 0.001 Curie; 1 Curie = 1,000 millicurie.
Physical inventory	the process by which a site or facility helps ensure and confirms the presence and location of an active or stored source.

Radiation area	an area where a major portion of the body could receive a dose equivalent to an excess of 0.05 mSv (5 mrem) in any one hour at 30 cm (1 ft) from the radiation source or from any surface that the radiation penetrates
Rem (R)	acronym for Radiation Equivalent in Man. A unit of dose equivalent. One rem is equal to Q times the number of rads (a measure of absorbed dose), where the factor Q is dependent on the type of radiation which is being absorbed. For beta and gamma emitters, Q = 1; for alpha emitters, Q = 20. One rem, assuming Q = 1, is equal to 0.01 Sievert.
RSO	Radiological Safety Officer
RSP	Radiological Safety Program
Sealed source	sealed sources are usually small metal containers in which a specific amount of radioactive material is sealed. They may also be inert metals or plastic onto which a thin film of radioactivity has been attached, known as plated sources. Some sources may be alpha, beta, gamma, or a combination of these emitters. Radioactive sources come in a variety of shapes and sizes, from "button sources" used for calibrating instruments to much larger sources used for measuring the moisture content of soil and for measuring density or thickness of materials. Sealed sources may have as little activity as a fraction of a millicurie (mCi) and as much as hundreds of curies (Ci). Sealed Sources are usually enclosed within housing or on plating that prevents the escape of the radioactive source material. As long as they remain sealed, the housing remains intact, and the devices are handled and used properly, the devices do not present a significant contamination hazard from the radioactive source material within. In fact, manufacturers of these devices must demonstrate their protectiveness in order to receive a license to manufacture and sell them. However, they may present a significant external exposure hazard depending upon the properties of the radionuclide and the amount of activity present.
Shielding	physical barriers, such as sealed source housings (e.g., lead and Lucite®) used to reduce exposure to the energies emitted from radioactive source material and to contain the source material to prevent contamination of the local environment and area personnel.
Shutter	a mechanism equipped on some sealed sources that controls the emission of the radiation beam from the source housing.
Sievert (Sv)	an SI-derived unit of dose equivalent. 1 Sv = 100 rem
Source	a radioactive material or a radiation generating plant or equipment, also called an ionising radiation source or radioactive source
Source material	the actual radioisotope (or radioactive material) encased inside the housing or on the plating of a sealed source.

Supervised area	any area not already designated as a controlled area but where occupational exposure conditions are kept under review even though specific protection measures and safety provisions are not normally needed

For any other term or acronym used in this procedure, definitions as given in HZL PSM standard will be applicable.

5. Responsibilities

Location Head

- Help ensure adequate commitment of resources to implement and sustain the elements of this standard
- Assign a competent person as zone champion to drive and oversee the implementation of this standard
- Confirm that all business decisions involving Hazardous chemicals include assessing the risk of handling and storage operations to personnel, the public, the environment, and the site so that the interests of each are appropriately protected
- Shall appoint sites RSO (Radiological Safety Officer)
- Promote the value of elements contained in this standard

Unit Head

- Ensure that the handling and storage of hazardous chemicals is consistent with this standard
- Assign a competent person as UIC member to drive, administer and overlook the implementation of this standard in his / her unit
- Help ensure that adequate levels of experience and expertise in handling and storage of hazardous chemicals are maintained on-site
- Support the zone champion of this standard, Zone PSM sub-committee and Zone Apex committee in effective implementing this standard in his / her unit
- Support the UIC member (and Zone Champion, if applicable) and make him or her available to participate in activities pertaining to implementation of this standard
- Promote the value of elements contained in this standard

Line Management

- Line management of each site has the responsibility to effectively implement this standard and ensure compliance.

Zone PSM Sub-committee

- Responsible to oversee and provide guidance for the implementation of this standard at sites
- Support the zone champion and UIC member in effective implementing this standard
- Conduct periodic self-audits against compliance of this standard.

Zone Champion

- Drive, oversee and provide guidance for the implementation of this standard at his / her zone
- Attend regularly zone PSM sub-committee meeting
- Communicate the compliance status, progress and concerns on implementation of this standard to zone PSM champion / location head / unit head
- Maintain a database that contains a record of all activities pertaining to implementation of this standard at zone
- Analyze internal the company and external industry incident investigation key learnings and trends for the applicable hazardous chemicals
- Be aware of and share information about the latest safety technology (e.g., personal protective equipment, materials of construction, instrumentation, monitoring devices, and mechanical integrity methods).
- Develop and maintain a comprehensive audit program for the zone against this standard

UIC Member

- Drive, oversee and provide guidance for the implementation of this standard at his / her unit
- Apprise zone champion and unit head of the compliance status, progress and concerns on implementation of this standard at his / her unit
- Maintain a database that contains a record of all activities pertaining to implementation of this standard at site
- Analyze internal the company and external industry incident investigation key learnings and trends for the applicable hazardous chemicals
- Be aware of and share information about the latest safety technology (e.g., personal protective equipment, materials of construction, instrumentation, monitoring devices, and mechanical integrity methods).
- Develop and maintain a comprehensive audit program for the site against this standard

PT Leader

- Ensure that MSDS of hazardous chemicals are available, accessible to all users and regularly undated.

Site SHE leader

- Ensure that all Hazardous Chemical used within the site have been identified
- Help ensure that audits are conducted against this standard
- Help ensure effective Management of Change followed for any change involving handling and storage of hazardous chemicals
- Help ensure that baseline risk evaluations for handling and storage of hazardous chemicals are conducted and written SOPs/SWPs are developed based on that and implemented effectively

Site Logistics

- Help ensure effective selection and periodic review of transportation carriers / containers involving hazardous chemicals

All personnel who are exposed to hazards of hazardous chemicals

- Ensure the compliance with the requirements of this standard pertaining to his / her job functions in accordance with any information, training or reasonable instruction provided to him / her
- Use the PPE as required by the Site Procedures in accordance with any information, training or reasonable instruction provided to him / her
- Responsible for his or her own safety and for the safety of others who may be affected by his / her work

6. Standards/Guideline

6.1 General Guidance for Control of Hazardous Chemicals

6.1.1 Classification of hazardous chemicals

The classification of Hazardous Chemicals as recommended by the UN Committee of Experts on the Transport of Dangerous Goods (UNCETDG) has been widely adopted and used for transport and handling of Hazardous Chemicals. In India, recommendations of the TDG committee of Experts have been incorporated in the Motor Vehicle Rules, 1989 for the purpose of classification of Hazardous Chemicals.

Under this system, Hazardous Chemicals are assigned to one of nine classes according to the hazard or the most predominant of the hazards they present. Some of these classes are subdivided into divisions according to appropriate criteria. These classes and divisions are:

Class 1: Explosives

Division 1.1: Substances and articles which have a mass explosion hazard

Division 1.2: Substances and articles which have a projection hazard but not a mass explosion hazard

Division 1.3: Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard

Division 1.4: Substances and articles which present no significant hazard

Division 1.5: Very insensitive substances which have a mass explosion hazard

Division 1.6: Extremely insensitive articles which do not have a mass explosion hazard

Class 2: Gases

Division 2.1: Flammable gases

Division 2.2: Non-flammable, non-toxic gases

Division 2.3: Toxic gases

Class 3: Flammable liquids

Class 4: Flammable solids; substances liable to spontaneous combustion; substances which, on contact with water, emit flammable gases

Division 4.1: Flammable solids, self-reactive substances and solid desensitised explosives

Division 4.2: Substances liable to spontaneous combustion

Division 4.3: Substances which in contact with water emit flammable gases

Class 5: Oxidising substances and organic peroxides

Division 5.1: Oxidising substances

Division 5.2: Organic peroxides

Class 6: Toxic and infectious substances

Division 6.1: Toxic substances

Division 6.2: Infectious substances

Class 7: Radioactive material

Class 8: Corrosive substances

Class 9: Miscellaneous dangerous substances and articles, including environmentally hazardous substances.

The numerical order of the classes and divisions is not that of the degree of danger.

For further details and explanations on classification of Hazardous Chemicals, refer **Annexure-1**.

6.1.2 Assignment of packing groups

Hazardous chemicals of all classes and divisions except of Class 2, Division 6.2 and Class 7 are allocated among the three packing groups according to their degree of hazard in transport as follows:

(a) **Packing group I:** Substances and preparations presenting high danger

(b) **Packing group II:** Substances and preparations presenting medium danger

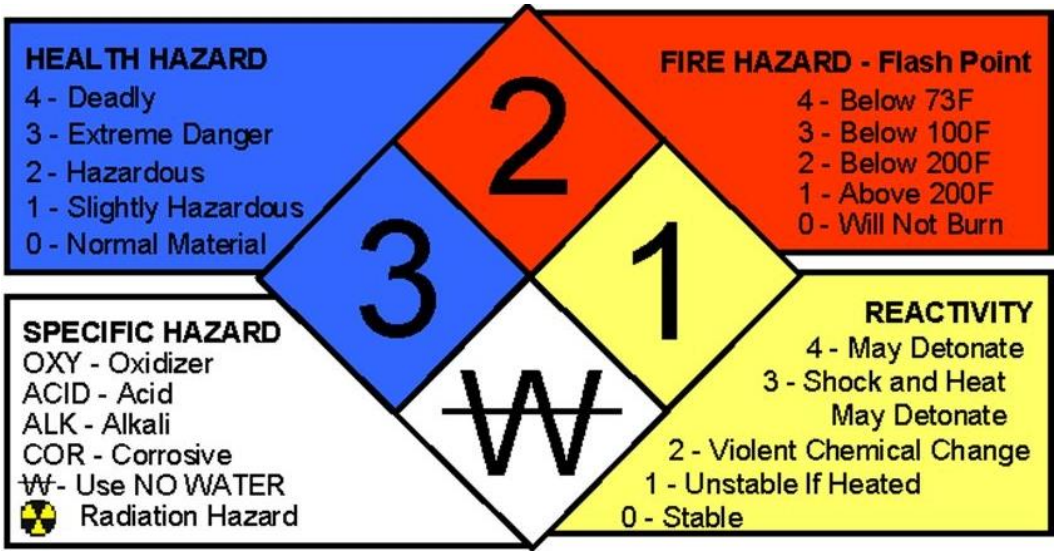
(c) **Packing group III:** Substances and preparations presenting low danger

6.1.3 NFPA 704: Pictorial representation of hazard

NFPA 704 is a standard maintained by the National Fire Protection Association of USA. It defines the **NFPA diamond symbol** which is universally accepted and followed as a standard HAZCOM signage for handling, storage and transportation of hazardous substances.

It is used by emergency personnel to quickly and easily identify the risks posed by hazardous materials. This helps determine what, if any, special equipment should be used, procedures followed, or precautions taken during the initial stages of an emergency response.

In 4-Colour Diamond system of communication of Hazards as shown in the figure below, the four divisions are color-coded with red indicating flammability, blue indicating level of health hazard, yellow for chemical reactivity, and white containing codes for special hazards. Each of health, flammability and reactivity is rated on a scale from 0 (no hazard) to 4 (severe risk) in the ascending order of hazard intensity.



These Fire Diamond in sign form are found on the outside doors or walls and the inside of many facilities that use chemicals in their daily processes. As per NFPA, signs be located in the following locations: (1) Two exterior walls or enclosures containing a means of access to a building or facility; (2) Each access to a room or area; (3) Each principal means of access to an exterior storage area. Access, configuration, size, location and construction of the building will factor in the location and number of signs required.

Refer **Annexure-2** for explanatory details on NFPA diamond.

6.1.4 HAZCHEM Code

A Hazchem Code offers guidance on appropriate initial emergency response in a potentially dangerous situation such as leakage, spillage or fire involving the dangerous goods to which it relates.

The Hazchem Code is fully titled “Hazchem Emergency Action Code”. It is now frequently referred to simply as “Emergency Action Code” or “EAC”.

The HAZCHEM Code provides *advice* on:

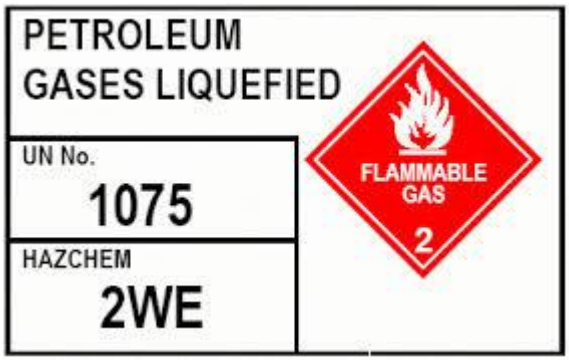
(a) The type of medium to be employed in combating incident caused by a dangerous substance where product has escaped, been spilt or is involved in fire.

(b) Possible violent reaction and hazard posed to the local population.

(c) Type of personal protection to be worn by persons combating the incident.

The Central Motor Vehicle Rules requires that the vehicles transporting hazardous chemicals to display Emergency Information Panel (EIP). The EIP requires display of Hazchem code.

The HAZCHEM Code *consists* of either two or three characters, the first being a numeral, followed by either one or two letters.



Refer **Annexure-3** for explanatory details on Hazchem Code.

6.1.5 Globally harmonized system of classification and labelling of chemicals (GHS)

To address global differences and eliminate confusion, the United Nations (UN) has created the Globally Harmonised System of Classification and Labelling of Chemicals (referred to as ‘GHS’).

The objective of the GHS is to promote global consistency by ensuring that countries have the same:

- Criteria for classifying chemicals, according to their health, environmental and physical (i.e. hazardous) properties; and
- Hazard communication requirements for substance labelling and material safety data sheets (MSDS).

GHS is not a formal treaty; rather it is an international agreement which is not legally binding or enforceable. So far 72 countries have implemented (or adopted for implementation) the GHS. India has not yet implemented GHS, but rules to implement GHS are expected to be issued very soon.

Refer **Annexure-4** for further details on Hazchem Code.

6.1.6 Thresholds

It is necessary to identify and meet regulatory requirements and/or any national or internationally accepted standards, wherever applicable, which are relevant in relation to the volume or tonnage of hazardous chemicals and occupational exposure limits for hazardous chemicals handled and/or stored at HZL sites.

6.1.7 Site inventory

i. A list (e.g., spreadsheet or database) of the materials that are present on the site and covered by this standard shall be maintained. In addition to production chemicals, support chemicals including chemicals used for maintenance and cleaning should also be included in the inventory. The list shall include the inventory of hazardous chemicals stored on the site as well as inventory of hazardous chemicals present in transport vehicles. An example template of Hazardous Materials Inventory is provided in **Annexure-5.**

ii. Sites shall establish and maintain a list of hazardous chemicals storage points (tanks, drum stores, storage yards etc.) present on the site (including redundant and empty tanks). The list shall include the maximum allowable inventory / capacity of the storage points, and an up-to-date (as applicable) assessment of the conditions of tanks.

iii. Hazardous chemicals storage points should also be marked up on the plan layout along with color coding of the area for the associated primary hazards (for e.g. red zone for flammable etc.). This marked up plant layout should be prominently displayed at key locations such as plant control rooms, fire control room, emergency control cell etc.

6.1.8 Process safety management

Storage, handling, loading and unloading facilities of hazardous chemicals shall be covered by Process Safety Policies, Standards, and Guidelines [including Statutory requirements] to determine and implement additional requirements for specific chemicals including but not limited to:

- providing adequate ventilation and lighting
- controlling ignition sources
- segregating from other hazardous materials
- storing away from heat and direct sunlight (may impact and degrade chemicals, deteriorate storage containers and labels)
- ensuring lids, caps and drain points are securely tightened
- suitable personal protective clothing and equipment required
- the type of drainage
- overfill protection
- containment and disposal required for inadvertent spills
- location of loading spots relative to other flammable liquid storage tanks
- the use of tank car access platforms for top loading or unloading,

- using flammable storage lockers /containers to store flammable and combustible liquids
- storing inorganic acids in corrosive or acid storage cabinets
- emergency response
- developing chemical and site specific SOPs
- the facility design itself

This standard establishes the minimum requirements and provide general guidance for safe storage and handling of hazardous chemicals.

6.1.9 Procurement of hazardous chemicals

A hazardous chemical approval process should be established for all procurement of hazardous chemicals. All hazardous chemicals brought to site by contractors should be identified prior to the work commencing.

Before accepting delivery of hazardous chemicals, the responsible person must ensure that:

- Work instructions / SOPs are available and being used for loading and unloading
- All chemicals are adequately labelled and MSDS available, and any damaged packages are returned to the supplier
- A review is undertaken to ensure that operations can respond to emergency incidents during loading and unloading, storage and use of the hazardous material
- All equipment required, including PPE, is available and the involved people have been trained in the correct use of the equipment
- Deliveries are only made to a supervised operation
- Consignment documentation is signed by an authorised operation's receiver (as far as is practicable)
- When bulk substances are received, the receiving container is correct, can contain the volume delivered, and is sufficiently clean for filling with the product being delivered

Any new hazardous chemical or a hazardous chemical with change in specifications shall be procured through MOC.

6.2 Material safety data sheet (MSDS) or Safety data sheet (SDS)

The hazards are identified from a MSDS / SDS which provide information on materials in a standardized format including chemical, safety, health and environmental hazards, safe handling and storage. Each site shall be responsible to establish for providing a system (preferably electronic system) to store and access MSDSs.

6.2.1 Availability of information to personnel

i. MSDSs shall be readily available to personnel in each area where the chemicals are used and they must be available in the appropriate local language(s).

ii. Personnel must know where to find MSDSs and how to read them. Where electronic versions of SDSs are provided, employees must be able to use a computer that is able to access the documents.

iii. A complete set of the MSDSs should be easily accessible to the occupational health resource and emergency response personnel and should be maintained and available at all times.

iv. Sites should maintain a backup system for SDSs in the event the primary means of access is unavailable. The backup system should be easily accessible to the site emergency response personnel, occupational health resource, occupational health service providers, and environmental resources.

6.2.2 Contents

i. MSDS format and content may be specified by local regulations. However, it is recommended that sites should use the internationally agreed 16-section ISO format provided in **Annexure-6** (in the form of checklist). This format is consistent with ANSI Z400.1-2010, ISO 11014-1, and GHS.

ii. MSDSs must be requested from the supplier before delivery and shall also be reviewed. Contact the vendor if data on the MSDS appears to be in conflict with what is known about the material and request that they provide a recently reviewed MSDS document.

iii. Vendor MSDSs shall be reviewed periodically to verify the most recent version is in the MSDS system. All hard copies of MSDSs that are retained shall be reviewed periodically by the person(s) who maintain them to confirm that each MSDS is up-to-date (i.e., by the site and/or area, as appropriate). Significant changes (e.g., toxicology data, exposure limits, and first-aid) shall be entered on MSDSs as soon as the information is received and no later than 90 days after the change is known.

6.2.3 When MSDS is required

Each hazardous chemical used or manufactured on the site must have an associated MSDS, either obtained from a supplier or developed by HZL. Examples include the following:

- All chemicals made or used in operations, including pilot plant or process development operations (e.g., raw materials, finished materials, intermediates, by-products, waste, and water-treatment agents) Process related isolated intermediates, including materials in storage or in discreet process equipment
- Maintenance materials (chemicals) and industrial cleaning agents
- Chemicals that present special hazards under fire conditions (e.g., oxygen), or other special hazards (e.g., asphyxiants)
- Fungicides, rodenticides, and herbicides
- *Chemicals intended for household and other cleaning agents, consumer paints, inks, and greases shall be included in the SDS system, unless they are only used in a normal consumer manner and in normal consumer quantities.*

From MSDS, a suitable and sufficient risk assessment shall be conducted to ascertain the likelihood of that hazard to safety, health or the environment being realized.

6.3 Risk management

i. Sites shall identify all hazardous chemicals (and all associated hazards within the reasonably available knowledge) received and/or stored at or shipped from their sites and prioritize them for attention according to their hazard and potential risk, for additional risk assessment and controls, as applicable.

ii. Sites shall, at a minimum, qualitatively evaluate and consider HSE risk-management options for hazardous chemicals being stored, moved and handled on site, to and from local warehouse, and in the site's local area as per HZL PHA standard. Quantitative or semi-quantitative risk evaluation, as appropriate, should also be employed on selective risk scenarios having potential for major or catastrophic consequences so as to ensure that adequate controls are in place and the residual risk is acceptable.

6.3.1 Hazards identification

i. The primary source for identifying the hazards associated with hazardous chemicals shall be the MSDS which shall be read in conjunction with the container label. To assist in identifying the relevant common hazards and noting other important hazard information from MSDS, a checklist has been provided at **Annexure-7**. However, site should exercise care in using this checklist as:

- Some properties in isolation may not normally be regarded as hazardous, however may increase the risk in the peculiar conditions that apply to the particular storage and handling activity or the surroundings, and should therefore be regarded as hazards.
- Different forms of the same substance may present different hazards e.g. a solid may not present a hazard but in the form of dust of respirable particle size will be a respiratory hazard.
- Preparations (mixtures / solutions) may be more hazardous than the original chemical itself, may contain substances that present additional hazards.

ii. Potential external hazard sources that are not directly involved with the storage and handling of a hazardous chemical, but may constitute a hazard for that storage and handling resulting in higher or additional risks shall also be identified. For e.g. any adjacent storage and handling of some other hazardous chemical, vehicle movements, possible extreme weather conditions etc.

iii. Additional information regarding hazards and risks associated with the use, handling and storage of hazardous chemicals can be obtained from the following sources:

- Incident records
- Previous risk assessments
- Consulting with the suppliers and employees
- Walking through and thoroughly inspecting the premises and the activities & methods of storage and handling
- Discussing risks with occupiers of nearby premises and the safety / emergency services / occupational health personnel

- UN Recommendations for the Transport of Dangerous Goods
- UN GHS
- Hazardous Chemical Information System (HCIS) - Safe Work Australia
- European Chemical Substances Information System (ESIS)
- Websites of Indian regulatory authorities
- International authoritative websites, such as those of international work health and safety agencies such as US Occupational Safety and Health Administration (OSHA), US Environmental Protection Agency (US EPA), European Commission Joint Research Centre's Institute for Health and Consumer Protection

6.3.2 Risk prioritization

In general, the following guidance may assist the sites in prioritization of hazardous chemicals for risk assessment and reduction activities. The site inventory and the volume of chemical handling (i.e. bulk vs. non-bulk) may also be considered in the prioritization.

i. The highest priority should be for the risk reduction of those chemicals with the potential to have widespread and significant adverse effects on human health and life, should an incident involving release of chemical occur. These are defined based on toxicity and vapor pressure and are designated as Highly Toxic Materials (HTMs). They include highly as well as extremely toxic chemicals classified under class 6 of Hazardous Chemicals Classification.

ii. After the HTMs, the next level of priority should most often be other toxic-by-inhalation (TIH) chemicals that do not meet the strict definition of HTMs. These may be treated by the site with the same focus on risk reduction as for the HTMs. They include toxic chemicals classified under class 6 of Hazardous Chemicals Classification.

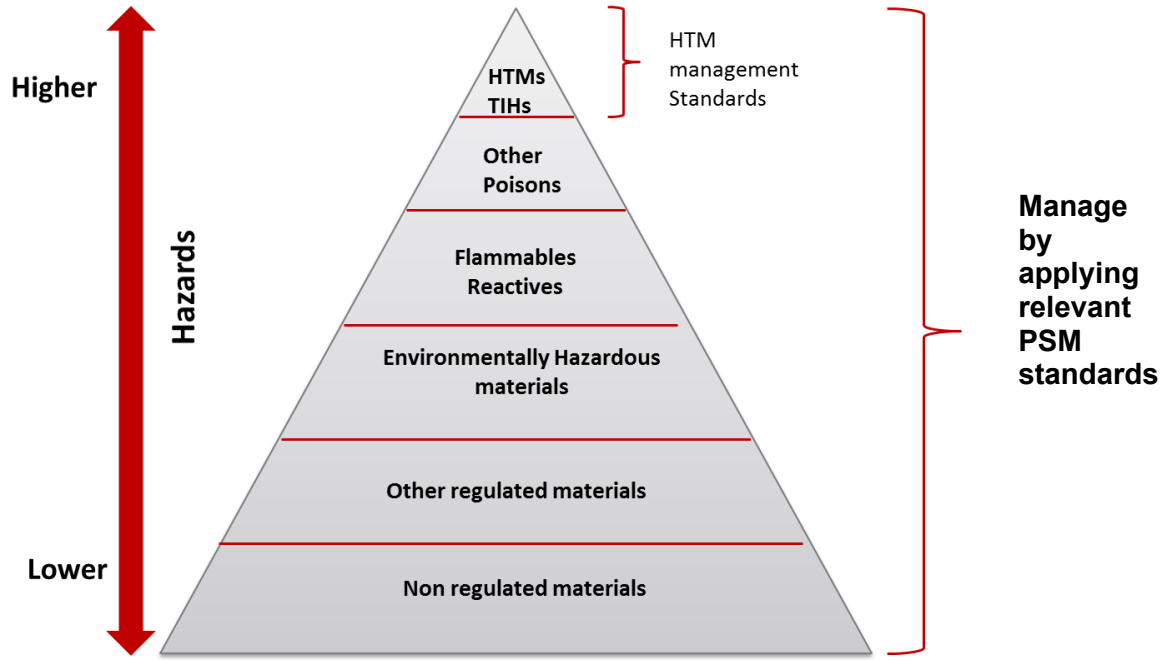
iii. Other poisons, especially those that may have strong public perceptions and concerns should also receive high priority for risk control.

iv. Next are chemicals such as flammable gases and potentially reactive or polymerizing materials that may require special attention as they could also result in high consequence events.

v. Environmentally hazardous chemicals may also warrant higher priority attention, depending on their potential to cause serious damage to the environment, and potential consequences from a spill (including complexity and success of remediation).

vi. Other regulated materials and non-regulated materials generally receive lower priority for risk assessment and controls (above strong set of baseline standards). However, on occasion a material that would not otherwise receive higher priority may be elevated due to special concerns. These might be based on public perception or perhaps a security concern, such as theft or potential deliberate misuse.

The following pyramid illustrates the recommenced prioritization scheme for handling and storage of hazardous chemicals that may be used by the sites:



6.3.3 Risk assessment

i. A range of descriptive, qualitative, and quantitative tools may be used for risk assessment. However, as a minimum, JSA and/or HAZOP/What if, as applicable, shall be utilized for carrying out risk assessment.

ii. The type and depth of risk assessment that should be conducted will depend on the nature of the work being performed and hazards of chemicals.

a) **Basic assessment** shall consist of reviewing the label and MSDS of the hazardous chemicals and assessing the risks and control measures involved in their use by JSA. Basic risk assessment may be undertaken for low risk chemicals provided the hazards and associated risks are well-known and have well established and accepted control measures.

b) **Generic assessment** may be conducted by a particular site for a chemical or identical chemical that is handled and stored by multiple sites. The generic assessment can then be horizontally deployed to other sites. A number of different hazardous chemicals may also be grouped for generic assessment on the basis of their form, properties and the way they are used or handled. Generic assessment shall consist of JSA as well as HAZOP/What If (as applicable).

When conducting a generic assessment, it is important that the workplace, tasks and hazardous chemicals being assessed are identical in characteristics, properties, potential hazards and risks. Generic assessments are not appropriate for high risk chemicals and should be avoided.

c) **Detailed assessment** may be needed when there is a significant or uncertain risk to health and life, and for high risk chemicals such as highly toxic or flammable chemicals, carcinogens, mutagens, reproductive toxicants or sensitization agents etc. In order to complete a detailed assessment, further information / expertise may be sought and it

may be necessary in some cases to engage external professional assistance to undertake a more detailed assessment.

iii. Both physicochemical and health (immediate or long term) risks shall be considered in risk assessment.

iv. Following things shall be considered in assessing health risks:

- The routes of entry by which the chemical can affect your health
- The physical form and concentration
- The chemical and physical properties of the substance
- Determining who could be exposed, and when this could occur
- How often is exposure likely to occur and for how long?
- What is the estimated exposure to hazardous chemical?
- Complying with exposure standards

v. Prevailing work practices and conditions should be examined in consultation with and observing workers.

Workers may sometimes not adhere strictly to standard operating procedures for certain tasks. This could be because they have devised a more efficient and/or safer method for performing that task, or because the control measures or PPE provided make it cumbersome and difficult. Workers should be encouraged to share their views and concerns on working practices and be involved in discussions on how to improve working methods. Also, it is good practice to find out what changes in workplace activities occur during cleaning, maintenance, breakdowns and during staff absences or shortages.

vi. Risk assessments may be broad and cover multiple aspects of the handling and storage operations or may focus on specific issues such as container design or emergency response.

6.3.4 Risk control

i. Identified risks associated with hazardous chemicals must be managed by the hierarchy of control:

- Sires must always aim to eliminate a hazard and associated risk first. If this is not reasonably practicable, attempt should be made to find suitable less hazardous alternate chemicals. The inventory of all hazardous chemicals for that matter must be kept as minimum as possible.
- Where the above do not achieve the necessary risk reduction, the risk must be minimised by using one or more of the following approaches:
    - **Isolation** (Use of closed systems, placing a process, or a part of it, within an enclosure, isolating hazardous areas with access control, separation of hazardous chemicals from other incompatible chemicals or workers or occupied buildings etc.)
    - **Implementing engineering controls** (automation, interlocks, ventilation, containment etc.)

- **Administrative controls** (SOPs, reducing the duration and/or frequency of workers' exposure etc.)
- **Use of Personal protective equipment (PPE)** as a last resort when all other reasonably practicable control measures have been used and the risk has not been eliminated, or as interim protection until higher level controls are implemented. For some high risk activities, such as spray painting, abrasive blasting and some emergency response actions, PPE should always be used to supplement higher level control measures.

ii. Substances or preparations that contain substances, that are classified as carcinogens, teratogens, mutagens or sensitisers must not be introduced unless no suitable alternative can be found. The handling and storage of these substances, which pose very high risks to health, must be strictly controlled.

iii. Appropriate risk-management activities should be determined through site Apex committee reviews in consultation with Site and corporate PSM sub-committee, as appropriate.

iv. The risk-management options may be chemical specific or general (for e.g., signs on local roads to indicate preferred route into plant or plant signs that direct truck traffic to avoid low overhangs and tight turns).

v. Sites should consider taking additional measures, as required, to reduce risk for high risk activities. Most of additional measures will require management of change (MOC) for implementation.

vi. Sites shall ensure that control measures implemented are properly used and maintained in good condition by regular inspection/audits, overhauling and testing as applicable.

vii. Control measures shall be reviewed (and revised if necessary) as per HZL risk management practices to ensure their effectiveness.

6.4 Specific control measures

This section provides information on key control measures that should be considered when managing risks from handling and storage of hazardous chemicals. The information provided in this section is general in nature and aims to provide an understanding of the principles involved in managing the risks. Additional control measures may be required based on risk assessment / process safety reviews.

6.4.1 Design and maintaining mechanical integrity

i. Proper design and maintaining its mechanical integrity is the most effective control measure to reduce risk to an optimal level. The storage and associated handling facilities shall be designed, inspected and maintained as per applicable HZL and/or internationally established RAGAGEP (Recognized and Generally Accepted Good Engineering Practices).

ii. It shall be ensured that there is provision of material-specific storage for extremely hazardous or reactive materials. Selection of materials of construction shall compatible with hazardous chemical stored for all parts of storage and delivery systems.

iii. Tanks shall not be reused for different products for which they are not designed, without MOC and ensuring material compatibility.

6.4.2 Segregation of hazardous chemicals

i. To prevent dangerous interaction, hazardous chemicals shall be kept apart (segregated) from all other chemicals with which they are not compatible. The inadvertent mixing of inventory can produce toxic vapor/gas, fire or explosion.

ii. Segregation can be achieved by storing and handling incompatible goods in separate areas or by the use of physical barriers or distances within the same area.

iii. A number of international guidelines are available for separating chemicals and should be referred while evaluating the storage of hazardous chemicals. For e.g. useful guidance for segregating incompatible dangerous goods is provided in Australian/New Zealand Standard AS/NZS 3833 “The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers”.

iv. As a minimum, stored chemicals should be separated into the following categories:

I. Flammables

II. Oxidizers

III. Corrosives

IV. Acids

V. Bases

VI. Highly Reactive (such as organic peroxides)

VII. Toxics

VIII. Low Hazard

v. **Annexure-7 & 8** should also be referred which prescribes some additional precautions to segregate the storage of hazardous chemicals.

Note- *While the above methodology is simple to implement, it is important to take the actual hazards of the various chemicals into account when determining storage hierarchy as many chemicals have multiple hazards resulting in the potential complexities in storing multiple chemicals together.*

vi. Acids shall not be stored with reactive metals, including sodium, potassium and magnesium and sodium cyanide, iron sulfide, calcium carbide and other compounds that can react to produce toxic fumes/gases.

vii. Flammable, highly flammable and extremely flammable substances shall not be stored with any other types of hazardous substances. Special attention is required in case of Oxidizing and Water Sensitive Substances which must be stored away from all flammable materials even if they are only slightly flammable. This will ensure that they would not contribute to a potential fire and so any fire with common flammables can be extinguished using common suppression methods. Attention shall also be paid to any chemicals that have temperature sensitivity either high or low. This is especially true for organic peroxides some of which become instable at normal ambient temperatures.

viii. Water Sensitive Substances: These substances react with water or steam to produce flammable or explosive gases and evolve heat, e.g. Conc. acids like sulphuric acid, glacial ethnoic 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.

ix. Explosives shall not be stored in close proximity to any other hazardous substance.

x. Toxic substances shall be evaluated more stringently and shall not be stored with any other substance except harmful and irritant substances.

xi. A flammable toxic should be isolated even within its storage area to prevent accidental release.

xii. Oxidizing material must be kept away from substance which are reducing agents.

xiii. When segregating incompatible chemicals, potential of mingling of spilled materials through secondary containment, drains or sewers shall also be evaluated.

xiv. As a general rule, hazardous chemicals should not be stored above or below other goods with which they may interact.

xv. Sites shall develop and enforce procedures, and personnel involved in the storage and handling of hazardous chemicals be trained and supervised to ensure segregation is maintained at all times.

xvi. Regular cleaning of chemical storage areas and their surrounding must be ensured to avoid developing unsafe conditions.

6.4.3 Separation by physical means

i. Risks shall be minimized by physical separation / isolation of hazardous chemicals from other work areas, other hazardous chemicals storage and handling areas, potential ignition sources, occupied buildings, people and other property. Isolation may be achieved by distance, the use of effective barriers or a combination of both.

ii. As far as practicable, separation distances should be determined and applied in such a way that the resultant risk, as determined through the risk assessment process would not require the application of additional control measures.

6.4.4 Secondary containment

i. All spills of hazardous chemicals, other than gases, shall be contained on the site by the installations of physical spill containment devices.

ii. All storage containers shall be placed in, or on, a suitable secondary containment system. Secondary containment shall allow the controlled recovery or treatment of any spilled materials. In the event of a fire, this shall reduce the risk of burning liquids spreading.

iii. The minimum volume of the secondary containment shall be as per the following table:

Type	Minimum secondary containment volume

Single Drum	Secondary containment for drum storage can be provided by a drip tray or any other method with at least 25% of the volume of the drum
Multiple Drums	Secondary containment for drum storage can be provided by a drip tray or any other method with at least 25% of the total drum storage
Single IBC	Secondary containment must be at least 110% of the container volume
Multiple IBC	Secondary containment with a minimum of either 25% of the total volume of the containers or 110% of the largest container, whichever is greater volume.
Tank	110% of tank volume
Multiple tanks	If there is more than one tank stored in the system, the secondary containment must be capable of storing 110% of the biggest tank's capacity or 25% of the total capacity (and combined tank storage volume in above-ground tanks equal or greater than 1,000 litres), whichever is greater.

iv. For large external stores, 25% containment may result in low containment walls. These may be quickly overwhelmed by rainfall or fire-fighting agents. An additional 100mm height on the walls should be considered to provide additional support.

v. Where containers are stored inside buildings, it is recommended that facilities should be designed proportionate to the risk.

vi. Containment methods include a bund (which can be around, incorporated into, a storage facility). For containers it can be a drip tray, dispensing sump trolley, sump pallets, bunded dispensing station, decking, drum racking (internal or external) with integrated bund, dedicated internal / external store with containment and any other system that will prevent a spilled product escaping.

vii. The construction of the secondary containment systems shall be suitable for the materials being stored. Systems can be prefabricated from steel, plastic, fibre glass or built from in-situ concrete or masonry bund with suitable lining (impervious, chemically resistant material) to ensure no permeability. All walls and floors shall not be permeable and shall be resistant to degradation from materials stored.

viii. The location of secondary containment and storage needs to consider the following factors:

- Minimising risk of vehicle impact
- Preventing the build-up of rainwater in the containment which could be contaminated by drips, leaks or spills
- Reducing the risk of exposure to from extremes of temperature that could affect the contents or integrity of the containers.
- Flood plains including high tidal water levels

ix. If storage must be within these areas, suitable protection shall be provided such as bollards to protect storage areas from vehicle traffic, protection against rising flood waters, etc.

x. Where possible, secondary containment should be designed to prevent rainwater ingress for example a canopy or covered area. Where this cannot be achieved, rainwater ingress may occur and need to be ensure there are procedures in place. Where there is collected water, which may include potential spills or chemical residues, this will reduce the capacity and will need to be pumped (e.g. sump fitted to base) or bailed out in a controlled way. If there is the potential for it to contain hazardous materials, the waste should be disposed of appropriately.

xi. The secondary containment shall not be directly connected with any drainage. However, the dyke should have facility, as appropriate and applicable, to:

- drain off / pump out rain water
- route high volume spillage / leakage to suitable neutralizing pit nearby
- discharge safe effluent to oily water system

xii. Electricity (e.g. electrical cables) should be carried over the secondary containment system and shall not penetrate it.

xiii. The secondary containment shall prevent contamination of groundwater or soil.

xiv. See **Annexure- 13 and 14** for some examples

6.4.5 Control of ignition sources

Ignition sources can be any energy source that has the potential to ignite a fuel. They can be categorised into three broad types: flames, sparks and heat. Some common examples of ignition sources are provided below.

Common examples of ignition sources

Type of ignition source	Examples
Flames	• Welding flames, Oil or gas heaters, pilot lights, lighters and matches • incandescent materials such as glowing coals or lighted cigarettes, cigars and pipes
Sparks	• Welding arcs, starters for fluorescent lighting, arcing contacts on electric motors and switchgear, electrical equipment like power points / lighting, cigarette lighters, switches and telephones • radio transmitters and mobile phones • Static electricity including from friction sources • Lightning • vehicle exhausts • Friction from drilling, grinding, scraping of metal on concrete

Heat	• Hot surfaces including light bulbs, ovens, radiators or heaters, flue pipes • vehicle engines and exhaust systems, pumps and generators • Exothermic chemical reactions (those which generate heat)

Hazardous chemicals storage and handling areas where flammable or explosive atmospheres may be present, shall be free of potential sources of ignition, except under controlled conditions. This may be achieved by using one or more of the following approaches:

- Separation and segregation (see section 6.4.2 and 6.4.3)
- use of intrinsically safe electrical equipment
- proper earthing of electrical equipment
- Provision of adequate grounding (earthing & bonding) for tank farms, transfer stations and other equipment to protect against electrostatic build-up on all metal (or other conducting) components. For example, some IBCs will have earthing strips and metals drums can be placed on an earthed metal plate when transferring or dispensing product.
- Lightening protection for tank farms
- use of flame arresting devices on vents from flammable storage containers
- Controlling ignition sources from vehicles such as use of spark arrestor on vehicle exhaust
- implementing administrative controls such as hot work permit, no smoking zone etc.

The auto-ignition temperature of the hazardous chemical should be considered while evaluating control of ignition sources as some hazardous chemicals may ignite spontaneously above certain temperatures.

6.4.6 Control of hazardous atmosphere

6.4.6.1 Reducing vapour emissions

Accumulation of vapours creates the potential for a hazardous area to exist. Vapour emissions resulting from storage and handling of hazardous chemicals can be minimised by using one or more of the following approaches:

- the use of enclosed transfer systems and vapour recovery connections
- keeping lids of containers open only for the minimum period required for transfer
- minimising exposed surface areas
- avoidance of splash filling
- minimising the temperature of liquids being transferred
- storing containers of hazardous chemicals away from sources of heat (for example heaters or other heating appliances). When heated, the vapour pressure of flammable and combustible materials may increase resulting in

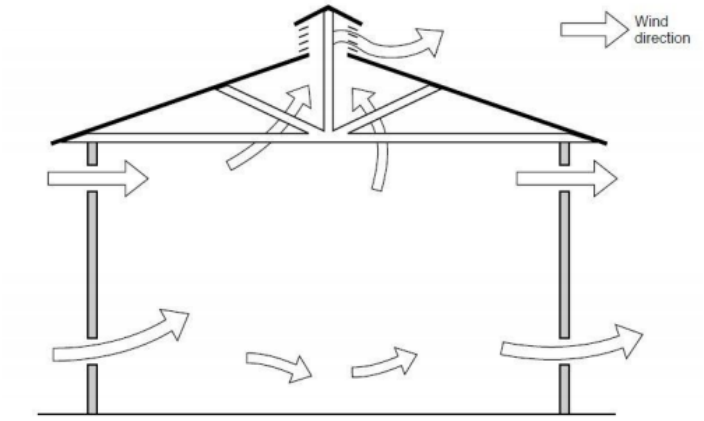
higher vapour emissions. Heat may also deteriorate packaging and increase the risk of failure of the container.

6.4.6.2 Ventilation

Ventilation is an important control measure of maintaining a safe atmosphere by the introduction or recirculation of air; by natural, forced or mechanical means in the storage and handling area of hazardous chemicals.

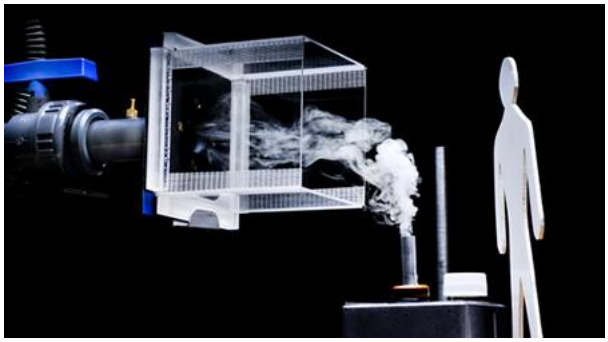
i. The storage and handling area of hazardous chemicals shall be well ventilated. Whenever it can be used and effective (for e.g. enough to ensure adequate ventilation of flammable substances), natural ventilation of the area by providing adequate openings to the open air is preferable to mechanical ventilation. In other circumstances, a general mechanical ventilation system may be required.

Example of the provision of natural ventilation through roof and wall vents from the *UK Health and Safety Executive (HSE) Publication HSG51.*



ii. Extraction ventilation such as Local exhaust ventilation (LEV), fully enclosed ventilation booth etc. should be used for effective control of highly hazardous airborne contaminants created in large quantities such as highly toxic contaminants or combustible dusts. LEV is applied close to the source of generation to remove airborne contaminants before they reach the breathing zone of workers in the area and is more effective than increasing general ventilation to dilute hazardous contaminants.

Example of LEV from *UK Health and Safety Executive*



iii. Ventilation systems should be suitable for the types of hazardous chemicals on the premises. For example, if a hazardous chemical has vapours which are denser than

air, these will accumulate in low lying areas. In this case, extraction of vapours should be from the lowest point and fresh air introduced from above.

iv. Exhaust gases and air should be discharged where it will not cause other hazards

v. To ensure the effectiveness and safe operations of ventilation systems, these should be designed in accordance with appropriate technical standards, and installed and maintained by qualified or experienced persons.

6.4.6.3 Purging

Purging involves introducing air or an inert gas into a confined space to displace oxygen and/or flammable, toxic or corrosive fumes.

i. Purging with inert gas is most commonly used above the liquid surface of reaction, mixing or bulk storage vessels to prevent surface oxidation or the formation of an explosive atmosphere.

ii. Purging of empty containers of hazardous chemicals with air or inert gas, as appropriate, may be required prior to maintenance or disposal activities.

6.4.7 Maintaining stability of hazardous chemicals

Some hazardous chemicals are inherently unstable, self-reactive or highly reactive, or they can become unstable under certain conditions during storage or handling.

i. It shall be ensured that the instability and reactions of such chemicals take place only under controlled conditions.

ii. To keep hazardous chemicals stable, sites should:

- follow manufacturer's instructions or instructions on the MSDS
- maintain specified proportions of ingredients, goods and other components that constitute the hazardous chemicals, for example phlegmatizers, diluents, solvents, wetting agents, desensitisers, inhibitors and/or other adulterants
- include a stabilising ingredient where appropriate
- keep the hazardous chemicals within any control temperature or pressure range where necessary
- keep the hazardous chemical and the packaging dry, unless the packages themselves are impervious to moisture.

iii. Some hazardous chemicals may provide an expiry date on the label. Where a chemical has passed its expiry date it should not be used but be disposed of in accordance with manufacturer's instructions and applicable regulations.

6.4.8 Impact protection

Appropriate control measures depending on the nature of risks shall be implemented for impact protection of storage tanks / containers including any attached pipe work or equipment.

i. Preferably, the handling and storage area of hazardous chemicals should be located away from trafficable areas and should only have controlled vehicle access. The

storage tanks / containers / storage racks including any attached pipe work or equipment should be fixed to stable foundations.

ii. Installation of crash protection measures, such as bollards and guardrails may also be considered as an alternative means of impact protection. These should be designed to absorb the energy of any reasonably foreseeable impact and minimise the likelihood of injury to anyone involved in the incident.

6.4.9 Transfer of hazardous chemicals

Transferring hazardous chemicals generally presents a far greater risk than for static storage. During the transfer process, the chemicals will frequently be unconfined at some stage of the transfer process that may include pouring or pumping from one container to another.

Following are the common methods that should be considered for eliminating or reducing risks during transfer operations:

- the use of enclosed transfer systems
- avoiding spillage or overflow, including overflow protection on receiving tanks
- providing emergency shut-offs to limit the amount of hazardous chemicals released during a loss of containment
- decanting of hazardous materials from or between drums or IBC's in accordance with an approved procedure
- providing a spill containment system
- reducing static electricity and vapour generation. This is particularly important for fire risk hazardous chemicals such as flammable liquids
- ensuring transfer fittings are compatible and fit for service
- avoiding sources of ignition
- installing flow and pressure regulators on pipe work or pumps
- installing interlocking of valves and switches
- implementing systems for detecting losses from pipe work and fittings, such as static pressure loss detectors, measurement to determine losses in transfer or external sensors.

Refer section 6.7 for more details.

6.4.10 Fire protection systems

Depending on risk assessment, appropriate fire protection system(s) such as fire extinguishers, hydrants, monitors, fire alarms, sprinkler systems etc. shall be provided at handling and storage areas of hazardous chemicals as per applicable HZL standards.

The fire protection system should have the capacity to quickly control and extinguish any fire that occurs involving the hazardous chemicals. It should also effectively protect the hazardous chemicals stored within the area from any nearby fire.

6.4.11 Drainage control

Surface water drains in the vicinity of hazardous chemicals handling and storage areas shall be protected to minimize risk of pollution and other risks associated with spreading of spillage through the use of protective pads, drain covers, isolation etc.

i. Handling and storage areas of hazardous chemicals should be impermeable and isolated from surface water drainage systems. The use of ramps, sumps or drainage shut-off valves should be used to minimise the risk of pollution.

ii. If surface water drains cannot be isolated, reusable drain covers should be used during delivery to prevent pollution if an incident occurs.

iii. If the area is external, a roof or canopy over the area may be used to help manage surface waters.

6.4.12 Access Control

i. *"Hazardous Chemical Designated Areas"* should be clearly defined to mark out if being used for: delivery, handling and transfer or decanting.

ii. These areas shall be declared a controlled (Prohibited / Restricted) Area with access only to authorized personal and shall be marked with appropriate signs or markings including warnings/precautions. These areas should be fenced and should have at least two exits.

6.4.13 Written work practices

Each site shall develop and implement site-specific written SOPs for all hazardous chemicals based on risk assessment. SOPs must include information on potential hazards, safety checks and controls in place, PPE, emergency response and handling, storage & disposal of wastes generated (if applicable), relevant checklists apart from the step by step procedure to safely complete the activities associated with storage and handling of a chemical including loading/unloading/transfer/filling as applicable.

Other site-specific procedures / safe work practices required for exposure monitoring and control, pollution control, management of MSDSs, management of spills and releases, control of ignition sources, access control, labelling & signage, hazard communication and compliance of any other provision contained in this standard or action item identified in risk assessment shall also be developed and implemented by each site.

These procedures shall be reviewed and updated at least annually, or earlier if required by a MOC, LFI (learning from incidents) or update in MSDS and/or associated risks.

6.4.14 Other administrative controls

Administrative controls should only be considered when other higher order control measures are not practicable, or to supplement other control measures.

Following are some common administrative controls, apart from written work practices and access control (see section 6.4.12 & 6.4.13), that should be considered for safe handling and storage of hazardous chemicals (as applicable):

i. Keeping only a minimum amount of liquid at the point of operation; only enough for use on one shift is a common rule. The main stock should be stored in a safe, isolated place.

ii. reducing the number of workers exposed to the chemical (for example by performing the task out of normal work hours or by restricting worker access to certain areas)

iii. reducing the duration and/or frequency of workers' exposure through specific work procedures (for example, job rotation)

iv. reducing quantities of hazardous chemicals through inventory reduction – this may include just in time ordering rather than storing large quantities of hazardous chemicals and prompt disposal of hazardous chemicals that are no longer required

v. reducing the period of time in which a chemical could escape into the work area (for example, by minimising the time that mixers, reactors or ovens are open to the environment both during and after use)

vi. safe work practices, including good housekeeping, including regular cleaning of work areas

vii. changing packaging material to minimise exposure during handling (for example purchasing liquids in ready to use packages instead of decanting from large containers)

viii. using vacuuming or wet methods to suppress dust that may be generated during dry sweeping

ix. keeping containers of hazardous chemicals tightly closed when not in use

x. cleaning up spills immediately

xi. prompt cleaning of residues from empty containers that have held hazardous chemicals

xii. prohibiting eating, drinking and smoking in potentially contaminated areas

xiii. providing washing facilities for rinsing off chemicals (e.g. hand washing, safety showers, laundering of clothes).

6.4.15 Personal protective equipment (PPE)

i. PPEs requirement shall be based on the type and amount of hazardous chemical, risks associated with handling and storage of that chemical, and existing control measures deployed. PPE must be suitable for the task being performed. Selection of the right type of PPE shall require consideration of the following factors:

- Information on PPEs to be used from MSDS
- Nature and level of the risks
- Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air
- Activity of workman and duration of work
- Comfort of workman when using PPE
- Operating characteristics and limitations of PPE
- Ease of maintenance and cleaning
- Conformity to Indian/International standards and availability of test certificate

At times a higher level of PPE may be required by the procedure or due to the task being carried out.

ii. Each site shall maintain an **Approved list of minimum PPEs** to be used for handling and storage activities of each hazardous chemical including any additional PPE requirements for specific tasks. All employees (including contractors) shall only use PPEs found on this list within the site.

iii. PPE requirements under expected routine or non-routine operating conditions for all handling and storage areas/tasks of hazardous chemicals shall be conspicuously and prominently displayed at the entrance of respective areas using appropriate signage and must be documented in respective SOP/Safe Work Procedure (SWP).

PPE display board

iv. PPEs shall be inspected prior to use and as appropriate during each use for defects such as holes, tears, scratches, signs of material deterioration, cracks, poor closure or any other sign of degradation which may affect the PPE performance. PPE with defects shall be immediately removed from service and replaced or repaired.

v. The selection, use and maintenance of PPEs shall be based on HZL PPE standards / guidelines. Refer **Annexure-9** as a general guide for PPE selection and use. **Annexure-10** gives general guidelines for selection of respiratory PPE for different types of Hazards.

6.5 Labelling

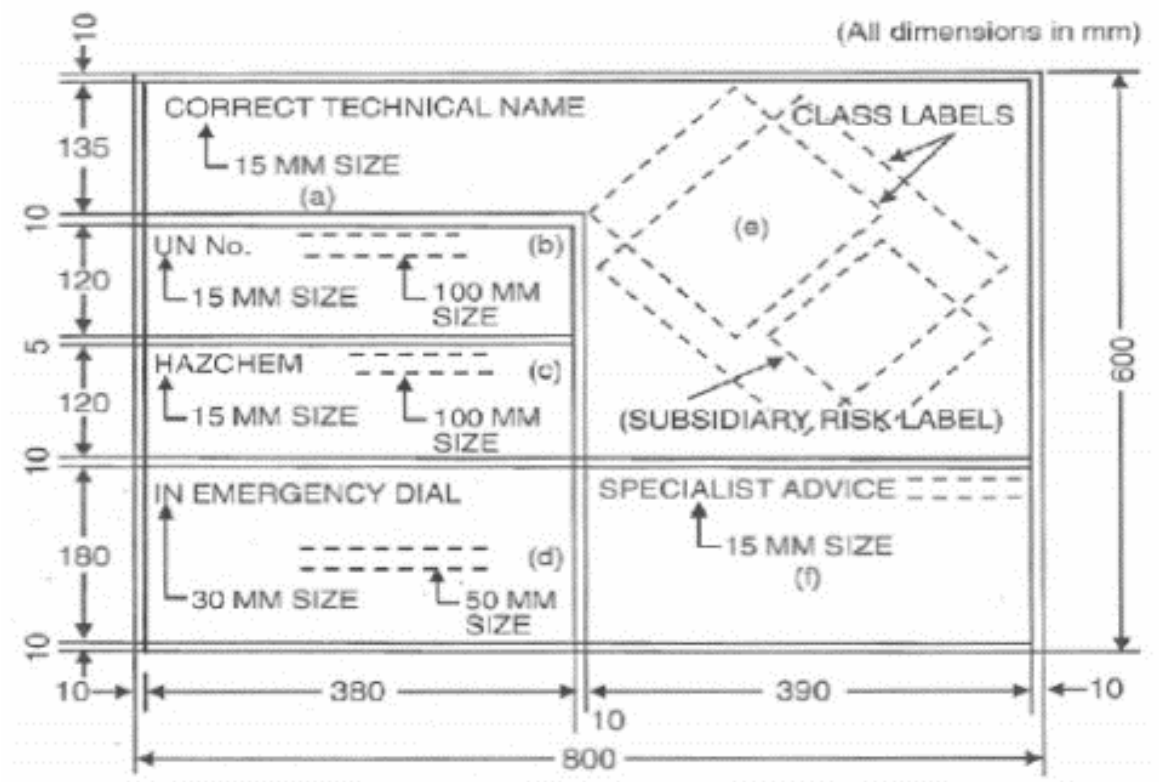
6.5.1 Labelling of transportation vehicles / containers carrying hazardous chemicals

i. The hazard shall be indicated on transportation containers, packages, and equipment containing hazardous chemicals at all times through labels, pictograms, markings, placards, or tags.

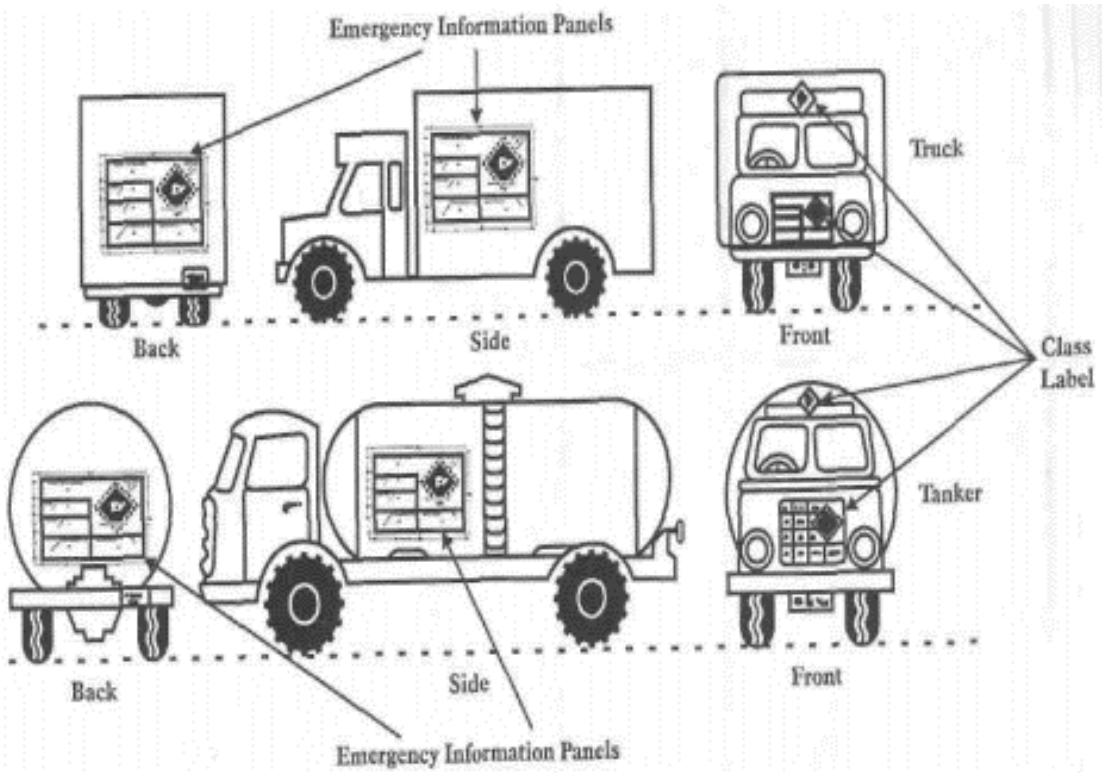
ii. UN GHS guidelines should be followed for indicating hazards. However, labels shall comply with local and national regulations and shall supersede the GHS guidelines in case of conflict.

iii. Every containers or vehicles used for transporting any dangerous or hazardous chemicals shall be legibly and conspicuously marked with an emergency information panel and class labels as shown below (Refer Central Motor Vehicle Rules – latest revision for further details). The above requirement shall be

included in the special conditions of the contracts with the supplier / transporter of the hazardous chemicals.



DETAILS OF EMERGENCY INFORMATION PANEL



FIXING EMERGENCY INFORMATION PANELS AND CLASS LABELS ON TRANSPORTATION VEHICLES / CONTAINERS

iv. Labels, markings, placards, or tags shall be retained on containers until the containers have been sufficiently cleaned of residue (i.e., product remaining in the container after unloading) to remove potential hazards or until they no longer contain hazardous chemicals.

v. Sites should have procedures to check that the hazard marking or labeling of incoming goods matches the information given in the relevant sections of the vendor's safety information or the safety data sheet.

vi. To ensure that any transportation vehicle / bulk container carrying hazardous chemicals is recognized from a distance, it is recommended that labels of NFPA diamond symbol (minimum size: 25cm X 25cm) set at an angle of 450 should be attached.

6.5.2 In-plant labeling of containers

i. All containers of hazardous chemicals at a site shall be labeled with a name that is traceable to the MSDS, and the labels shall comply with local and national regulations. The label must also include appropriate hazard warnings (e.g., GHS, National Fire Protection Association [NFPA] codes). Target organ effects and information about the appropriate PPE to use when handling the material should be part of the label.

ii. Information provided by equivalent means (displaying signs, placards warnings in immediate storage / work area) may also be acceptable. However, this is not the preferred method of labeling and must be used with proper judgement and caution.

iii. Labels / display boards shall be in the appropriate local language(s) and shall use pictograms / signs to the maximum extent possible.

iv. Labels / placard shall be prominently displayed. In the case of process equipment that extends more than one story, the labels should be visible on each floor in which the vessel exists.

v. Finished products shall be labeled as required by local and national regulations. If local regulations do not exist, refer to ANSI Z129.1-2010.

vi. Where known other specific hazards exist, the site shall post warnings to indicate the presence of the hazard (e.g., electrical arc flash, biological hazards, noise, asbestos, and ionizing radiation).

vii. Labels / placards shall be retained on containers until the containers have been sufficiently cleaned of residue to remove potential hazards or until they no longer contain hazardous chemicals.

6.5.3 Labeling of Storage Area

i. All storage area of hazardous chemicals at a site shall be provided with a HAZCOM display board / placard that is traceable to the MSDS. The display board shall comply with local and national regulations as applicable, and shall also include appropriate hazard warnings (e.g., GHS, National Fire Protection Association [NFPA] codes). Target organ effects, other known specific hazards and information about the appropriate PPE to use when handling the material should be part of the display board.

ii. HAZCOM display board shall be in the appropriate local language(s) and shall use pictograms / signs to the maximum extent possible and shall be prominently displayed.

6.6 Packaging

i. Hazardous Chemicals shall be supplied in a package which must:

- not allow the contents to escape when subject to normal handling
- not be adversely affected by the contents or be likely to come into contact with them
- ensure that any replaceable enclosures fitted must be able to be used repeatedly without the contents escaping.

ii. Sites should have procedures to check that the packaging of incoming goods is appropriate as the information given in the relevant sections of MSDS.

iii. Wherever Sites are supplier of a Hazardous Chemical, they shall ensure the use of appropriate packaging according to the class and division of that Hazardous Chemical.

iv. Refer UN GHS and UN recommendations for TDG for further information.

6.7 Loading and unloading

6.7.1 inspecting packagings and containers

i. The site shall have a procedure to help ensure that, before they are filled / unloaded, containers and packagings are inspected against specification requirements and for defects and integrity.

ii. Containers and packages shall also be inspected for leakage before shipment. Pre-shipment checklists must be used, signed, and kept on file. The checklists must be periodically reviewed for compliance and revised or updated to meet regulatory or the company changes.

6.7.2 Common Guidance

i. For loading chemicals or other products, sites shall have documented procedures that

- Define appropriate protective clothing for loading personnel.
- Prescribe complete securement procedures.
- Require personnel to use appropriate tools to perform securement.
- Require contract personnel to be aware of emergency procedures specific to the area.

ii. For unloading chemicals, sites shall have documented procedures that

- Specify the appropriate container or storage facility for receiving the product.
- Define the appropriate protective clothing for personnel who are responsible for unloading.
- Establish complete securement methods for returning empty containers.
- Require contract personnel to be aware of emergency procedures specific to the area.

iii. Positive identification shall be documented on the product containers to avoid the possibility of unloading into the wrong tank or container. Positive identification may be achieved by one of the following methods (in order of preference):

1. A sample is taken at the unloading location and a confirmatory laboratory test result is obtained before unloading.
2. The supplier or consignor carries out a confirmatory laboratory test and issues a certificate stating the designated CTU identification number and the name or description of the product that has been loaded into the container.
3. The product name, UN number, and CTU identification number on the shipping document are compared with the same information given on the CTU to determine if they match.

iv. Each site shall have a procedure for carrier employees involved in loading or unloading. These procedures must include general safety rules and specific safety rules pertaining to the area of operations.

Examples of recommended safety rules include rules for

- Smoking.
- The use of lighters and matches on site.
- The use of safety glasses.
- Where to park
- Control of vehicle movement
- No reverse movement, or no unguided reverse movement
- When and how to chock trailers.
- Key control
- Communication with plant personnel before loading and unloading.

v. With the exception of vendor-owned storage tanks, sites shall implement a process to help ensure that carrier employees communicate with site employees in the area prior to initiating bulk loading or unloading activities.

vi. When loading or unloading flammable liquids, the receiving container, all pipelines, the pump, and the storage container shall be grounded and, if necessary, bonded to prevent a fire or explosion from Lightning and Static Charge.

vii. Chemicals shall be unloaded by preferably by gravity or self-priming pumps. Pressure-assisted pump unloading or pressure unloading should be avoided, as far as reasonably practical.

viii. Sites shall have a process established to help ensure that loading and unloading hoses are inspected on receipt into the area and on a regular basis as long as they are in use. The inspection should include verification that the hose meets design specifications. A method to identify the hose and the inspection due date must be a part of the established process. Sites must also identify hoses that have restricted use for specific materials. Sites shall develop and implement an inspection program for Flexible Chemical Hoses for Process Safety Critical Applications. Such hoses shall be classified as PSM critical equipment to ensure that they receive adequate attention during their entire lifecycle and discarded promptly at end of their life.

ix. When a site permits a carrier, including a vendor carrier, to unload any chemicals using its own hose(s) for Process Safety Critical Applications, the contract with the carrier shall specify the following requirements:

- Hoses shall be identified with a permanent marking indicating the equipment piece number.
- Hoses shall be tagged with a permanent marking indicating the last and next inspection due dates.
- Vendors shall provide the company with a copy of their hose inspection and certification program.

x. CTUs positioned for loading or unloading shall be protected against unexpected movement during the transfer operation to eliminate the potential for hose breakage that could result in employee injury, release to the environment, fire, or explosion. Depending on the mode, appropriate securing devices (e.g., chocks, brakes, tie-offs, fifth-wheel support stands, kingpin locks, derail devices, switch locks, mooring lines, anchors, and warning signage) are commonly used to prevent accidental movement.

xi. In the absence of regulatory requirements, attendance by qualified humans or electronic monitors shall be provided during the bulk loading or unloading of any transport-regulated material, worldwide. The operator, who is either in physical attendance at the operation or using an electronic monitor, shall be able to take immediate action to shut down the transfer operation in an emergency such as by operating the remote shutdown mechanism. If regional or national regulations require higher levels of attendance, then these regulations also must be met.

xii. In case of physical attendance at the operation, the qualified person shall be alert, and have an unobstructed view of the loading / unloading operation.

xiii. When unloading starts, an inspection should be made to ensure that connections and lines are free of leaks and the lading is moving only to the intended receiving equipment.

xiv. Non-standard or unusual loading / unloading techniques such as pressurization, heating the lading, etc. shall have process hazards reviews before being done. Serious incidents have taken place in the chemical industry where this has not been done.

xv. The fill point is where the tanker delivery pipework connects to fill the tank. Fill points should have a lockable fill cap (or end blind in case of flanged connections) with a chain. The cap must be replaced to the pipe after reach delivery to protect from damage, corrosion and unauthorised use.

xvi. Flange connections should be preferred to coupling or threaded connections for connecting tanker with tanks (tanks fill points as well as tanker inlet/outlet)

xvii. Fill points should, where possible, be located within the secondary containment system or in a suitable cabinet with a drip tray to catch any oil spilled during deliveries. If outside the containment, a drip tray should be used during deliveries.

xviii. Where extended fill pipes are used, these should have shut-off valves. If there is more than one tank, separate fill points should be provided and should have their own shut-off valve.

xix. Tanker unloading / loading points shall be provided with suitable secondary containment, and all fill points and off-take points shall be clearly marked and labelled with the product type, tank capacity, and if appropriate tank number.

6.7.3 Loading of Tanks

i. Tanks as used here can be rail wagons, tank trucks, portable tanks, or ISO tanks.

ii. Before loading any container, it is important to determine residue contents, if any, so as to avoid mixing of incompatible materials.

iii. When opening any tank, it should be assumed that the tank is under pressure and contains residue from the previous lading. Pressure should be bled from the tank before removing any piping or valve fixture attached to the tank. Before any bolts are broken, a site work permit shall be followed. Bolts shall be removed from a fixture only after all of the fixture's bolts are loosened and the fixture's seal with the tank is broken.

iv. Before loading begins, bottom outlet valves should be checked to confirm they are closed. Valves should be proven leak free by loading the first few gallons (liters) with the bottom outlet caps removed. If leaks are detected, loading should be stopped and the valves and/or piping repaired or replaced. Internal emergency valves must also be checked.

6.7.3.1 Pre-Load inspection

A pre-unloading inspection shall be undertaken to confirm that connections / fittings and lines are compatible with the lading and are free of leaks and that the lading can move only to the intended receiving equipment. Pre-load inspections shall confirm the following:

- Is the tank immobilized or prevented from moving during the loading process?
- Is the tank secured on the highway or rail vehicle?
- Is there any evidence of leaks caused by damage to or corrosion of the tank?
- Are there any dents in the tank?
- Are there any cracks in the tank supports or bent braces?
- Is there any damage to ladders, safety railings, and walkways?
- Are safety relief devices, if present, clean, not corroded or damaged?
- Is the safety valve test certificate valid?
- Is the rupture disk, if equipped with a safety vent, has been thoroughly inspected to ensure its integrity?
- Is the tank test (visual or hydrostatic) date current?
- Are appropriate markings and placards properly displayed?

6.7.3.2 Post-Load inspection

It is a good practice to leak-test tanks of certain ladings after loading and before releasing them to the carrier if it can be done without releasing vapors to the atmosphere or creating explosive mixtures in or around the tank after the test pressure is released. All fittings and openings shall be securely closed before the tank leaves the site. Post-load inspections shall confirm the following:

- The tank has sufficient outage.
- The bottom outlet valves or coils are not leaking.
- The bottom fittings are secured properly.
- The top fittings are secured properly.

- The manway cover is seated properly and all securing nuts are present and wrench tightened in accordance with the manufacturer's specifications.
- All valves, including the top-operated bottom discharge valve, are securely closed, pinned, and sealed.
- All valve caps and/or plugs are in place and wrench tightened in accordance with the manufacturer's specifications.
- No product is leaking from any point.
- All protective housings and covers are in place, closed, pinned, and sealed.
- The bottom outlet valve cap gasket is in good condition.
- The bottom outlet valve cap and plug are wrench tight.
- The tank is properly secured in or on the road or rail vehicle.

6.7.4 Unloading of tanks

i. Tanks as used here can be rail wagons, tank trucks, portable tanks, or ISO tanks.

ii. It is recommended that dangerous goods in bulk containers be top unloaded wherever possible. Top unloading is generally less hazardous than bottom unloading because the flow of the goods can be controlled more easily, and there is less possibility of spilling the entire tank contents.

6.7.4.1 Pre-unload guidance

i. The tank contents shall be positively identified prior to unloading to avoid mixing incompatible materials in the storage tank. A positive-locking mechanism should be installed on the connector to prevent actual hook-up by unauthorized personnel.

ii. When opening any tank, it should be assumed that the tank is under pressure. Pressure should be bled from the tank before any piping or valve fixture attached to the tank is removed. Bolts shall be removed from a fixture only after all of the fixture's bolts are loosened and the fixture's seal with the tank is broken.

iii. Tanks that are bottom unloaded should have a reliable, effective shut-off valve that has a fusible section that causes the valve to close automatically in case of fire. Tanks should also have a closing valve that is at least 10 ft (3 m) from the tank filling openings and discharge outlets. This closing valve is for use in case of a fire or other accident. in addition, the control mechanism should be provided with a fusible section that causes the valve to close automatically in case of fire.

iv. Pre-Unloading inspections shall confirm the following:

- The tank is immobilized or prevented from moving during the unloading process.
- Ladders, safety railings, and walkways to be used during the unloading process are undamaged.
- Safety relief devices, if present, are clean (i.e., not corroded or damaged) and have a current proof of inspection.

v. To prevent accidental movement during unloading, a fail-safe mechanical means of securing the tank against the loading dock is recommended.

6.7.4.2 Post-unload guidance

Before releasing any piece of empty transportation equipment to a carrier, it is of critical importance to ensure all fittings, valves and openings are securely closed. This means even fittings that were not used in the unloading process should be tested for closure. Post-unload inspections shall confirm the following:

- The bottom fittings are secured properly.
- The top fittings are secured properly.
- The manway cover is seated properly, all securing nuts are present and wrench tightened in accordance with the manufacturer's specifications.
- All valves, including the top-operated bottom discharge valve, are securely closed, pinned, and sealed.
- All valve caps and/or plugs are in place and wrench tightened in accordance with the manufacturer's specifications.
- All protective housings and covers are in place, closed, pinned, and sealed.
- The bottom outlet valve cap gasket is in good condition.
- The bottom outlet valve cap and plug are wrench tight.
- The tank is properly secured in or on the road or rail vehicle.

6.7.5 Pressure and pressure-assisted pump unloading

i. All pressure-assisted unloading shall follow a written operating procedure that has been reviewed by a PHA.

ii. Pressurizing shipping containers with compressed gas of any kind to either unload them or assist pump priming presents potential hazards from stored energy, regardless of the material being unloaded. If the containers, piping, hoses, or other equipment are defective, or the stored energy is not properly controlled, the container may fail, exposing personnel to physical or chemical hazards (or both). Failure to consistently control the stored energy has resulted in serious incidents and injuries.

iii. Pressure unloading shall be used only when it has been determined by appropriate PHA to be the only reasonable means of affecting a transfer or be the least hazardous transfer method for a particular material.

iv. When materials are pressure unloaded or pump unloading is assisted by pressurizing, the following shall apply:

- When the design pressure is not shown on the container, it shall be determined prior to pressure unloading.
- The unloading pressure shall not exceed the design pressure of the container or the relief device set pressure, whichever is lower. The container shall be in test

date and shall have been pressure tested in accordance with required regulations and standards.

v. Pressure should be supplied from site sources (air or nitrogen header, compressor, or vaporizer). Pressure shall be controlled by regulator and relief devices located in the site pressure supply line. The site relief device must be set at or below the carrier's equipment or relief set pressure. In addition, the supply piping should be kept as small as possible and/or fixed orifices installed to limit the maximum gas flow.

vi. Compressed air shall not be used to unload flammable or combustible liquids. Precautions should be taken to avoid contaminating the material being unloaded with moisture or oil from the pressure supply source.

vii. Generally, the use of compressors or pumps on carrier (vendor) equipment (e.g., tank trucks) is not recommended due to the difficulty in determining the adequacy of design and maintenance of such equipment and the attendant relief devices. Exceptions should be considered only when deliveries are infrequent, use of carrier's equipment has been reviewed and documented by a process hazards review, and the carrier has verified with site personnel that these systems are properly designed and maintained. In these cases, use of the carrier's equipment shall be permitted only after it has been determined that these systems are properly designed and maintained.

viii. Material of construction for hose, hose fittings, gaskets, and loading arms shall be compatible with the material being handled. Unloading hoses shall be regularly inspected and pressure tested, except when hoses would be adversely affected by reaction between the material being transferred and test liquid residues. In such cases, the hoses shall be regularly inspected and periodically replaced. When unloading at the company facilities, the company-owned hoses should be used in compliance with the company Specifications for Flexible Chemical Hose for Process Safety Management Applications.

ix. When pressurizing is required to establish pump prime or to prevent pump cavitation, which could lead to pump damage, overheating, and/or thermal decomposition of the material, only the minimum pressure (not to exceed 20 psi [138 kPa]) shall be used.

6.7.6 Loading and unloading of Packaged goods containers

i. Tractor trailers should not be used for transporting containers of hazardous chemicals.

ii. Container as used here can be box wagons, trucks, trailers, or freight containers. Refer also to the section in this guideline on Rail or Road Transportation for sample checklists.

iii. Fatalities, injuries, and incidents have occurred while opening and closing box wagon (boxcar) doors. Therefore, to minimize the potential for injuries while opening and closing all box wagon doors, a procedure shall be available for inspecting the complete door assembly for defects before work begins.

iv. Trailers shall be properly supported loading and/or unloading. Jack stands and dolly supports, if used, should be periodically inspected and maintained in good condition.

v. A procedure shall be developed for preventing cargo fallout when the container doors are opened.

vi. The following are common sources of damage to contents of van trailers, freight containers, and boxcars:

- Side sway, severe shocks, and rough roadbeds experienced during rail shipment and movement in the rail switching yard
- Side sway, rough roads, and sudden deceleration of trailers during highway movement
- Friction generated between the lading and the sidewalls and the usual friction between the lading and the floor
- Excessive slack or voids in the load or a poorly blocked and braced load

Sites shall ensure that Packaged goods received at or shipped from site are adequately secured in containers to prevent any damage to the contents during transportation.

6.7.6.1 Loading

i. Inspections of cargo transport units (CTUs) used for packaged goods containers shall confirm the following:

- The CTU is immobilized to prevent it from moving while it is being loaded.
- The roof, sidewalls, and floor of the CTU are sound, tight, and with no obvious defects that may create safety hazards or contribute to product damage.
- The sidewalls and floor are free of protruding nails, bolts, holes, steel strapping stubs, anchor plates, uneven boards, and weak spots.
- The CTU is clean and free of any material that may have leaked from packages.

ii. During loading, the material's weight should be distributed evenly over the trailer or container floor. The sequence of work should be from one side to the other, rather than working one side of the trailer or container only.

iii. Shippers shall brace the lading securely in rail boxcars, truckloads, and intermodal freight containers. After loading, one last check should be made to confirm that the lading is secure.

iv. Whenever the company is responsible for final loading, it is recommended that digital photographs be taken of the secured load and kept on file with shipping papers and checklists.

v. The truck driver should be afforded an opportunity to view the loaded trailer or container and note the contents on the bill of lading before it is sealed.

6.7.6.2 Unloading

i. Pre-unload inspections of cargo transport units (CTUs) used for packaged goods containers shall confirm the following:

– The CTU is immobilized to prevent it from moving while it is being unloaded.

– There are no containers leaking onto the container floor or into the container air space.

ii. The container should be clean and free of any material that may have leaked from the packages before it is released back into transportation.

6.7.7 New or modified loading and/or unloading operations and facilities

A process hazard analysis (PHA) shall be done for all new or modified loading and/or unloading operating areas or on a schedule consistent with the cyclical PHA revalidation found in the HZL PSM Standard. The PHA should consider

- Changes that have occurred since prior PHA.
- Personal protective equipment for the operations.
- The availability of safety shower and eyewash facilities.
- Contractor safety during the orientation of truck drivers or others.
- Lockout procedures.
- Overflow containment measures.
- Fall protection procedures.
- Maintenance and support of cargo transfer fittings.
- Leak-test procedures for fittings.
- Operating procedures.

6.8 Control of particular risks associated with specific hazardous substances

This section provides some specific guidance on certain specific hazardous substances based on their classification. This Section shall be read in conjunction with other Sections of this standard, as applicable, for other requirements / guidelines.

6.8.1 Liquefied Petroleum Gas (LPG)

- Gas detection equipment should be installed to detect gas where an explosive atmosphere could develop and provide an automatic alarm before dangerous levels of gas are reached so that immediate action may be taken. The gas detector should emit an audible sound and have a visual display.
- Install and maintain appropriate fire protection systems including automatic sprinklers

6.8.2 Flammable Liquids

- Store flammable liquids in suitable closed tanks / portable containers kept in a safe position in a separate storage area, or in a purpose-made (fire resisting) bin or cupboard

- Store and use them in a safe place where there is good ventilation and no source of ignition
- Small quantities of flammable liquids, not exceeding 50 litres, may be kept in a workroom or laboratory provided that they are contained in closed vessels in areas of fire resisting structure and have secondary containment.
- All containers, cupboards and bins must be clearly and boldly marked with the symbol " flammable liquid".
- Keep containers closed when not in use. If possible, use safety containers which have self-closing lids
- Dispense liquids over a tray and keep some non-flammable absorbent material handy to mop up spills
- Dispose of contaminated materials safely

6.8.3 Flammable / Combustible Dusts

Finely divided flammable / combustible dusts dispersed in the workplace atmosphere can, if ignited, explode violently and cause a lot of damage. However, they are often overlooked.

Dust explosions usually occur where combustible dusts (or fibres, for example from paper, grain, finely divided organic compounds and metals) have accumulated and are then disturbed and released into the air, coming into contact with an ignition source. Common ways in which dusts can be disturbed include from wind when opening doors or windows, during cleaning or sweeping up of waste or using compressed air to blow out material accumulated in crevices, gaps or in machinery.

Dusts may also be generated transferring materials, such as filling the hold of a ship or a silo with grain (liberating grain dust). Dust clouds can also be generated by pressure from an explosion in another area, causing damage and propagation much greater than the original explosion.

Dust-air mixtures can be classified as hazardous atmospheres in the same way as other flammable materials like vapours from flammable liquids and gases. However, the classification of dust hazardous atmospheres is complex and depends on many factors, including the rate of dust dispersion and sedimentation characteristics, and particle size.

If handling flammable dusts, the following should be considered:

- Keep the working area dust-free (below LEL) by regular cleaning, and vacuuming spillages as they occur in addition to right enclosures and dust collection systems.
- Some dust handling plant has special safety features built in. The purpose of these nee should be properly understood and they should be maintained in good working order.
- Processes that generate fine particles, like grinding and milling of flour and nanomaterials or an aerosol (for instance, fine droplets in air) form of flammable liquid can present significant risks. Special control measures may be needed for handling such materials.

6.8.4 Flammable Solids

Risks can be minimised by:

- ensuring the storage and handling area is constructed from non-combustible materials
- ensuring there is sufficient means of escape in the event of an emergency. For example, use of outward opening doors, and removing all non-essential furniture and equipment from the work area to allow unimpeded access to the emergency exit. Make sure that gangways and exits from storage and working areas are kept clear of packaging materials, finished products containing flammable solids etc. as in the event of fire, gangways and exits could become obscured by smoke.
- eliminating all ignition sources, including
    - using intrinsically safe electrical wiring and equipment suitable for use in hazardous areas
    - guard or enclose heating elements and other electrical equipment to prevent ignition or decomposition of flammable solids
    - keeping the temperature of any surfaces and equipment (including enclosures) to a suitably safe temperature for the material being used
- installation of an automatic sprinkler system
- preventing the accumulations of excessive amounts of waste materials

6.8.5 Self-reactive substances and substances which in contact with water emit flammable gas (class 4 dangerous goods)

There are a number of key considerations for controlling the fire risks from storing and handling the above types of hazardous chemicals. These include:

- ensuring non-combustible materials are used in the construction of buildings and storage areas
- installing and maintaining appropriate fire protection systems. No water, foam or carbon dioxide should be used as a fire suppressant as it may generate flammable gases, an extremely dangerous explosion hazard, particularly if fire is in a confined environment.
- ensuring ignition and heating sources are controlled within the storage and handling areas
- ensuring adequate ventilation and/or extraction is provided to avoid creation of a hazardous atmosphere or hazardous area
- installation of explosion doors or vents if there is the potential that flammable gases or vapour could be formed or there is the potential to form combustible dusts
- ensuring that the storage area is moisture free and protected from the elements
- ensuring that measures are taken to protect light or temperature sensitive materials, for example, by installing temperature controls or protecting from direct sunlight.

Tanks to be used for storing or handling these hazardous chemicals should be designed and operated to ensure that:

- moisture cannot enter the tanks

- valves and fittings are readily accessible, easily operated and operate as designed
- if practicable, remote operation for primary shut off valves at the tank is provided.

6.8.6 Oxidizing agents

Oxidising substances are hazardous chemicals that are reactive and can support combustion. They can react and are incompatible with a range of other substances including organic materials (wood, paper) and hydrocarbon solvents. Always refer to the MSDS to check for any incompatibilities with other materials being stored or handled.

It is important to note that, since oxidisers provide oxygen through the chemical reaction, rather than air being the oxygen source, a risk of fire or explosion can still exist even if these materials are handled under an inert atmosphere like nitrogen

Unintended dangerous reactions of oxidising agents can be avoided by observing the following precautions:

- keep away from combustible or readily oxidisable materials, including fuel containers, sulfur and powdered metal and any other incompatible materials. Stores of oxidisers should be a reasonable distance away (for example, at least 5 m)
- handle oxidisers in compatible containers and with compatible equipment to avoid a dangerous reaction occurring
- place packages and containers on clean pallets, racks or shelving to allow easier detection of leaks and to prevent contact with other substances. Some oxidising chemicals can ignite on contact with timber, therefore, old and weathered pallets should not be used
- Eliminate sources of heat if practicable. If this is not practicable, ensure that heat sources do not allow the oxidising agents to be heated to within about 15°C of their decomposition temperature
- keep packages closed when not in use to avoid spillage
- do not park or drive any vehicles (e.g. forklifts) nearby because heat from the engine or fuel or oil leaks may cause a dangerous occurrence
- do not store any liquids above oxidizing agents in case leaks cause incompatible materials to spill onto the oxidising substance
- do not allow accumulation of dust and keep surfaces clean in areas where oxidising substances are handled in the workplace
- clean up spillages immediately and dispose of waste in accordance with your local regulations. Do not mix substances in the waste bin because they might react or cause a fire.
- Do not allow rough handling of containers of Oxidising Agents leading to leakage *as these materials are generally corrosive*

6.8.7 Organic peroxides

Organic peroxides are capable of self-reaction and stabilizers are usually necessary. Some are classified as “Goods too dangerous to be transported” and extreme caution is needed when storing or handling these materials.

Like oxidising agents, organic peroxides can be highly reactive with incompatible materials and precautions are necessary to avoid unintended reactions occurring. Risks can be eliminated or minimised by observing the following precautions:

- keep packages in a specifically designated and designed cabinet, room or external storage building containing explosion vents and/or doors to limit the effects in the event of an explosion
- keep a suitable safety zone (e.g. 5 m) opposite the cabinet or storeroom doors and blow out panels
- use cabinet doors with friction or magnetic catches to allow any pressure build up to escape more easily
- keep nothing else in the organic peroxides store. If this is not practicable, then measures should be taken to ensure that incompatible materials cannot come into contact with the organic peroxides
- keep the storage area free of waste, dirt, dust or metal filings (these could react with spillages) or any combustible materials
- eliminate ignition sources inside, or outside within a suitable exclusion zone (e.g. 3m) of the storage area or entrance to the store
- keep packages on sealed or laminated hardwood or coated metal shelves free from rust or corrosion to avoid a harmful reaction in the event of a spill
- keep a space of at least 100 mm between the packages and the floor, ceiling, or walls. Fitting a guarding system or raised shelving can assist with this
- keep suitable spill containment equipment close to the store which can be accessed quickly and used in the event of a spillage
- if opening packages, take them at least 3 m clear of the store. Reseal all packages before returning them to the store.

Temperature controls can be important in the safe handling and storage of organic peroxides. To avoid harmful reactions or decomposition of the organic peroxides due to temperature:

- determine any critical temperatures including any recommended maximum temperature.
  The label and MSDS may provide this information. Otherwise, other sources should be consulted. Keep the store within the recommended temperature range for the different types of organic peroxides present and keep organic peroxides out of direct sunlight
- do not permit heating to be installed in the storage area.

If cooling or refrigeration is required to maintain the desired temperature in the storage area, expert advice should be obtained because air conditioners and unmodified refrigerators are potential ignition sources.

6.8.8 Corrosives

Risks associated with storage and handling of corrosive substances and mixtures can be minimised by observing the guidance:

- Corrosive substances and mixtures can be either alkaline or acidic and these two categories are incompatible. Acids should never be stored with alkaline chemicals due to the potential for harmful reactions. Some reactions of acids and alkaline chemicals can be highly exothermic and rapidly generate large amounts of gas, causing an explosion risk.
- Isolate the storage area of corrosive substances and mixtures from the rest of the plant by impervious walls and floor. Otherwise, a separate building should be used. A provisional plan for safe cleanup of spillage and disposal of contaminated materials should be posted in the storage area.
- Water shall never be poured into the acid
- Caustic soda on gloves, boots or floors produces a very slippery surface. If spills occur they must be cleaned up immediately
- The flooring of the area where corrosive chemicals are stored, shall be impervious and made of corrosion resistant materials
- Do not allow rough handling of containers of corrosive chemicals leading to leakage
- Ensure close handling of corrosive chemicals free from any leakage. Chemicals that are corrosive to metals can cause damage to plant and equipment, such as containers, pipes, fixtures and fittings. This can lead to leaks or complete failure and loss of containment of the other chemical.

6.8.9 Toxic Substances

- Isolate the storage area from the rest of the plant by impervious walls and floor. Otherwise, a separate building should be used. A provisional plan for safe clean up of spillage and disposal of contaminated materials should be posted in the storage area.
- Highly toxic chemicals, such as cyanides and soluble oxalates, should be kept in containers of a distinctive shape if they must be handled manually.

6.8.10 Compressed air

Compressed air can be hazardous and should be handled carefully. For example, the sudden release of gas can cause hearing damage or even rupture an eardrum. Compressed air can also deeply penetrate the skin resulting in an air bubble in the blood stream known as an embolism. Even a small quantity of air or other gas in the blood can be fatal.

- Ensuring workers are trained to handle compressed air properly can eliminate many of the associated risks.
- Training and work procedures should emphasize the safe use of air tools and safeguard against the deliberate misuse of compressed air.
- Also, maintaining air receivers properly prevents the potential for an explosive rupture.

6.9 Chemical Drums / Portable Containers Safety

Handling and storage of hazardous chemicals in portable containers (drums / barrels / carboys / totes etc.) pose significant potential hazard as

(a) each container of a cluster of containers can become a source of leakage;

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

This section outlines some specific requirements and guidelines for safe handling and storage of Chemical Drums / Portable Containers. This Section shall be read in conjunction with other Sections of this standard, as applicable, for other requirements / guidelines.

6.9.1 Identification and Marking

i. Each container shall be labeled indelibly for clear identification. Containers that have had chemicals transferred into them (decanted), and containers of chemical wastes shall also be labelled correctly. Immediate use containers (the complete task, including rendering the container free of dangerous goods, would be completed within a single shift) may be exempted from labelling requirements.

ii. Never use a substance from an unmarked container. If the contents of the container are not known, this should be clearly marked on the container, for example, 'Caution - do not use: unknown substance'. Such a container should be stored in isolation until its contents can be identified and, if it is then found to be hazardous, the container is appropriately labelled. If the contents cannot be identified, they should be disposed of in accordance with relevant waste management requirements.

6.9.2 Storage

i. All portable containers shall be designed and constructed to standards suitable for the purpose. They should be robust and have well-fitting lids or tops to prevent leakage of liquid or vapour. For example, Petroleum Cans and drums should normally be made from metal (although 5 litre plastic containers designed to meet local regulations can also be used. However, plastic containers will, however, fail more quickly than metal ones in the event of a fire).

ii. Portable containers shall be stacked and stored properly in a stable and secure manner, preferably in a well ventilated shed (preferably away from process units), out of direct sunlight and with impermeable floor sloping away from containers. Different materials should be stored in different designated areas, separated by wide aisles.

iii. Containers of Highly toxic substances and mixtures must be stored separately under strict security. Storage should be locked up at all times and dispensed only by authorized personnel.

iv. The liquid containers should never be filled full with the liquid chemical. There should be sufficient ullage to take care of thermal expansion.

v. A minimum amount of hazardous chemical should be kept at the point of operation; only enough for use on one shift is a common rule. The main stock should be stored in a safe, isolated place.

vi. Drums shall not be stored directly on top of one another to reduce the risk of drums splitting under pressure or drums falling. The full drums should preferably be stored in a single tier with the bung (lid) up in an orderly manner so that all parts of the storage space are accessible, or should be stacked in racks, preferably with a separate rack for each material. These racks should be arranged to permit easy access for moving the drums in and out and for ready inspection of stock.

vii. Barrels may be stacked vertically with packing between the tiers, but are more conveniently handled if they are stored in racks similar to those used for drums.

viii. Boxed carboys should generally be stacked not higher than two tiers and never higher than three. Not more than two tiers should be used for carboys of corrosive substances like Acid and alkali. Containers must be stored (c) Containers shall be stored at a convenient height for handling; high shelving increases the risk of containers being dropped.

ix. When storing containers on shelving or other storage systems, hazardous chemicals should not be stored above or below other chemicals or other things which may be incompatible, potentially interact or contaminate.

x. Before carboy boxes of corrosive chemicals (for e.g. acid) are handled, they should be inspected for corrosion or weakening of the wood.

xi. Periodic (at least weekly) site inspection should be carried out to ensure that there is no leakage from any of the drums. Repair or remove any damage or unsuitable containers as soon as identified.

xii. Empty containers should be removed away, made free of its contents and the stoppers / lids replaced before being kept in safe place. Safe disposal of empty containers of hazardous chemicals should be done based on guidelines given by the manufacturers.

6.9.3 Handling

i. Manual handling of portable containers should be avoided. It is preferable to use fork-lifters, hand truck, or pallet jack or suitable cradles as appropriate along with safe lifting techniques.

ii. The safest way to handle portable containers is to use mechanical powered lift equipment (Forklifts) with lifting clamps. Forklifts have handles long enough to keep persons handling them away from splashes / spillage, in case containers are dropped. There is also less danger of dropping a container(s) with this kind of truck than with the standard two-wheeled truck. This truck becomes a much safer device for handling drums and barrels if it has a bed curved to fit the drum and a hook to catch the chime. Use of pallets for transporting portable containers is also an acceptable and common practice.

iii. All containers must be closed and sealed prior to moving. Workers handling liquid containers should ensure tightening of caps and prevent leaks during storage and transportation.

iv. Loads must not be stacked on the transport mechanism or vehicle in a manner that blocks the operator’s vision.

v. Containers must be loaded and / or stacked in a stable and secure manner on the transport mechanism or vehicle so as to prevent them from falling over or dropping.

Heavy objects should be loaded at the bottom of a forklift, hand truck, or pallet jack. Bulky or awkward items should be secured while in transport.

vi. No obstacles should block the unloading area or delivery paths. Only trained and authorized personnel are allowed to operate a forklift or use other powered material-handling equipment.

vii. Containers containing hazardous chemicals shall not be subjected to rough handling, and to impact or shocks so as to prevent their damage leading to spillage of chemical.

viii. Portable containers should be earthed before use with bonding clips connected by a wire to the fixed earthed plant or by some other equally effective method. Care must be exercised w.r.t. any unearthed metal components in transfer systems, such as in valves, dispenser heads or sections of piping which may need additional earthing straps. *"Use of portable or permanent grounding strap is mandatory on drums/containers containing flammables. The grounding source MUST be tested and verified to ensure a correct grounding path."*

ix. Special care must be taken when decanting from containers into smaller vessels. These vessels should be closed receptacles rather than open containers such as buckets. Experience has shown that corrosive liquids in an open container can be easily spilt during transfer. (g)

x. If corrosive liquid chemicals are stored in drums, a drum pump shall be used for transferring the liquid from drum to a secondary small container for use in the process unit.

xi. Use of buckets should be best avoided for conveying hazardous chemicals. However, if they are used, the distance, a worker is required to carry a bucket of hazardous chemical, should be short (preferably not more than 3 m) and buckets shall not be filled more than half full. If a bucket is used regularly for conveying a particular chemical, it should be properly labelled.

xii. The safest way to empty a carboy is to move the liquid by suction from a vacuum pump or aspirator or start a siphon with a rubber bulb or ejector. The carboy inclinator, if it holds the carboy firmly by the top, as well as the sides and automatically returns to the neutral position on being released, may also be used.

xiii. Compressed air, even from a hand pump, should not be used on a carboy. Pouring by hand or starting pipettes or siphons by mouth suction should never be permitted. Mechanical pumps are not desirable unless they are self-priming or have sufficient suction force to start themselves.

xiv. Workers should position himself such that he / she is in the upwind direction so that even in case of accidental release of a chemical, he is safe.

See **Annexure- 13 and 14** for some examples.

6.10 Compressed Gas Cylinder Safety

The storage of gases in heavy, highly pressurized metal containers, apart from the nature of chemical gas, significantly amplifies the hazard of the storage gas cylinders.

This section outlines some specific requirements and guidelines for safe handling and storage of Compressed Gas Cylinders. This Section shall be read in conjunction with other Sections of this standard, as applicable, for other requirements / guidelines.

6.10.1 General Requirements

i. Cylinder nozzle should be suitably protected against damage. The cylinder valves shall be provided with security cap on the outlet to act as a secondary means of safeguard. Oil or similar lubricant shall not be used on valves or other fittings of cylinders containing gas.

ii. Cylinder valves must be closed and protective caps in place when the cylinder is not in use. Cylinders with regulators connected to manifold systems, piping or welding apparatus are "in use."

iii. Leaking or damaged cylinders or cylinders with expired hydrostatic tests should never be accepted on the site. If such cylinders are discovered on the site, they must be removed from service, tagged, and stored outside to a safe place. If contents are toxic, a warning sign must be posted. The supplier shall be contacted for return or repair. Under no circumstances any attempt shall be made to repair a cylinder or valve by an unauthorized person.

iv. The due date of hydrostatic test for cylinder is should be marked on the metal ring inserted between the cylinder valve and cylinder neck.

v. Standard (authorised manufacturer with ISI marked) cylinder-valve outlet connections shall always be used to prevent mixing of incompatible gases.

vi. The outlet threads used vary in diameter; some are internal, some are external; some are right-handed, some are left-handed. The threads on cylinder valves, regulators and other fittings should be examined to ensure they correspond and undamaged.

vii. Cylinders should be equipped with either a hand wheel or stem valve. For cylinders equipped with a stem valve, the valve spindle key should remain on the stem while the cylinder is in service.

viii. Closed systems supplied by Compressed Gas Cylinders must always be equipped with pressure relief devices unless the system is designed to the same requirements as the cylinders, in which case a sign shall be installed at the supply connection stating the design pressure of the system.

ix. Site personnel must not refill cylinders. Filling small cylinders from a large cylinder shall be prohibited, except for SCBA.

x. Alterations or repair of cylinders by Plant personnel shall be prohibited.

xi. Only wrenches or tools provided by the cylinder supplier should be used to open or close a valve.

xii. Some valves may require washers; this should be checked before the regulator is fitted.

xiii. Plastic piping shall not be used for any portion of a high pressure system.

xiv. Do not use cast iron pipe for chlorine.

xv. Do not conceal distribution lines where a high concentration of a leaking hazardous gas can build up and cause an accident.

xvi. Copper piping shall not be used for acetylene.

xvii. Piping systems should be inspected for leaks on a regular basis. Special attention should be given to fittings as well as possible cracks that may have developed.

xviii. Testing, inspections, and maintenance primarily are the responsibility of the owner of the cylinder. However, it is essential when using purchased gases to ensure that the container is in a safe condition by examining for corrosion, damage, and other obvious deficiencies. Ensure thickness of all high pressure gas cylinders are measured once in every six months.

xix. Suitable warning sign boards to be displayed at gas charging stations.

6.10.2 Identification and Marking

i. Markings shall be by stenciling, stamping, or labeling, and shall not be readily removable. It is also to be remembered that labels on caps have little value because caps are interchangeable.

ii. For proper identification of the chemical, all cylinders shall have the proper colour as prescribed by The Gas Cylinders Rules 1981.

iii. Cylinders must be clearly identified with commonly accepted name of contents, state of the chemical stored (i.e. gas or liquid) and the associated hazard (i.e., flammable). Markings / labels should also include:

(a) Owner's / manufacturer's name and date of filling

(b) Specification to which cylinder has been made

(c) Date of last hydrostatic test

(d) Working pressure and test pressure

(e) Tare weight

(f) Water capacity and proper identification colour of the chemical

iv. The cylinder shall be checked for proper markings on receipt. If found not in order, the cylinder shall not be accepted for use and should be returned to the supplier.

v. A cylinder which has lost its identification shall be removed from storage and conspicuously labeled as "Unknown" until re-identification by analysis is made and cylinder marked. Such cylinders may be returned to the supplier post re-identification.

vi. Breathing air and medical oxygen shall be analyzed before use.

vii. Gauges on Oxygen regulators shall be marked "USE NO OIL."

6.10.3 Storage

i. Cylinders shall be stored in approved areas and shall never be stored against furnaces, radiators, or other sources of heat.

ii. Cylinders stored outside shall be covered adequately to protect from ice, snow and direct sunlight. Any gas, other than compressed air, should be stored in a well ventilated area. Cylinder should not be kept near gangways / elevators to avoid any hard object striking them.

iii. The storage facility should not be located within twenty feet of combustible substances or structures unless the cylinder facility is suitably protected by firewall or sprinklers.

iv. Cylinders containing flammable gases and toxic gases shall be kept separated from each other and from cylinders containing other types of gases be an adequate distance or by a suitable partition wall.

v. For flammable gases, the cylinder storage area shall be made of non-combustible materials and flame proof fittings shall be used.

vi. All flammable gas storage areas must be labeled "NO OPEN FLAMES" or "FLAMMABLE" by appropriate signs or markings. This shall not be located under electric wires and shall be away from flammable substances such as grease and oil, open flames, areas where electrical sparks are generated, or where other sources of ignition may be present.

vii. Oxygen and oxidizing gas cylinders in storage, full or empty, shall be separated from combustible materials, especially oil, grease, or reserve stocks of acetylene, carbide, or other fuel gas cylinders by a minimum of 20 feet, or by a fire resistant partition at least five feet high having a minimum rating of 30 minutes.

viii. All cylinders shall be restrained / secured at all times to prevent tipping or rolling. Cylinders may be attached to a bench top, individually to the wall, placed in a holding cage, or have a non-tip base attached. Chains or sturdy straps may be used to secure them.

ix. Cylinders shall be stored with protective caps in place. Do not restrain / secure cylinders by their valves or collars.

x. To ensure the in-built safety features of a cylinder function correctly, cylinders of liquefied flammable gas need to be positioned so that the safety relief device is in direct contact with the vapour space within the cylinder. All cylinders shall be stored upright unless the design permits other positions. One ton containers shall be stored in normal horizontal position and secured against movement.

xi. Cylinders of different gases shall not be stored within the same restraining device.

xii. Empty and charged cylinders should not be stored together within the same restraining device. All empty cylinders shall be tagged "empty."

xiii. Small propane and calibration gas cylinders stored in cabinets shall be placed in a holder and in an upright position.

xiv. The floor level at storage area should be sufficiently above ground level to prevent water logging and corrosion. Flooring of the storage area should not be wet or muddy.

xv. Periodic inspection of cylinders for ascertaining leakage should be made. Automatic gas detectors, as appropriate and applicable, should be provided at suitable points for identification and early warning of leakage from a cylinder.

xvi. Large empty compressed gas cylinders shall be returned to the manufacturers for reuse / disposal.

xvii. Small empty compressed gas cylinders shall be collected in each area and kept in a safe place. Safe disposal of these empty cylinders of hazardous chemicals should be done based on guidelines given by the manufacturers.

6.10.4 Handling

i. Cylinders shall be adequately supported during handling. Conveyors, trolleys and cradles of adequate strength shall, as far as possible, be used when moving the cylinders. Cylinders should be unloaded using fork-lifter, hoist etc. Manual handling is not recommended.

ii. Cylinders shall never be lifted with electromagnets or slings. The protective cap / Valve hoods shall never be used for lifting / supporting.

iii. Cylinders shall be transported and handled upright, secured from tipping, valves closed, and protective caps in place. Liquefied gases must be shipped upright (except one ton containers).

iv. Cylinders used / handled / transported in horizontal position shall be properly stacked taking care to prevent knocking, dropping or rolling of cylinders.

v. The cylinders shall be handled carefully and not be allowed to drop / slide / bump against any other cylinder or hard object. It shall to be ensured periodically that the cylinder is not leaking from valve / body.

vi. For increased flow rate of gas, suitable vaporizer can be used. Direct heating of the cylinder with steam or flame shall not be done.

vii. Oxygen cylinders shall not be handled with oily hands, gloves, or other oil contaminated equipment.

viii. Pressure gauge and flow measuring device should be used to monitor flow.

ix. Non return valve shall be used to prevent back flow of process fluid into the partially empty / empty cylinder.

x. Cylinders shall be placed with the valve accessible at all times. The main cylinder valve shall be closed as soon as it is no longer necessary that it be open (i.e., it should never be left open when the equipment is unattended or not operating).

xi. When LPG powered equipment is not to be used within seven hours, LPG supply valve must be closed and engine run until engine shuts off.

xii. Cylinder valves should be opened slowly except Oxygen cylinder. Open up the oxygen cylinder valve stem just a crack. Once the needle of the high pressure gauge has stopped, open up the valve all the way. This back seats the valve.

xiii. Oxygen cylinders must have the valve opened up all the way because of the high pressure in the cylinder. This prevents the high-pressure gas from leaking out through the threaded stem.

xiv. When opening the valve on a cylinder containing an irritating or toxic gas, the user should position the cylinder with the valve pointing away from them and warn those working nearby. One common practice is to use a natural bristle broom to “sweep” the air in front of the person.

xv. Regulators are gas specific and not necessarily interchangeable. Always make sure that the regulator and valve fittings are compatible and correct range, calibrated pressure gauges with ISI Mark are used.

xvi. After the regulator is attached, the cylinder valve should be opened just enough to indicate pressure on the regulator gauge (no more than one full turn) and all the connections checked with soap solutions for leaks.

xvii. A cylinder should never be emptied to a pressure lower than 25 psi (the residual contents may become contaminated if the valve is left open).

xviii. When the cylinder is not required to be used for a considerable period of time, it should be disconnected from process and if possible, the lines bled. The disconnected cylinder should be kept completely closed, at storage, and marked accordingly.

xix. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability.

xx. Once a cylinder is consumed, close the cylinder valve fully first and then the process valve. Gently remove the connection, put an ‘Empty’ label on the cylinder and store at the location specified for empty cylinders.

See **Annexure- 14** for some examples.

6.11 Control of Radioactive Materials / Ionizing Radiations

This section provides requirements and guidance for safety and health considerations and precautions applying to the handling and storage of all radioactive materials (whether sealed sources or unsealed, loose sources) including industrial X-ray equipment. It does not cover patients exposed to medical X-rays.

6.11.1 General Requirements

6.11.1.1 Licence

The Atomic Energy Regulatory Board (AERB) regulates the transfer, use, storage, and disposal of radioactive materials in India and specify the establishment of management systems required to ensure proper handling and storage of radioisotopes only by trained and qualified personnel.

i. Sites shall ensure that all applicable regulatory consents (Licence, authorisation, registration or approval) are in place prior to possession and/or use of any ionizing radiation source (a radioactive material or radiation generating equipment).

ii. Sites shall establish a program that will ensure that all procedures involving any ionizing radiation source are carried out in compliance with conditions stipulated by applicable regulatory consent and other regulatory requirements.

6.11.1.2 Radiological Safety Officer (RSO)

Sites using ionizing radiation sources shall designate, with the written approval of the AERB or any other competent authority authorized by AERB, a qualified and suitably experienced individual as Radiological Safety Officer (RSO).

i. The RSO shall be responsible to implement and manage the radiation safety program for the site as outlined in this section (Section-6.12 of this standard). The RSO shall also determine if additional country / local regulations apply and shall help ensure that all applicable regulatory requirements are followed.

ii. This individual shall be appointed by Location Head. His/Her authority, duties, responsibilities, and radiation safety activities shall be designated in writing by Location Head.

iii. An alternate or assistant RSO should also be appointed by Location Head to assume the duties and responsibilities of the RSO in his/her absence.

iv. PRIOR to purchasing, using, transferring or disposing of any radioactive material, the radiation safety officer or alternate(s) shall be contacted to discuss appropriate procedures. No person shall use radioactive material, devices containing sealed radioactive sources, or any equipment that produces ionizing radiation without the express consent and authorization of the RSO.

6.11.1.3 Authorized Users

An authorized user shall be an individual recognized by the RSO and/or license conditions as having met the necessary requirements to work with radioactive materials or radioactive sources.

6.11.1.4 Radiation Safety Program (RSP)

Each site shall establish its own Radiation Safety Program (RSP) (as applicable) on the basis of a prior risk assessment. The RSP must provide a detailed description of how the site/facility will handle the receipt, storage, use, and disposal of ionizing radiation sources with regards to personnel, facility, environmental, and public safety.

i. The basic principles of time, distance, and shielding shall be applied to the safe use of ionizing radiation sources to help ensure that exposure of personnel shall be maintained As Low As Reasonably Achievable (ALARA), i.e., decreasing the amount of time spent in a radiation field or working with a radiation source, increasing one's distance from a radiation source, and use of shielding between oneself and the radiation source all decrease one's potential exposure to a radiation source.

ii. The RSP documentation shall include radiation safety manual and/or radiation safety SOPs, and should typically cover the following information:
- Responsibilities
- Radiation safety resources
- Dose limits or targets
- Dose control methods / dosimetry
- Monitoring program
- Storage & usage areas
- Authorization to receive and use
- Receiving and delivery
- Inventory control
- Specific work practices / procedures / forms (as applicable)
- PPE
- Contamination control
- Waste storage and disposal
- Transportation
- Emergency planning
- Training
- Audits
- Recordkeeping

iii. The RSP shall be endorsed by the RSO, communicated to and made available to all authorized users of ionizing radiation sources and reviewed periodically. Any changes to the RSP shall be communicated to all authorized users of ionizing radiation sources.

6.11.1.5 Inventory Control

Sites with active or stored sources (whether sealed sources or unsealed, loose sources) shall maintain an inventory of these sources.

i. This documentation, to be maintained by the site or facility RSO, must include the following items for each source:
- Model number (if applicable)
- Serial number (if applicable)
- Radioisotope
- Radioactivity
- Date of manufacture
- Location of the source
- Custodian of the source (if other than the RSO)

ii. Sites may elect to assign a uniquely identifying internal tracking number to each source. This information should also be included in the inventory listing.

iii. Inventories shall be reviewed at least every six months and updated immediately to reflect any changes (i.e., change in location or custodian). The means and frequency of these updates should be established by the RSO and documented in the RSP.

iv. All sources, active and stored, shall be physically inventoried every six months or according to the site or facility license conditions or local applicable regulations. A physical inventory helps ensure and confirms that the source(s) is still at the site or facility in the location identified in the site inventory list. Documentation of this inventory audit shall be maintained by the RSO. AERB or any other regulatory body may require

copies of this documentation on some frequency. An example of a physical inventory audit checklist is provided in **Annexure-9.**

6.11.1.6 Procurement and receipt

i. Sites shall establish procedures as a part of RSP for requesting, procuring, receiving and unpacking radioactive sources or any other radioactive materials including tritium exit signs (see Section 6.11.10). Procedures should also cover identifying and addressing soiled or leaking sources / packages.

ii. The RSO shall review and approve requests for procurement of all new sources. The RSO shall help ensure that procurement of the sealed source is permitted by the site or facility license conditions including maximum permitted inventory, or he or she must submit a license amendment to the appropriate licensing agency prior to procurement.

iii. The vendor shall supply all applicable regulatory consents and a current leak test certificate in case of non-gas sealed sources to the site RSO prior to delivery. The RSO shall also be notified, at least 3 days in advance, of the intended date of source delivery.

iv. Sources shall be received at the site receiving area (preferably a centralized location) and the RSO notified upon receipt. The RSO or his/her designate shall inspect and survey the source with a radiation survey meter to help ensure that no leakage has occurred during shipping. Radiation checks must be made as soon as practicable after receipt of the package, but not later than 3 hours after the package is received. The source shall then be secured and stored until installation / use. Radiation surveys shall be conducted before and during unpacking of the source, and during and after its installation in case of sealed source. All surveys shall be documented.

v. It should be noted that for certain receipt of sources, wipe tests may be required depending on the characteristics of the materials.

6.11.1.7 Storage, Security and Control

i. Sources must be secured at all times. Sources are considered secured if they are being used by an authorized user, under the authorized users visual observation, or secured in locked location.

ii. When not in use, radiation sources shall be secured and stored in specially designated and constructed radiation storage area. The storage area shall be kept locked and possession of the keys shall be controlled by the RSO or designate(s).

iii. Areas where sources are stored / used should be registered by RSO.

iv. Areas where sources are stored / used should be protected by fire suppression systems to avoid the potential for airborne contamination in the event of a fire. Localized contaminations due to fire suppression are more easily addressed in post-event decontamination assessments.

v. Sources that are no longer required should be returned to the manufacturer when possible or properly disposed.

6.11.1.8 Labels and Postings

i. The site shall post radiation symbol or warning signage conspicuously and prominently at all times indicating the presence of the source as required by AERB or other local applicable regulations:

(a) on externally visible surfaces of radiation equipment or instruments, and containers for storage of radioactive materials; packages for radioactive materials and vehicles carrying such packages. For example, equipment containing sealed sources, such as gas chromatographs equipped with electron capture devices (ECDs) or process vessels containing a level detector
(b) at the entrance to the room housing the radiation generating equipment
(c) at the entrance of controlled area and supervised area where sources are used or stored.

ii. Sources have manufacturer labeling as to the type and amount of the radioisotope(s) contained in the source. These labels shall not be removed or defaced.

iii. At a minimum, the universal radiation trefoil symbol (magenta on a high visibility yellow background) and warning sign as prescribed by AERB shall be used for this purpose. Radiation signage, in addition to the trefoil, should include a description of the radioactive materials in use or storage (i.e., the radioisotopes), and emergency contact information. See **Annexure-10.**

iv. Within any area, radioactive material use/storage areas shall be readily identifiable from non-radioactive material use/storage areas by delineation with trefoil tape or stickers.

6.11.1.9 Units of dose and exposure

Many existing regulations, documents, and instruments use traditional units, while others use the International System of Units (SI units). Below **Table** provides conversion between SI units and traditional units.

Units of dose and exposure

Quantity	SI name (symbol)	Traditional name (symbol)	Conversion factor
Exposure	coulomb/kg (C/kg)	roentgen (R)	1 R = 2.58 x 10^{-4} C/kg
Absorbed dose	Gray (Gy)	rad (rad)	1 rad = 0.01 Gy
Dose equivalent	Sievert (Sv)	rem (rem)	1 rem = 0.01 Sv

6.11.1.10 Custodial changes, returns, and disposal

i. The RSO shall be notified of any custodial changes or location changes regarding a source.

ii. Sources that are no longer needed shall either be returned to the vendor or disposed of using an appropriate vendor. Return and disposal of sealed source material to the manufacturer shall be coordinated and documented by the RSO. If return to the manufacturer is not possible, the RSO shall determine an appropriate vendor to conduct the disposal. Regulatory agencies shall be notified of the return or disposal if required by local regulations. The RSO shall maintain records of all returned and disposed sources.

6.11.2 Contamination Monitoring and Control

i. Policies and procedures shall be established as part of the radiation safety program (RSP) to eliminate or minimize radiation contamination.

ii. Work with loose sources should be conducted in chemical fume hoods, ventilated enclosures, or glove boxes to minimize potential airborne contamination. These engineering control devices shall also be labeled with radiation trefoil stickers and/or tape.

iii. Secondary containment, containers or trays, should be used to contain and minimize the effect of spills from loose sources. Secondary containers shall also be labeled with radiation trefoil symbol and/or tape.

iv. Plastic-backed absorbent pads or liners should be used as much as possible to contain spills from loose sources and aid in decontamination efforts.

v. Areas where radiation sources are used or stored must be periodically assessed for contamination. The site radiation safety program shall specify the frequency of these assessments. Most radiation safety programs require periodic contamination monitoring using leak (wipe) testing and/or meter surveys. The regulatory consent may dictate the assessment frequency.

6.11.2.1 Leak testing

i. Periodic wipe tests shall be performed on all loose and sealed radioactive sources to detect contamination and to help ensure that the containment is still intact.

ii. Leak tests shall be conducted on sealed sources at least every six months or as specified by the site or facility's license or local applicable regulations. The manufacturer or supplier will normally advise about periodic leak testing and the methods to adopt to give the required level of assurance that radioactive material will not be allowed to disperse. it is advisable to increase the frequency when a sealed source is going to be retained in use beyond the recommended working life given to the source capsule by the supplier or manufacturer.

iii. Leak tests shall also be performed on sealed sources when damage is suspected from harsh or improper use, transit, or dropping.

iv. Use of a monthly wipe test program is recommended for loose sources.

v. For most programs, it is usually more cost-effective to conduct the leak test in-house and have the wipe samples analyzed by an accredited or licensed third-party laboratory.

6.11.2.2 Leak Test Exemptions

i. Some sealed sources may be exempt from leak testing requirements and the exemption should be specified in the site or facility's license or local applicable regulations. Generally, these include static eliminators, tritium exit signs, smoke detectors, and sealed sources containing gaseous tritium or krypton-85.

ii. Sealed sources in storage are exempt from standard leak test requirements. However, they shall be leak tested every ten years or more frequently as specified in the site or facility license or local applicable regulations. Sources removed from storage (e.g., for active use, return to manufacturer, or for disposal) shall be leak tested prior to removal unless the source has been leak tested within the last six months.

6.11.2.3 Conducting leak tests

Typically, when using a third-party laboratory for leak test analysis, the laboratory supplies the leak test kit. The kit usually contains an envelope with a large cotton swab in a resealable plastic bag. The leak tests are performed as given below, and the individual swab (sample) is placed back into the bag and sealed. Information on the source (internal inventory control number, source manufacturer, type of radioisotope, amount of radioactivity, and date of leak test) is written on the provided envelope and returned to the third-party laboratory for analysis.

i. **Sealed Sources:** Follow the vendor's instructions for leak testing the sealed source. This involves removing the cotton swab and wiping around the source housing and shutter control (not the actual source itself), if applicable, or according to the source manufacturer's specifications.

ii. **Loose Sources:** Utilize a pre-printed map of the use/storage area that identifies the location of wipe test samples. These sample points should correspond to areas where sources are typically used and have the greater potential for contamination. An example of a wipe test map is shown in **Annexure-11**. To conduct a wipe test, individual pieces of cotton swabs are wiped over an area of approximately 100 cm2 at identified sample points.

6.11.2.4 Leak test results

i. After analysis, the vendor laboratory should provide a copy of the leak test result(s) to the site. The documentation should include the information provided on the source, the date of the analysis, and the leak test result. Results shall not exceed 0.005 μCi (185 Bq) of loose radioactivity per 100 cm^2. If the results exceed this value, the unit shall be immediately taken out of service.

ii. The licensing agency may require notification per the site or facility license conditions or local applicable regulations. The manufacturer of the sealed source shall be contacted to determine whether the source can be repaired or must be returned to the manufacturer for disposal.

iii. All records of leak test results including wipe test maps shall be documented and retained by the RSO according to site / facility license conditions or local applicable regulations.

6.11.2.5 Radiation Surveys

A radiation survey can help pinpoint areas of contamination and, when used in conjunction with wipe testing, can aid in the detection of fixed contamination.

i. A radiation survey of all radioactive sources areas (Loose, sealed, equipment), except those in authorized storage vaults shall be made at least semiannually by the RSO or other qualified representative to help ensure that no excessive levels of radiation exist from leakage, contamination or equipment malfunction. Surveys shall also be conducted after initial installation, repairs, and whenever changes are made that could adversely affect radiation protection. More frequent surveys shall be made if required by local regulations and/or license.

ii. Surveys should be conducted under a representative range of operating conditions or under "worst-case" conditions.

iii. To detect fixed contamination from loose sources, survey meter should be slowly moved over the suspect areas.

iv. Typically, sources / suspect areas should be checked for maximum radiation level at a distance of 1 foot (30 cm) from the source holder / suspect areas. Maximum permissible radiation shall be 2 mR/hr.

v. The RSO can choose to conduct annual surveys of specific devices (for e.g. a specific X-ray machine) for which the results of at least two years of semiannual surveys have shown no detectable radiation and if permitted by local regulations, license, and/or permit.

vi. If the source is located in an electrically classified area, then intrinsically safe radiation survey meters shall be used or the work shall be done under an approved hot work or flame permit.

6.11.2.6 Radiation Surveys Instruments

i. Instruments used for performing necessary survey work are available from many vendors (or surveys may be contracted to outside firms). To be suitable for survey work, a radiation survey meter should be portable, battery operated, and able to provide a measuring range no greater than 0–0.25 mSv (0–25 mrem) per hour on its most sensitive range. When ordering survey meters, the intended specific use should be stated.

ii. Survey instruments shall be calibrated at least annually or more frequently if required by license or local regulations. A calibration certificate sticker shall be attached to the meter.

6.11.2.7 Contamination Action Levels

Radiation safety programs shall establish contamination action levels which require escalating notifications and user-actions with increasing contamination levels. Contamination levels exceeding the site/facility action levels shall be documented.

6.11.3 Shutter Controls (Applicable only for Sealed Sources)

Some sealed sources, particularly those gauges used in flow, level, or density applications, may be equipped with a shutter mechanism. The shutter is typically controlled by a lever that can be placed in the “on” or “off” position. (The source housing is usually marked with these words). When the shutter is in the “off” position, the window in the source housing through which the radiation beam is emitted is closed and the radiation beam is terminated. When the shutter is in the “on” position, the window is open and the radiation beam exits the housing, passes through the target (e.g., reactor vessel), and impinges upon a detector on the other side of the target.

Sealed sources equipped with shutter mechanisms shall be inspected and tested at least every six months or as specified by the site or facility license or local applicable regulations. All inspections and tests shall be documented (see **Annexure- 9** for an example of a sealed source survey form).

6.11.3.1 Shutter Control Inspections

i. Shutter inspections shall be conducted to help ensure that the shutter control lever is free from obstructions and able to move freely from one setting to the other. Shutter control tests shall be conducted to verify operation and functionality of the shutter. Obstructions preventing the free movement of the shutter control lever shall be removed.

ii. Hands, arms, and other body parts shall not be placed between the sealed source and the target/detector without closing and locking-out the shutter and verifying the lock-out with a survey meter. (See section 6.13.1.2). The RSO shall review and modify, as appropriate, its “lock-out” procedures whenever a new device is obtained to incorporate the device manufacturer’s recommendations.

iii. Sealed sources with inoperable shutter controls shall be immediately locked-out, if possible, and the manufacturer contacted.

6.11.3.2 Shutter Control Tests

i. Sealed sources equipped with shutter controls shall be monitored in both the “on” and “off” positions. Results shall be documented. The unit shall be immediately locked-out and the manufacturer contacted if there is little or no difference in the meter readings with the shutter closed or opened as this indicates a malfunctioning shutter control mechanism.

ii. Readings shall also be collected at several locations around the source housing at a distance of 1 foot (30 cm) and recorded (see **Annexure-9**). Meter readings at a distance of 1 foot (30 cm) from the source housing shall not exceed 2 mR/hr (0.02 mSv/hr), or other applicable local regulatory requirements at any one location.

iii. Meter readings should be compared to the previous survey readings. Significant changes in results (i.e., an increase from one period to the next) may indicate a failure of the shielding in the source housing or a problem with the shutter control mechanism.

6.11.4 Installation, Repairs, and Removal of Sealed Sources

i. Only qualified manufacturer or distributor representatives, or their designates, or individuals specifically licensed by the governing regulatory agency shall install, repair, or remove sealed sources.

ii. For some sources, such as ECDs, the manufacturer may permit the user or RSO to remove the source following directions provided by the manufacturer.

iii. All removed sources shall be returned to the manufacturer, disposed, or placed in secure storage by the RSO.

iv. Sealed source containers or capsules shall not be opened.

6.11.4.1 Routine Maintenance and Checks

i. Sealed source custodians shall routinely clean and maintain the sealed sources according to the manufacturer’s recommendations and instructions. Routine

maintenance includes removal of exterior residues from the source housing, external lubrication of the shutter mechanism, calibration, and electronic repairs. Individuals performing routine maintenance shall have adequate training and experience.

ii. Routine checks should be carried out at least once a month provided that additional checks are carried out following any maintenance or repair which could have affected the source. Records should be kept of these checks. If the source is portable, e.g. nuclear moisture/density gauges or Operation radiography containers, daily checks and records (on each working day the equipment is used) are recommended.

iii. Shutter controls shall be locked-out during routine maintenance.

6.11.4.2 Non-Routine Maintenance and Repairs

i. Non-routine maintenance or repair shall be performed by the fixed gauge manufacturer, distributor, or a person specially authorized by a governing regulatory agency. Non-routine procedures include any maintenance or repair that involves or potentially affects components related to the radiological safety of the gauge such as the source, source holder, source drive mechanism, shutter, shutter control, or shielding and any other activity during which personnel could receive radiation doses exceeding the governing regulatory agency limits.

ii. Shutter controls shall be locked-out in the off position during non-routine maintenance and repairs unless the issue requiring such activities precludes this lock-out (e.g., stuck shutter control mechanism).

6.11.5 Exposure limits

i. Exposure of personnel shall be maintained as low as reasonably achievable (ALARA) based on personal dosimetry results.

ii. Occupational dose limits from AERB for exposures from ionising radiations for workers and the members of the public are shown in below **Tables,** and shall be adhered.

iii. In addition, the occupational radiation exposure to a declared pregnant woman shall not exceed 1 mSv (0.1 rem = 100mrem) of whole body exposure during the entire pregnancy.

iv. The limits on effective dose apply to the sum of effective doses from external as well as internal sources. The limits exclude the exposures due to natural background radiation and medical exposures.

v. Calendar year shall be used for all prescribed dose limits.

Dose limits for occupational workers

Body part	Effective Occupational Dose limits
Whole body—deep dose	30 mSv (3 rem) per year 20 mSv/yr (2 rem) averaged over five consecutive years

Extremities (hands and forearms, feet, and ankles)	500 mSv (50 rem) per year
Skin of the whole body—shallow dose	500 mSv (50 rem) per year
Lens of the eye	150 mSv (15 rem) per year

Dose limits for apprentices and trainees between 16 and 18 years of age

Body part	Effective Occupational Dose
Whole body—deep dose	6 mSv (0.6 rem) per year
Extremities (hands and forearms, feet, and ankles)	150 mSv (15 rem) per year
Skin of the whole body—shallow dose	150 mSv (15 rem) per year
Lens of the eye	50 mSv (5 rem) per year

Note: The ALARA concept applies and these levels are well above doses that people should receive. If significant doses can occur to people, they should be reduced using the factors of time (minimizing the time exposed to the source), distance (increasing the distance from the source), and shielding (increasing the shielding as needed).

Dose Limits for individual members of the public

Body part	Effective Occupational Dose limits
Whole body—deep dose	1 mSv (100 millirem) per year
Skin of the whole body—shallow dose	50 mSv (5 rem) per year
Lens of the eye	15 mSv (1.5 rem) per year

6.11.6 Personnel Monitoring Requirements (Dosimetry)

i. No person under the age of 18 years shall be employed as a worker.

ii. No person under the age of 16 years shall be taken as trainee or employed as an apprentice for radiation work and shall not be permitted in radiation areas.

iii. Whole body and/or finger (or wrist) personal dosimeters, either film badges, thermo luminescent dosimeters (TLD), or optically stimulated luminescence dosimeters, shall be worn by

- Personnel operating medical X-ray units.
- Personnel operating industrial X-ray equipment

- Personnel likely to receive a dose in any calendar quarter exceeding 10 percent of that specified in Section 6.12.5.

iv. The site radiation safety program (RSP) shall indicate at what levels of activities personnel dosimetry is required. The RSO shall consult local regulations to determine if whole body or finger dosimeters are required and the monitoring periods. If such requirements are not specified in the regulations, the RSO shall determine which type shall be worn and the exposure monitoring periods.

v. The RSO shall also consult local regulations to determine if any health surveillance is required.

vi. It is recommended that personal exposure monitoring and analysis should be carried out on at least on quarterly basis, and the site RSO should dispense new badges every 3 months.

vii. All dosimeter results shall be recorded on a suitable form as specified by local regulations and include the employee's name and an identifying number.

viii. Such records shall be preserved during the working life of each worker, and afterwards until the worker attains or would have attained the age of Seventy five years, or not less than thirty years after the termination of the work involving occupational exposure whichever is later.

ix. A worker shall have access to his personnel monitoring and the health surveillance records. Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, should be reported in writing to the individual and shall contain applicable statements required the by local or governmental agencies.

x. The RSO should review all personnel exposure records for each monitoring period to determine if there are any exposure trends which may require investigation and/or corrective measures. A plan should be on hand for investigating any dosimeter results above or below normal levels promptly and thoroughly. If results exceed permissible limits, the RSO shall issue a written incident report to the appropriate statutory authorities and notify the affected employee(s) and appropriate line and site management.

xi. If collected dosimeter data indicates a low probability of exceeding 10 percent of the permissible annual exposure limits, dosimetry use / full-time badging may be determined as unnecessary if allowed by applicable regulations and this justification to discontinue dosimetry shall be documented. However, it is recommended that, annually, a few representative operators wear dosimeters for one calendar quarter to help ensure that operators' exposure remains negligible, and further reduce exposure levels to ALARA.

6.11.7 Personal Protective Equipment

i. The type of personal protective equipment (PPE) required will be dependent upon the type and amount of radioactive source used and shall be established prior to commencing its use or storage. The site radiation safety program shall specify the minimum PPE requirements for source users and identify any additional PPE

requirements based on the type (potential hazards) and amount of radioactive source used.

ii. At a minimum, safety glasses with side-shields and disposable nitrile gloves should be used. Laboratory coats, gauntlets (sleeves), shoe coverings, face shields, lead-lined aprons, and respiratory protection may be required depending upon the work tasks involving radioactive sources.

iii. PPE must not be taken out of the source use area unless monitored and determined to be free of contamination. Contaminated PPE must be disposed of properly.

6.11.8 X-ray Machines: Additional Safety Considerations

Unlike radioactive isotopes, which emit radiation continuously, x-rays are generated by electrical current and can be turned on and off as needed. X-rays are produced near any equipment or areas where high-energy electrons are generated and slowed down by impingement upon a target. X-rays occur most frequently in vacuum equipment, where there is an electron beam of 20,000 volts (V) or more.

i. It shall be verified by monitoring that at lower voltages, the X-rays are soft (i.e., low energy) and may be completely absorbed by the surrounding case or shielding. Therefore, X-ray safety hazards must be anticipated in many types of equipment other than conventional X-ray generators. Examples of conventional X-ray generators are X-ray machines, X-ray diffraction, X-ray fluorescence spectroscopic equipment, cyclotrons, and other particle accelerators. An example of an unconventional X-ray generator is an electron microscope.

ii. Localized radiation burns produced by the high intensity primary x-ray beam is the principal hazard associated with the use of analytical x-ray equipment. A localized radiation burn could occur within 1-2 seconds of contact with the primary beam. Symptoms of a localized radiation burn could take up to several weeks to manifest, depending on the dose.

iii. Most severe injuries have occurred during non-routine operations such as repair and alignment. Alignment procedures recommended by the manufacturer of the x-ray system shall be utilized if available.

6.11.8.1 Shielding

i. X-ray installations should be designed and installed for minimum radiation leakage during routine use.

ii. X-ray tube housing shall be such that leakage measured 5 cm from its surface with all shutters closed is less than 2.5 mrem in one hour.

6.11.8.2 Access and signs

i. Access to areas where there are X-ray installations shall be controlled.

ii. Areas or rooms where X-ray equipment is present shall be posted as required by local regulation. See section 6.12.1.8.

iii. X-ray equipment shall be labeled with the radiation symbol and the words “CAUTION HIGH INTENSITY X-RAY BEAM” on the X-ray sources housing and “CAUTION RADIATION – THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED” near any switch that energizes an X-ray tube.

iv. Radiation areas as defined shall be posted with the conventional radiation symbol and the wording shown below:

v. High radiation as defined shall be posted with the conventional radiation symbol and the wording shown below:

6.11.8.3 Radiation Control Devices

i. Radiation control devices shall be installed in all high radiation areas to either automatically reduce the radiation level below the 1 millisieverts (mSv) (100 millirem [mrem]) per hour level or sound an alarm.

ii. These devices should be placed for optimum detection of leaks or malfunctioning switches or shutters. Ionization chamber-type devices typically are preferred for these types of applications. Periodic checks for device response shall be performed (monthly is suggested).

6.11.8.4 Safety Devices

i. Safety devices on X-ray equipment (e.g., interlocks and shutters) shall be maintained in working order. Checks to help ensure that the safety devices are operating properly shall be performed at least every six months and the results documented. Additional checks should be performed periodically as determined by the operator, supervisor, or RSO. These checks do not require formal documentation. The equipment operator is responsible for helping to ensure that these checks are completed.

ii. X-ray equipment shall not be used while any interlocks are malfunctioning. Interlocks also should not be bypassed during normal operation. If any exceptions are necessary (e.g., non-routine maintenance operations), the RSO should be notified to help ensure that appropriate precautions are followed. Site interlock bypass procedures must be followed.

iii. The main switch rather than interlocks shall be used for routine shutdown in preparation for repairs.

Note: Serious X-ray exposures have occurred from direct exposure to the beam when interlocks were defeated.

6.11.8.5 Warning Devices

i. Open-beam configurations shall be provided with a readily discernible indication of one or both of the following, depending on the manner in which the beam is controlled:
   - X-Ray tube status (ON/OFF) located near the radiation tube housing
   - Shutter status (OPEN/CLOSED) located near each port on the radiation source housing if the primary beam is controlled in this manner

ii. A red light should be provided at the entrance of X-ray room or area, and it should be made 'ON' during exposures.

iii. In the case of open top enclosures, red lights should be provided on the top of the walls and should be made 'ON' during exposures as a warning to the crane operator.

6.11.8.6 Exposure Monitoring

i. If collected dosimeter data indicates a low probability of exceeding 10 percent of the limits, full-time badging of X-ray equipment operators may be discontinued if allowed by applicable regulations. See Section 6.12.6. However, TLD badges shall be placed near the x-ray equipment to verify that exposures remain negligible.

ii. Finger or wrist dosimetric devices shall be provided to and shall be used by:
   - X-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and
   - Personnel maintaining x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the x-ray system is disassembled or removed.

6.11.9 Industrial Radiography: Additional Safety Considerations

i. Industrial radiography refers to the use of penetrating radiation such as x-rays, gamma rays, or neutrons to inspect metal castings or welds for internal flaws. Radiography at the company sites or facilities is typically contracted to a licensed third-party and managed by a site or facility construction engineer, project leader, or contract administrator.

ii. All phases of industrial radiography, both gamma- and x-ray, must be performed by licensed and trained radiographers and assistant radiographers.

iii. No radioactive material or X-ray machine shall be brought onto any site without prior authorization by the site RSO.

iv. Only $Cobalt_{60}$ and $Iridium_{192}$ should be used as radiographic isotopes for industrial radiography. If any other isotopes are used, special procedures shall be developed that may increase the frequency of surveys of the source containment for leaks.

v. The site or facility RSO shall be informed of all proposed radiographic work in advance and shall approve all planned radiography work. This shall require that a Radiographic Inspection Permit be completed by originator and furnished to site RSO at least 2 days prior to starting radiographic work and signed by the site RPO. see Annexure 4 – Sample Radiography Inspection Permit.

vi. The original permit will be retained by the site RSO and a copy will be issued to originator so as to obtain area work permit from the area operations representative.

vii. The construction engineer or project leader shall provide the above information to all members of construction supervision whose employees may be affected by the radiography.

viii. If there is any change in any of the information provided in Radiography Inspection Permit at any time, the radiographic contractor shall stop the work and promptly notify the site/facility RSO and construction supervision/project leader.

ix. Plant personnel will not handle radiographic equipment, assist the radiographer, or enter the barricaded area while work is being performed. Provisions may be made for access to the barricaded area for necessary operating and maintenance functions, or to re orient the barricades, provided that the radiation source is shielded or deactivated and the area surveyed to assure that the radiation level does not exceed 2.0 mR/hr.

x. Radiography should be carried out at a time and place where occupancy is least.

xi. The completion date of the radiographic work must agree with that indicated on the permit. If additional time is required, the permit shall be returned to the RPO for revision.

6.11.9.1 Storage and Handling

i. The contractor radiographer shall be responsible for the handling of radioisotopes within the plant boundaries. This includes shielding, vehicle placarding, and security of the sources.

ii. Radiation sources used in radiography shall not be stored on the site/facility without prior approval of the RSO and the site/facility construction manager or designee. Temporary storage of radiation sources in the radiographer's vehicle shall only be permitted if the vehicle is locked, the keys are removed, and radiation-warning signs are prominently displayed.

6.11.9.2 Barricades and Sign

i. The radiographic contractor shall determine and erect a barricade of sufficient size based on the type and strength of the source used so the estimated radiation doses do not exceed 2 mR per hour above background radiation at any point along the perimeter.

ii. Prior to moving the radioactive source from its shielding container, caution signs reading "Caution – Radiation Area" or "Caution – Radiography in Progress" shall be placed on the barricade in conspicuous places and at all probable entrance points.

iii. Inside the perimeter barricade, the contractor should also erect a barricade of sufficient size so that the estimated radiation doses do not exceed 5,000 mR per hour. "Very High Radiation Area" warning signs should be placed on all sides of the barricade.

iv. Before the radiographic work begins, the radioactive source shall be exposed so the radiographer and the site/facility RSO, or designee, can ensure that the estimated radiation dose at the barricade is 2 mR per hour or less. The radiographic work may be performed only after the site/facility RSO, or designee, is satisfied with the suitability of the barricade. If, at any time, the estimated radiation dose exceeds 2 mR per hour at the perimeter of the barricade, the radiographic contractor shall secure the source and reposition the barricade to maintain 2 mR per hour.

v. Immediately after the barricade and signs have been erected and prior to exposing the radioactive source, the construction engineer, or designee, shall visually check to ensure that no unauthorized employees are within the barricaded areas. The radiography contractor is obligated to keep unauthorized personnel outside of the barricaded area while the source is exposed. The barricaded area should then be continuously patrolled to prevent accidental entry into the restricted area.

vi. Preferably, if space is not a constraint, the contractor should erect as large a barricade as possible (minimum 15 Meter), not merely the minimum barricade. If the minimum barricade is established and the source is lost during an exposure, the contractor must quickly reposition the minimum barricades to take into consideration the extra exposure time for source retrieval.

6.11.9.3 Personal Monitoring

i. At a minimum, all personnel entering the barricaded area shall wear a radiation monitoring badge and a self-reading dosimeter.

ii. All site employees who will be continually present at the barricade to the restricted area or who require periodic access into the barricaded area shall wear a radiation film badge or a pocket dosimeter.

6.11.9.4 Damaged or Malfunctioning Equipment

Any exposure equipment or accessories that are damaged or malfunctioning shall be removed from the site.

6.11.9.5 Unusual Incident or Activity

i. The contractor radiographer shall immediately notify the Construction engineer or project engineer and the site RSO of any unusual incident that is related in any way to the radiographic work. This includes incidents that involve the radiography contractor's employees who are performing the radiographic work or any HZL employee or contract personnel. The contractor radiographer and construction engineer shall provide full details of any such incident.

ii. In the event of any unusual incident or activity related to the performance of the radiographer, the HZL representative will immediately notify the site RSO. A serious incident will trigger a full investigation, which will be detailed in writing and attached to the radiographic inspection permit.

6.11.10 Tritium exit signs

Tritium exit signs contain the radioactive material hydrogen-3, which is known as tritium. This type of sign has historically been used in areas where electrical power was either not available or created additional hazards. However, the disposal of these signs can be costly. Photoluminescent exit signs, which also do not use electrical power, are preferred over tritium exit signs as they do not contain a radioactive material.

Sites shall not purchase new tritium exit signs, including signs to be used as replacements for existing tritium signs, unless the site has determined and documented that there are no other acceptable alternatives. The RSO, or site-appointed responsible person, shall review and approve the procurement of new tritium exit signs.

Sites with tritium exit signs shall have the following program elements in place:

i. The site RSO shall maintain a written inventory of all tritium signs (in use and stored) that includes location of the sign, manufacturer, model number, and serial number. If the site does not have an RSO, the site shall appoint an individual responsible for these elements. This individual shall be knowledgeable of local regulatory requirements governing the possession, use, storage, and disposal of tritium exit signs.

ii. Every 6 months, the site RSO, or designate, shall conduct a physical inventory to verify that all signs are in place and not damaged. The physical inventory shall be documented. One method is to document the physical inventory in the same spreadsheet that is used for the written inventory.

iii. Damaged or missing signs shall be reported to the appropriate regulatory agencies if required by local regulations.

iv. Signs that are no longer needed shall either be returned to the vendor or disposed of using an appropriate vendor. Regulatory agencies shall be notified of the return or disposal if required by local regulations. Tritium exit signs removed from service shall be stored in a secure location until such time that they can disposed of or returned.

6.11.11 Decontamination

i. Areas of contamination exceeding the site contamination action levels, must be decontaminated to below the minimum action level. Identification of contaminated areas and subsequent decontamination efforts shall be documented.

ii. Loose contamination can usually be readily removed by wiping down the affected area with a commercially-available decontamination solution, warm soapy water, or a 70% methanol solution. Materials used in decontamination efforts must be disposed of properly.

iii. Decontamination efforts must be assessed by resurveying the affected area. It is highly recommended that a combination of wipe test and meter survey be used in determining the effectiveness of the decontamination efforts. Areas considered free of contamination by wipe testing but considered contaminated by meter surveys may indicate the presence of fixed contamination (not easily removable) and may require more extensive decontamination efforts (sanding, grinding, or removal of affected material).

6.11.12 Radioactive Waste Storage and Disposal

i. Radioactive waste storage and disposal methods may be dictated by the site license and must be documented in the radiation safety program. Identification and waste labeling requirements must follow regulatory, radiation safety program, and site/facility requirements.

ii. Liquid radioactive waste should be collected in sealable, leak-proof containers and placed inside of suitable secondary containers. Radiation trefoil symbol stickers or tape must be affixed to the primary and secondary container and must indicate the radioisotope waste collected. Liquid radioactive waste container lids must be completely closed when not in use.

iii. Solid, dry radioactive waste, such as paper towels, absorbent padding, and disposable gloves should be collected in lined drums or containers. Use of liners with printed radiation trefoil symbols is highly recommended. The waste drums or containers must also be posted with the radiation trefoil symbol and indicate the radioisotope waste collected.

iv. Radioactive waste storage is only permitted in areas registered for and posted such purposes. Access to these areas should be limited to authorized users and waste handling personnel.

v. Radioactive waste must not be disposed of in normal, non-radioactive laboratory or office trash unless the site license specifies non-radioactive waste threshold criteria.

6.11.13 On-site Transportation

On-site movement of radioactive source shall be accomplished via “hand carry” or through use of authorized site transportation vehicles.

6.11.14 Emergency Procedures

The purpose of emergency response is to respond to a radiological emergency in such a way that minimizes personnel exposures, prevents the spread of contamination, maintains control of the situation, and keeps our employees and the public informed.

i. Emergency procedures and plans shall be established in case of an accident involving a radioactive source or in the event of damage to a sealed source. These procedures and plans shall also address cases of personal exposures, potential source housing leakage (as a result of a leak test) or issues identified with the shutter control mechanism (through either inspection or testing).

ii. The radiation safety program shall establish contamination criteria by which source use areas must be shut-down and barricaded until contamination levels can be determined and decontamination / emergency plans established.

iii. At a minimum the following shall be employed in the event of an emergency involving a source:

- All work on or within 20 feet (6 meters) of the affected source shall cease immediately.
- A barricade shall be erected at a distance of 20 feet (6 meters) from the affected source
- Users and any potentially contaminated individuals shall not leave the scene until emergency assistance arrives.
- Response, treatment and examination of personal exposures
- The site RSO shall be immediately notified.
- Appropriate line and site/facility management and safety resources must be notified of any contaminated radioactive source use/storage areas requiring shut-down, barricading, and decontamination.

- The source manufacturer and/or distributor shall be contacted for guidance and assistance.
- The local governing regulatory agency shall be notified if and as required by local regulatory requirements.

6.11.15 Regulatory Agency Notifications

Local governing regulatory agencies may require notification on matters relating to the safety and security of a source such as the following:

- Loss of a source
- Theft of a source
- Leak test result / personal exposure / environmental release exceeding local regulatory agency limits
- Accident involving a source
- Damage to a source

The sites or facilities that employ sealed sources shall determine and document the notification and reporting requirements of their local, governing regulatory agency.

6.11.16 Training

i. Radioactive source training shall be required for persons who handle radioactive sources. In addition to the elements of this section, training should include the following:
   - The basic characteristics of radiation
   - Half-life and radiation units
   - Natural background and other sources of radiation exposure
   - The biological effects of radiation exposure
   - The risks of radiation exposure
   - Rules and regulations
   - Annual radiation dose limits
   - The site or facility ALARA Philosophy
   - The properties of the sources used at the site or facility
   - Site or facility-specific guidelines and requirements for handling sources

ii. People working with X-ray equipment shall receive training in the hazards of X-rays and proper operation of the equipment, which includes identification of the hazards, location of equipment, and purpose of interlocks and other safety devices.

iii. Radiation Safety Awareness training shall be provided for all persons who work or frequent near radioactive sources.

iv. The RSO shall complete any additional training as required by the site or facility license or local applicable regulations. It is highly recommended that individuals designated as an RSO or Assistant RSO attend a course specifically designed for the training of

RSOs from BARC (Bhabha Atomic Research Centre). Refresher training at least every five years is also highly recommended.

v. In addition, people shall receive any other training that is required by the state or local regulatory agency.

vi. Refresher training shall be provided at least every three years.

6.12 Monitoring exposure in the workplace

The levels of airborne contaminants in a workplace are governed by “maximum exposure limits” (MELs) and by “occupational exposure standards” (OES). Collectively these terms are referred to as “occupational exposure limits” (OEL) or “permissible exposure limits” (PELs) for a particular substance or mixture that must not be exceeded. There are three types of occupational exposure standard:

- 8-hour time-weighted average (TWA)
- peak limitation / Ceiling limit (MEL)
- short term exposure limit (STEL)

Exposure standards are based on the airborne concentrations of individual substances that, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers. They do not represent a fine dividing line between a healthy and unhealthy work environment.

As the name suggests maximum exposure limit (ceiling limit) is the absolute exposure limit for a particular substance or mixture that must not be exceeded at any time.

The limits for substances in use at HZL sites should be obtained from applicable regulations or HZL internal guidelines. Where no OEL has been established, the “Threshold Limit Value” (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH) should be used.

i. Each site shall ensure that compliance with OELs is achieved by the application of appropriate control measures according to the hierarchy of control.

ii. The risk assessment will define whether the exposure limits are likely to be exceeded. If it is probable that the levels are exceeded, then atmosphere monitoring shall be undertaken to quantify the levels in the atmosphere and institute the correct control measures to avoid risks to health of those exposed.

iii. Each site shall also consider the special needs to protect particular groups of employees who may be at an increased e.g., inexperienced trainees and young people aged under 18 years of age; pregnant workers; disabled workers; and any employees known to be susceptible to certain illnesses such as dermatitis, asthma or other diseases which may be caused by exposure to hazardous materials.

6.13 Health monitoring

Health monitoring of a person means monitoring the person to identify changes in the person’s health status because of exposure to certain substances. It involves the collection of data in order to evaluate the effects of exposure and to confirm that the absorbed dose is within safe levels. This allows decisions to be made about implementing ways to eliminate or minimise

the worker's risk of exposure, for example, reassigning to other duties that involve less exposure or improving control measures.

i. Regulations, HZL internal guidelines or monitoring results and a risk assessment by a trained Occupational Hygienist can mandate health surveillance.

ii. Where the hazard is high and the symptoms may not be recognisable (long-term chronic effects) then Health monitoring must be in place and agreed by the doctor or company medical officer. Generic results should be linked back to the risk assessment of the Occupational Hygienist, so that preventive actions can be implemented.

iii. Personal records shall be kept for all persons / employees who undergo Health monitoring and these records must include details of exposure to hazardous substances, biological hazards and harmful physical agents. Retrievable personal medical data including incidents/overexposure cases must not be used outside of Medical Sections without the written consent of that person.

iv. If the Health monitoring results indicate that a worker is experiencing adverse health effects or signs of exposure to a hazardous chemical, the control measure must be reviewed and if necessary revised.

6.14 Emergency preparedness

- Emergency safety shower(s) and eye wash fountain(s) shall be provided within reasonable distance of unobstructed travel as per applicable HZL standard / guidelines.
- Leak detection may be used in conjunction with secondary containment, particularly in high-risk locations. Leak detection is especially important where secondary containment is not feasible or practical.
- Site shall develop and implement chemical specific procedures for dealing with spills and damaged containers.as part of emergency response.
- Spill clean-up equipment / kit including and PPE appropriate to the chemical being handled shall be provided at storage areas as well as on all vehicles transporting drums and IBCs. Examples of what should be included in a spill kit are: absorbent pads, booms or absorbent socks, spill granules, PPE, disposal bags & ties etc. These shall be stored in known locations within close proximity of hazardous chemical storage and use.
- It is recommended that sites have a quarantine area where leaking containers can be placed safely. Sites should also have equipment available to seal leaks at delivery and handling areas, or other high risk locations so that temporary seals can be made. Sites should also have metal and plastic trays for leaking IBCs and portable containers.
- Damaged or leaking containers should be stored in a designated area/building well away from the main buildings so that is well ventilated, equipped with appropriate security features and has segregated areas
- Dedicated personnel must be trained in the use of Spill clean-up equipment / kit, PPE and rescue.
- MSDSs must be available for emergency services at places which are not affected by the emergency.

- For emergency handling associated with Radioactive sources, see section 6.11.14.

7. Management systems

7.1 Support resources

HZL and its sites' HSE and PSM resources must be made available to assist with implementation of this standard.

The zone champion should involve the legal department or the Regulating bodies to seek information on statutory requirements.

7.2 Management records

Each site must maintain records to document its compliance with this standard.

Records shall be retained in compliance with the statutory requirements and the HZL Corporate Records Policy. Their retention times must be established and recorded.

Records must be stored and maintained in such a way that they are retrievable and protected against damage, deterioration or loss. Wherever possible, use of digital records in place of paper records is recommended.

MSDSs (both vendor and HZL generated) are considered to be a significant part of a site's PT package, and as such, shall be retained according to HZL PT standard / guidelines.

Risk assessment and SOPs / SWPs are considered to be a part of site's PSM program, and as such, shall be retained according to HZL PSM standard.

7.3 Audits

Audits shall be carried out to check for desired compliance with this standard at the sites along with other elements of PSM. Scheduling and type of the audits are governed as per HZL PSM standard.

Sites should evaluate their procedures, training records and conditions of regulatory permits / consents to confirm regulatory compliance and to determine whether SOPs/SWPs are adequate for safe storage and handling of hazardous chemicals.

7.4 Standard renewal process

This standard shall be reviewed and revised as necessary and, at a minimum, not later than two years from the date of the last revision.

7.5 Deviation process

i. The requirements of this document are mandatory. Any Deviation(s) from this standard must be endorsed by Unit Head and authorized by the Location Head after consultation with the HSE, site PSM Leader and legal department where needed.

ii. Deviations must be documented, and documentation must include the relevant facts supporting the deviation decision and the interim measures to be put in place to achieve acceptable levels of HSE protection. Deviation authorisation must be reviewed periodically and no less frequently than every 3 years.

iii. Emergency deviations must be authorized by the unit head when, as a result of an unforeseen event or situation, there is inadequate time to process a formal deviation. Emergency deviations shall be authorized only where it is not feasible to comply with a requirement in this standard. Emergency deviations shall be short in duration, not to exceed the time to perform the task at hand. Appropriate SHE resources shall be consulted.

iv. A copy of the deviation must be sent to the Corporate PSM leader / champion.

7.6 Training and communication

i. All personnel (HZL employees as well as contract workers) who are engaged in activities involving handling and storage of hazardous chemicals shall receive initial classroom based training on Chemical Handling and Storage. The elements of proper training must include the following:

Module A: General Awareness and Instructions

- The nature of the hazardous chemicals involved and the significant risks to which individuals may potentially be exposed or that could be released into the environment
- the labelling of containers of hazardous chemicals and other hazard communication signage, the information that each part of the label / signage provides and why the information is being provided
- Where to find MSDSs and how to read them
- General control measures including health and safety rules, procedures, rules and precautions in place, how to use / comply with them correctly
- Use, maintenance and storage of any personal protective equipment (PPE) required to control risks to which individuals may potentially be exposed and the limitations of the PPE
- Routes of exposure, including target organs
- Signs and symptoms of presence and exposure
- any health monitoring which may be required
- General knowledge of safety and emergency response information / procedures, and self-protection measures and practices for preventing incidents/accidents
- Worker’s rights and obligations

Module B: Job Specific Information and Instructions

- Significant hazards of the hazardous chemical involved

- Job specific risks and control measures implemented, how to use and maintain them correctly
- The specific requirements of the legal regulations, this standard and any other site standard / procedure as they relate to their job functions.
- Job specific work practices and procedures to be followed in the loading / unloading, handling, storage, transportation, cleaning up and disposal of hazardous chemical they handle
- Inspection of the specific equipment / containers they load/unload
- the selection, use, maintenance and storage of job specific personal protective equipment (PPE) required to control risks and the limitations of the PPE
- Job specific exposure and health monitoring programs where applicable
- Job specific arrangements and procedures in place to deal with emergencies, including evacuation procedures, containing and cleaning up spills and first aid instructions
- Their role and responsibilities

It may be appropriate for training to be done by categories of chemicals (e.g., flammable, solvents, asphyxiants, and corrosives) rather than on an individual, specific chemical basis.

Separate field sessions may also be added in this training program to incorporate job specific practical training under the direct supervision of a properly trained person.

ii. All personnel (HZL employees as well as contract workers) who are directly not engaged in activities involving handling and storage of hazardous chemicals but are exposed to on-site hazards of hazardous chemicals shall receive initial classroom based General Awareness training on Chemical Handling and Storage (only Module A as described above in this section).

iii. Training requirements for handling and storage of radioactive materials have been specified in section 6.4.16.

iv. Each site must also maintain an adequate number of professional, well trained, and knowledgeable employees who have a thorough understanding of all the sections of this standard including relevant statutory requirements.

v. The amount of detail and extent of training will depend on the nature of the hazards, the complexity of the work procedures and control measures required to minimise the risks, and on competency requirements & qualifications of target receivers. Training and instruction must be provided in such a way and language that it is easily understood by the target receivers.

vi. Relevant and appropriate training on Chemical Handling and Storage (Module A/Module B/field sessions) shall be imparted to personnel on initial assignment, upon transfer to a new assignment, upon addition of new materials in the work process, and periodically thereafter. Additional training may be needed when an existing chemical is used in a different way, in a different physical form, or in a larger volume.

vii. Each site must ensure that any contractor whose work entails the handling of hazardous chemicals receive appropriate training including the requirements for regulatory compliance and the consequences of deviation.

viii. Personnel must be tested by appropriate means on the training subjects covered in this section to verify their understanding. A formal method to certify job knowledge must also be part of the training programme.

ix. Prior to completing this training, personnel may perform the job functions involving handling and storage of hazardous chemicals as long as they perform those functions under the direct supervision of a properly trained person who has the ability to take corrective action. However, in case of newly recruited employee or contract worker, this period shall in no case be more than 90 days after job appointment.

x. Refresher training will be carried out as determined by Zone PSM Sub-committee based on training needs identification but at least every three years. It is recommended to conduct annual refresher and supplementary training on Chemical Handling and Storage.

xi. New hazard information that is received shall be communicated to personnel and incorporated into the appropriate training programs. For some information, waiting until the next training session may be appropriate. Other information should be promptly communicated (e.g., new carcinogen classification).

7.6.1 Documentation of training

Training records shall be documented, including dates and names of personnel trained, contents of the training, and if applicable, the name and qualification of the person(s) who conducted the training. Training records shall be retained in compliance with the statutory requirements and the HZL Corporate Records Policy. Sites should verify the effectiveness of training. This may be accomplished through successful completion of a test or skill demonstration.

Annexure-1: Classification of hazardous chemicals

Class 1: Explosives

i) **Explosive substance** is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases;

ii) **Pyrotechnic** substance is a substance or a mixture of substances designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reactions;

iii) **Explosive** *article* is an article containing one or more explosive substances;

iv) **Phlegmatised** means that a substance (or "phlegmatiser") has been added to an explosive to enhance its safety in handling and transport. The phlegmatiser renders the explosive insensitive, or less sensitive, to the following actions: heat, shock, impact, percussion or friction. Typical phlegmatising agents include, but are not limited to: wax, paper, water, polymers (such as chlorofluoropolymers), alcohol and oils (such as petroleum jelly and paraffin).

Divisions and labels (pictograms)

Class 1 is divided into six divisions as follows:

Hazard labels (pictograms)	Symbol Details	Divisions
	Symbol: Exploding Bomb Colour of Symbol: Black Background: Orange *The asterisks are replaced by the class number and compatibility code or to be left blank if explosive is the subsidiary risk.	**Division 1.1** Substances and articles which have a mass explosion hazard (a mass explosion is one which affects almost the entire load virtually instantaneously); **Division 1.2** Substances and articles which have a projection hazard but not a mass explosion hazard; **Division 1.3** Substances and articles which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. This division comprises substances and articles: (i) which give rise to considerable radiant heat; or (ii) which burn one after another, producing minor blast or projection effects or both;

	Symbol: Only Number Colour of Symbol: Black Background: Orange *The asterisks are replaced by the compatibility code or to be left blank if explosive is the subsidiary risk.	**Division 1.4** Substances and articles which present no significant hazard. This division comprises substances and articles which present only a small hazard in the event of ignition or initiation during transport. The effects are largely confined to the package and no projection of fragments of appreciable size or range is to be expected. An external fire will not cause virtually instantaneous explosion of almost the entire contents of the package
	Symbol: Only Number Colour of Symbol: Black Background: Orange *The asterisks are replaced by the compatibility code (Here “D”) or to be left blank if explosive is the subsidiary risk.	**Division 1.5** Very insensitive substances which have a mass explosion hazard This division comprises substances which have a mass explosion hazard but are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport; **NOTE:** The probability of transition from burning to detonation is greater when large quantities are carried in a ship.
	Symbol: Only Number Colour of Symbol: Black Background: Orange *The asterisks are replaced by the compatibility code (Here “N”) or to be left blank if explosive is the subsidiary risk.	**Division 1.6** Extremely insensitive articles which do not have a mass explosion hazard This division comprises articles which contain only extremely insensitive substances and which demonstrate a negligible probability of accidental initiation or propagation.

Compatibility groups

Goods of Class 1 are also assigned to one of thirteen compatibility groups which identify the kinds of explosive substances and articles that are deemed to be compatible.
For more details, refer GHS or UN MODEL regulation on TDG.

Class 2: Gases

i) A gas is a substance which:

(a) at 50 °C has a vapour pressure greater than 300 kPa; or

(b) is completely gaseous at 20 °C at a standard pressure of 101.3 kPa.

ii) The transport condition of a gas is described according to its physical state as:

(a) **Compressed gas** - a gas which when packaged under pressure for transport is entirely gaseous at -50 °C; this category includes all gases with a critical temperature less than or equal to -50 °C;

Examples are Chlorine, Nitrogen, Ammonia cylinders etc.

(b) **Liquefied gas** -a gas which when packaged under pressure for transport is partially liquid at temperatures above -50 °C. A distinction is made between:

(i) **High pressure liquefied gas** - a gas with a critical temperature between -50 °C and +65 °C, and

(ii) **Low pressure liquefied gas** - a gas with a critical temperature above +65 °C;

(c) **Refrigerated liquefied gas** - a gas which when packaged for transport is made partially liquid because of its low temperature;

(d) **Dissolved gas** - a gas which when packaged under pressure for transport is dissolved in a liquid phase solvent.

(e) **Adsorbed gas** – a gas which when packaged for transport is adsorbed onto a solid porous material resulting in an internal receptacle pressure of less than 101.3 kPa at 20 °C and less than 300 kPa at 50 °C.

iii) The class comprises compressed gases, liquefied gases, dissolved gases, refrigerated liquefied gases, mixtures of one or more gases with one or more vapours of substances of other classes, articles charged with a gas and aerosols.

Divisions and labels (pictograms)

Substances of Class 2 are assigned to one of three divisions based on the primary hazard of the gas as follows:

Hazard labels (pictograms)	Symbol Details	Divisions
 	Symbol: Flame Colour of Symbol: Black or White Background: Red The symbol, the number and the border line may be shown in white instead of black.	**Division 2.1 Flammable gases:** Gases which at 20 °C and a standard pressure of 101.3 kPa: (i) are ignitable when in a mixture of 13 per cent or less by volume with air; or (ii) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit. Flammability should be determined by tests or by calculation in accordance with methods adopted by ISO (see ISO 10156:2010) or by Bureau of Indian Standards ISI Number 1446 of 1985.
 	Symbol: Gas cylinder Colour of Symbol: Black or White Background: Green The symbol, the number and the border line may be shown in white instead of black. Yellow background with black symbol (Flame over circle) is used for oxygen (compressed gas or refrigerated liquid).	**Division 2.2 Non-flammable, non-toxic gases**: Gases which: (i) are asphyxiant – gases which dilute or replace the oxygen normally in the atmosphere; or (ii) are oxidising – gases which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does; or (iii) do not come under the other divisions; **NOTE:** in (ii) above, "gases which cause or contribute to the combustion of other material more than air does" means pure gases or gas mixtures with an oxidising power greater than 23.5% as determined by a method specified in ISO 10156:2010.

	Symbol: Skull and Cross Bones Colour of Symbol: Black Background: White	**Division 2.3 Toxic gases:** Gases which: (i) are known to be so toxic or corrosive to humans as to pose a hazard to health; or (ii) are presumed to be toxic or corrosive to humans because they have an LC_{50} value (as defined in ….) equal to or less than 5,000 ml/m^3 (ppm). **NOTE:** Gases meeting the above criteria owing to their corrosivity are to be classified as toxic with a subsidiary corrosive risk.

Class 3: Flammable Liquids

Flammable liquid means a liquid having a flash point of not more than 93°C. Substances and mixtures of this hazard class are assigned to one of four hazard categories on the basis of the flash point and boiling point (See Table below). Flash Point is determined by closed cup methods.

Category	Description	Criteria
1	Extremely flammable liquids	Flash point < 23°C (73°F) and initial boiling point ≤ 35°C (95°F)
2	Very highly flammable liquids	Flash point < 23 °C (73°F) and initial boiling point > 35°C (95°F)
3	Highly flammable liquids	Flash point ≥ 23 °C (73°F) and ≤ 60 °C (140°F)
4	Flammable liquids	Flash point > 60 °C (140°F) and ≤ 93 °C (200°F)

Hazard labels (pictograms)

Symbol: Flame Background: Green

Colour of Symbol: Black or White (The symbol, the number and the border line may be shown in black or white)

Notes: 1) Name of the liquid such as GASOLINE may be used in place of FLAMMABLE. 2) If liquid is categorized as flammable or combustible, the word combustible may be used in place of FLAMMABLE.

Classification of Liquids as per NFPA 30 (only for information)

Liquids are also classified as per NFPA 30 in many countries as given below:

Flammable Liquid

Any liquid that has a closed-cup flash point below 100°F (37.8°C) and a Reid vapor pressure that does not exceed an absolute pressure of 40 psi (276 kPa) at 100°F (37.8°C). Flammable liquids shall be classified as Class I liquids and shall be further sub-classified in accordance with the following:

(1) **Class IA Liquid** — Any liquid that has a flash point below 73°F (22.8°C) and a boiling point below 100°F (37.8°C)

(2) **Class IB Liquid** — Any liquid that has a flash point below 73°F (22.8°C) and a boiling point at or above 100°F (37.8°C)

(3) **Class IC Liquid** — Any liquid that has a flash point at or above 73°F (22.8°C), but below 100°F (37.8°C)

Characteristics of Class – I liquids:

When released in appreciable quantity, a Class – I liquid will begin to evaporate at a rate that depends on its volatility: the lower the flash point, the greater the volatility; hence, the faster the evaporation. The vapors of Class – I liquids form ignitable mixtures with air at ambient temperatures more or less readily. Even when evolved rapidly, the vapors tend to disperse rapidly, becoming diluted to a concentration below the lower flammable limit. Until this dispersion takes place, however, these vapors will behave like heavier-than-air gases. Class – I liquids normally will produce ignitable mixtures that will travel some finite distance from the point of origin; thus, they will normally require area classification for proper electrical system design.

Combustible Liquid

Any liquid that has a closed-cup flash point at or above 100°F (37.8°C). A combustible liquid will form an ignitable mixture only when heated above its flash point. Combustible liquids shall be classified in accordance with the following:

(1) **Class II Liquid** — Any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C)

With Class – II liquids, the degree of hazard is lower because the vapor release rate is low at the normal handling and storage temperatures. In general, these liquids will not form ignitable mixtures with air at ambient temperatures unless heated above their flash points. Also, the vapors will not travel as far because they tend to condense as they are cooled by ambient air. Class – II liquids should be considered capable of producing an ignitable mixture near the point of release when handled, processed, or stored under conditions where the liquid may exceed its flash point.

(2) **Class III Liquid** — Any liquid that has a flash point at or above 140°F (60°C)

(a) **Class IIIA Liquid** — Any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C)

These liquids do not form ignitable mixtures with air at ambient temperatures unless heated above their flash points. Furthermore, the vapors cool rapidly in air and condense. Hence, the extent of the area requiring electrical classification will be very small or nonexistent.

(b) Class IIIB Liquid — Any liquid that has a flash point at or above 200°F (93°C)

These liquids seldom evolve enough vapors to form ignitable mixtures even when heated, and they are seldom ignited by properly installed and maintained general-purpose electrical equipment. A Class – IIIB liquid will cool below its flash point very quickly when released. Class IIIB Liquids are not generally considered hazardous.

CLASS 4 - FLAMMABLE SOLIDS; SUBSTANCES LIABLE TO SPONTANEOUS COMBUSTION; SUBSTANCES WHICH, IN CONTACT WITH WATER, EMIT FLAMMABLE GASES (Reactive)

Class 4 is divided into three divisions as follows:

Hazard labels (pictograms)	Symbol Details	Divisions
	Symbol: Flame Colour of Symbol: Black Background: White with vertical red stripes	**Division 4.1 Flammable solids** Solids that are readily combustible, or may cause or contribute to fire through friction. Readily combustible solids are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly. Self-reactive substances or mixtures are thermally unstable liquids or solids liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air). This definition excludes materials classified under the GHS as explosive, organic peroxides or as oxidizing.
	Symbol: Flame Colour of Symbol: Black Background: Upper half White and lower half Red	**Division 4.2 Substances or mixtures liable to spontaneous combustion:** It includes: **Pyrophoric substances**, which are substances or mixtures (liquid or solid), which even in small quantities ignite within five minutes of coming in contact with air. These are the Division 4.2 substances are the most liable to spontaneous combustion. **Self-heating substances**, which are substances or mixtures (liquid or solid) other than pyrophoric substances or mixtures, which, by reaction with air and without energy supply, is liable to self-heat. This substance or mixture differs from a pyrophoric substance in that it will ignite only

		when in large amounts (kilograms) and after long periods of time (hours or days). ***Note:*** Self-heating of a substance is a process where the gradual reaction of that substance with oxygen (in air) generates heat. If the rate of heat production exceeds the rate of heat loss, then the temperature of the substance will rise which, after an induction time, may lead to self-ignition and combustion.
	Symbol: Flame Colour of Symbol: Black or white (The symbol, the number and the border line may be shown in black or white) Background: Blue	**Division 4.3 Substances or mixtures which in contact with water emit flammable gases**: Solid or liquid Substances or mixtures, which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities. Such mixtures are easily ignited by all ordinary sources of ignition, for example naked lights, sparking hand tools or unprotected lamps. The resulting blast wave and flames may endanger people and the environment.

Class 5: Oxidizers and Organic Peroxides

Class 5 is divided into two divisions as follows:

Hazard labels (pictograms)	Symbol Details	Divisions
	Symbol: Flame over circle Colour of Symbol: Black Background: Yellow	**Division 5.1 Oxidising substances** A solid or liquid substance or mixture which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause or contribute to the combustion of other material. Such substances may be contained in an article.
 	Symbol: Flame Or Flame over circle Colour of Symbol: Black or Black or white (The symbol, the number and the border line may be shown in black or white) Background: Yellow or Upper half Red and lower half Yellow	**Division 5.2 Organic peroxides** An organic peroxide is an organic liquid or solid substance which contains the bivalent -O-O- structure and may be considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Organic peroxides are thermally unstable substances, which may undergo exothermic self-accelerating decomposition. In addition, they may have one or more of the following properties: (i) be liable to explosive decomposition; (ii) burn rapidly; (iii) be sensitive to impact or friction; (iv) react dangerously with other substances;

Class 6 - Toxic and Infectious Substances

Class 6 is divided into two divisions as follows:

Division 6.1 Toxic substances

These are substances liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact. Such substances are categorized on the basis of "Acute toxicity" by oral, dermal or inhalation route.

Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Chemicals having the values of acute toxicity as given below in table and which owing to their physical and chemical properties, are capable of producing major accident hazards:

Sr.No	Toxicity	Oral toxicity LD50 (mg/kg bodyweight)	Dermal toxicity LD50 (mg/kg bodyweight)	Inhalation toxicity LC50 (mg/l)
1.	Extremely toxic	< 5	<40	< 0.5
2.	Highly toxic	>5-50	>40-200	> 0.5 - 2.0
3.	Toxic	>50-200	> 200-1000	>2-10

Notes:

(1) LD_{50} oral in rats
(2) LD_{50} Dermal coetaneous in rats or rabbits
(3) LC_{50} by inhalation (four hours) in rats.

Hazard labels (pictograms)

Symbol: Skull and crossbones

Colour of Symbol: Black

Background: White

Division 6.2 Infectious substances

These are substances known or reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsiae, parasites, fungi) and other agents such as prions, which can cause disease in humans or animals.

Hazard labels (pictograms)

Symbol: three crescents superimposed on a circle

Colour of Symbol: Black

Background: White

Class 7: Radioactive Materials

Radioactive materials mean any material containing radionuclide where both the activity concentration and the total activity in the consignment exceed the values specified, depending on the type of material by the Atomic Energy Commission of India.

Hazard labels (pictograms)

Symbol: 3 segments of a circle a number

Colour of Symbol: Black

Background: Upper Half Yellow and Lower Half White

Class 8: Corrosives

Corrosive substances are substances which by chemical action will cause severe damage when in contact with living tissue (Skin Corrosion) in the case of leakage will materially damage or even destroy other goods or the means of transport. They may also cause other hazards.

Skin Corrosion is the production of irreversible damage of the **skin**; namely, visible necrosis through the epidermis and into the epidermis, following the application of a test substance for up to 4 hours.

Hazard labels (pictograms)

Symbol: liquids spilling from two glass vessels and attacking a hand and metal

Colour of Symbol: Black

Background: Upper half White and lower half Black with White border.

Class 9 - Miscellaneous Dangerous Substances and Articles, Including Environmentally Hazardous Substances

Class 9 substances and articles (miscellaneous dangerous substances and articles) are substances and articles which, during transport present a danger not covered by other classes.

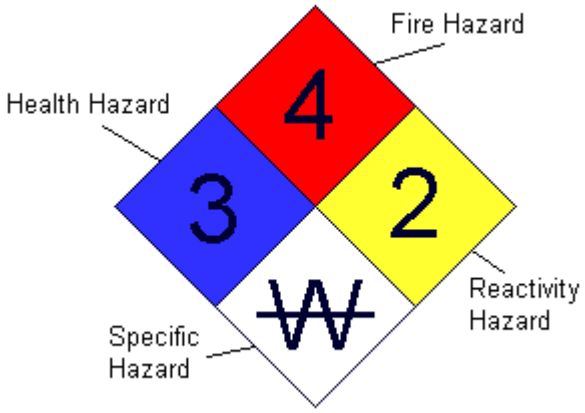
Hazard labels (pictograms)

Symbol: None

Colour of Symbol: Black

Background: Upper half with Black Stripe

Annexure-2: NFPA Diamond



FLAMMABILITY (RED) is the degree of susceptibility of materials to burning. The scale of flammability shall be as under:

0 Will not burn

1 Must be preheated to burn. Flash point above 200°F.

2 Ignites with moderate heat. Flash point 100°F – 200°F. ***[WARNING]***

3 Ignites at room temperature. Flash point 73°F – 99°F. ***[HAZARDOUS]***

4 Highly flammable liquids and explosive gases. Flash point below 73°F.***[EXTREMELY DANGEROUS]***

FLAMMABILITY – Detailed explanation of ratings

4 Very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air. Shut off flow of gas or liquid and keep cooling water streams on exposed tanks or containers. Use water spray carefully in the vicinity of dusts so as not to create dust clouds.

3 Liquids, which can be ignited under almost, all normal temperature conditions. Water may be ineffective on these liquids because of their low flash points. Solids which form coarse dusts, solids in shredded or fibrous form that create flash fires, solids that burn rapidly, usually because they contain their own oxygen, and any material that ignites spontaneously at normal temperatures in air.

2 Liquids which must be moderately heated before ignition will occur and solids that readily give off flammable vapours. Water spray may be used to extinguish the fire because the material can be cooled to below its flash point.

1 Materials that must be pre-heated before ignition can occur. Water may cause frothing of liquids with this flammability rating number if it gets below the surface of the liquid and turns to steam. However, water spray gently applied to the surface will

cause a frothing which will extinguish the fire. Most combustible solids have flammability rating of 1.

0 Materials that will not burn.

REACTIVITY (YELLOW) is the degree of susceptibility of materials to release energy. The scale of reactivity shall be as under:

0 Normally stable at all temperatures. Not reactive with water.

1 It may become unstable when heated or mixed with water. ***[CAUTION]***

2 Normally unstable or may have violent chemical change when mixed with water. ***[HAZARDOUS]***

3 Explodes when exposed to confined heat, shock, or when mixed with water. ***[DANGEROUS]***

4 Explodes at room temperature. ***[EXTREMELY DANGEROUS]***\

REACTIVITY– Detailed explanation of ratings

4 Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Includes materials, which are sensitive to mechanical or localized thermal shock. If a chemical with this hazard rating is in an advanced or massive fire, the area should be evacuated.

3 Materials which in themselves are capable of detonation or of explosive decomposition or of explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. Includes materials which are sensitive to thermal or mechanical shock at elevated temperature and pressure or which react explosively with water without requiring of confinement. Firefighting should be done from an explosion-resistant location.

2 Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Includes materials which can undergo chemical change with rapid release of energy at normal temperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. Also includes those materials which may react violently with water or which may form potentially explosive mixtures with water. In advanced or massive fires, firefighting should be done from a protected location.

1 Materials which in themselves are normally stable but which may become unstable at elevated temperature and pressure or which may react with water with some release of energy but not violently. Caution must be used in approaching the fire and applying water.

0 Materials which are normally stable even under fire exposure conditions and which are not reactive with water. Normal fire fighting procedures may be used.

HEALTH HAZARD (BLUE) is the degree of injury from burning materials. The scale of health hazard shall be as under:

0 Creates no unusual hazard.

1 Causes irritation or minor injury. ***[CAUTION]***

2 Intense exposure may be harmful. ***[HAZARDOUS]***

3 Avoid skin contact and inhalation. ***[EXTREMELY DANGEROUS]***

4 Too dangerous to enter without specialized protective equipment. ***[FATAL]***

HEALTH HAZARD– Detailed explanation of ratings

4 A few whiffs of the gas or vapour could cause death or the gas, vapour or liquid could be fatal on penetrating the fire fighters normal full protective clothing which is designed for resistance to heat. For most chemicals having a Health 4 rating, the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn.

3 Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing, including self- contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed.

2 Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus.

1 Materials only slightly hazardous to health. It may be desirable to wear self-contained breathing apparatus.

0 Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material.

OTHER (WHITE) indicates special warnings.

ACID: acid

ALK: alkali - radiation

COR: corrosive P – subject to polymerization when mixed with water

OXY: oxidizing chemicals W - do not use water

Explanation for bottom space (Colourless) :

The bottom space is primarily used to identify unusual reactivity with water. With a line through its centre alerts firefighting personnel to the possible hazard in use of water. This bottom space may also be used to identify a radiation hazard by the symbol. Oxidising chemicals are identified in the bottom space, as OXY.

Annexure-3: Hazchem code

SUBSTANCES	HAZCHEM CODE
Petrol	3 **Y** E
Methyl Alcohol	2 P E
LPG	2 W E
Ammonia Liquefied	2 P E
Sulphur	2 **Z**
Kerosene	3 **Y**

First Character (Extinguishing Media)

The first character, a numeral in the range of 1 to 4, indicates the type of medium to be employed by the fire services personnel.

1 Indicates use of water jet

2 Indicates use of water fog or fine water spray

3 Indicates use of normal foam such as water-based foam or protein based foam that is not alcohol resistant

4 Indicates use of a dry agent such as a dry chemical powder, e.g. sodium carbonate or dry sand

Where the numeral '**4'** appears, water shall not be allowed to contact the substances involved. Water may react violently with the substances or may cause poisonous or flammable vapours to be evolved.

A bullet '•' sometimes precedes the number 2 or 3.

•2 and •3, have the following meanings:

•2 denotes that alcohol resistant foam is the preferred firefighting medium but, if it is not available, fine water spray can be used.

•3 denotes that alcohol resistant foam is the preferred firefighting medium but, if it is not available, normal foam can be used.

For example, the Hazchem Code assigned to UN 1193 Ethyl Methyl Ketone in C3 is •2YE. The '•' here indicates to the emergency services that alcohol resistant foam is the preferred firefighting medium. However, if such foam is not available, fine water spray, as the next most effective medium, should be used.

Second Character

The second character in the code is a letter selected from the range P **,** R, S, T**, W, X, Y, Z.**

Meaning of Second Character of Hazchem Code

Letter	Risk of Violent Reaction or Explosion	Recommended Personal Protective Equipment	Appropriate Measures
P	Yes	Liquid-tight chemical protective clothing and breathing apparatus	Dilute
R	No		
S	Yes	Full fire kit and breathing apparatus	
T	No		
W	Yes	Liquid-tight chemical protective clothing and breathing apparatus	Contain
X	No		
Y	Yes	Full fire kit and breathing apparatus	
Z	No		

P, R, S & T shall always be written in normal font while **W, X, Y** & **Z** shall be written always in bold font even in reverse video] which indicates

- *the type of personal protection* to be worn,
- *the possibility of violent reaction, and*
- *whether the substances and the medium employed should be contained or the substances diluted*.

The characters are generally black on a white background.

Personal protection

- Where the second character of the EAC is S, T, Y or Z, normal firefighting clothing is appropriate, i.e. self-contained open circuit positive pressure compressed air breathing apparatus, worn in combination with fire kit, firefighters' gloves and firefighters' boots.
- Where the second character of the EAC is P, R, W or X, liquid-tight chemical protective clothing in combination with breathing apparatus should be used.

Occasionally, these letters may appear as under:

These characters, written in reversed video, indicate that breathing apparatus need only be worn if the substances are involved in a fire.

Violent Reaction

Where the second character of the EAC is a P, S, W or Y there is a danger that the substance can be violently or explosively reactive. This danger may be present due to one of the following:

- Violent or explosive decomposition of the material involved, including ignition or friction.

- The ignition of a flammable gas or vapour cloud (this danger exists for all flammable gases and flammable liquids with a flash point below 60 °C)
- The rapid acceleration of combustion due to the involvement of an oxidiser.
- A reaction with water which is itself violent and may also evolve flammable gases.

Contain/dilute

Where the second character of an EAC is W, X, Y or Z spillages and decontamination run-off should be prevented from entering drains and watercourses. Where the second character of the code is P, R, S or T spillages and decontamination run-off may be washed to drains with large quantities of water. Due care must however still be exercised to avoid unnecessary pollution of watercourses.

Third Character - E "Public Safety Hazard" (Optional)

An 'E' following the first two characters of an EAC indicates that there may be a public safety hazard outside the immediate area of the incident, and that the following actions should be considered:

1. People should be warned to stay indoors with all doors and windows closed, preferably in rooms upstairs and facing away from the incident. Ignition sources should be eliminated and any ventilation stopped.
2. Effects may spread beyond the immediate vicinity. All non-essential personnel should be instructed to move at least 250 metres away from the incident.
3. Police and Fire Brigade incident commanders should consult each other and with a product expert, or with a source of product expertise.
4. The possible need for subsequent evacuation should be considered, ***but it should be remembered that in most cases it will be safer to remain in a building than to evacuate.***

For quick interpretation of the code, following Hazchem Pocket Card shall be used:

HAZCHEM Emergency Action Code

FOR FIRE OR SPILLAGE

Substance / UN No. / HAZCHEM / Class Label / Contacts

1	COARSE SPRAY
2	FINE SPRAY
3	FOAM
4	DRY AGENT
•	ALCOHOL RESISTANT FOAM

P	V	LTS	DILUTE
R			
S	V	BA & FIRE KIT	
T			
W	V	LTS	CONTAIN
X			
Y	V	BA & FIRE KIT	
Z			

E	PUBLIC SAFETY HAZARD

Additional Information

DRY AGENT
Water **must not** be allowed to come into contact with the substance at risk.

ALCOHOL RESISTANT FOAM •2 or •3
Alcohol resistant foam is the preferred medium.
If not available:
- If **•2** – use Fine Spray or Water Fog
- If **•3** – use Normal Protein Foam

V
Substance can be violently or even explosively reactive, including combustion.

LTS
Liquid-Tight Chemical Protective Suit with BA.
Full **FIRE KIT** should also be worn for thermal protection if the substance is:
- Liquid Oxygen
- or Liquefied Toxic Gas (Division 2.3)
- or Toxic Gas with sub-risk 2.1 or 5.1
- or Class or sub-risk 3
- or Division 5.1 PGI with sub-risk 6.1 or 8
- or carried at temperature > 100 °C

DILUTE
May be washed to drain with large quantities of water.

CONTAIN
Prevent, by any means available, spillage from entering drains or water course.

E
People should be warned to stay indoors with all doors and windows closed, –but evacuation may need to be considered. Consult Control, Police and product expert.

Annexure-4: GHS (Globally Harmonized System of Classification and Labelling of Chemicals)

A. What is GHS

- Criteria for the classification of substances and mixtures according to their physical, health and environmental hazards
- It is a United Nations initiative to promote consistency in classification and labeling of chemicals worldwide
- Individual countries are adopting all or parts of the guidelines into their own laws and regulations

B. Why GHS

While transportation of dangerous goods is subject to national and international control, the dangerous goods are also subject to other kinds of controls /regulations, e.g. work safety regulations, consumer protection regulations, storage regulations, environment protection regulations. Each country has different ways to control various aspects of dangerous goods in a non-harmonized way. Different approach by different countries affected international trade in chemicals and dangerous products.

To ensure consistency between all these regulatory systems, the United Nations has developed mechanisms for the harmonization of hazard classification criteria and hazard communication tools (GHS) as well as for transport conditions for all modes for transport (TDG).

In 2003, the United Nations (UN) adopted the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). The GHS includes the following elements:

(i) Harmonised criteria for classifying substances and mixtures according to their health, environment and Physical hazards; and

(ii) Harmonised hazard communication elements, including requirements for labeling and safety data sheets (SDS).

C. GHS Objectives

As per GHS documents, the objectives of the Harmonization are as under:

(i) to enhance the protection of human health and environment by providing an internationally comprehensible system for HAZARD COMMUNICATION

(ii) to provide recognized framework for those countries without an existing system;

(iii) to reduce the need for testing and evaluation of chemicals

(iv) to facilitate international trade in chemicals whose hazards have been property assessed and identified on international basis.

The GHS covers all hazardous chemicals. Target audiences for the GHS include consumers, workers, transport workers, and emergency responders. The goal of GHS is to identify the intrinsic hazards found in substance and mixtures and to convey hazard information about these Hazards to all stake holders. The criteria for hazard classification are harmonized. Hazard statement, symbols and signal words have been standardized and harmonized and now form an integrated hazard communication system.

D. Classification of Hazardous Chemicals

Chemical hazards are classified by 28 criteria:

- 16 Physical hazards (e.g. flammability, oxidizing, explosive)
- 10 Health hazards (e.g. toxicity, skin and eye irritation, mutagenicity)
- 2 Environmental Hazards (e.g. toxic to aquatic organisms)

Classification of commercial products depends on whether the product is a pure chemical or a mixture:

- Substance classifications are based on results of toxicological studies
- Classification of mixtures is based on the concentrations of hazardous chemicals in the mixture (if no product-level data is available)

E. Label Elements

Hazard classification and label elements on the SDS should be identical to the label. This includes:

a. Signal word

b. Pictogram

c. Hazard statements

d. Precautionary phrases

Signal Word

- Used to alert the reader and indicate the relative level of severity of the hazard
- There are only two signal words, “Danger” and “Warning”
- “Danger” is used for the more severe hazards and “Warning” is used for the less severe hazards
- There will only be one signal word on the label no matter how many hazards a chemical may have. In these cases, the most severe signal word is required

Hazard Statements

- Describe the nature of the hazard(s). For example: “Causes damage to kidneys through prolonged or repeated exposure when absorbed through the skin.”
- All of the applicable hazard statements must appear on the label but statements may be combined where appropriate to reduce redundancies
- Users should always see the same statement for the same hazards, no matter what the chemical is or who produces it.

Precautionary Statements

- Recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to a hazardous chemical, improper storage, or handling.

  Examples:

  “Wear protective gloves”

  “Store in a well-ventilated place”

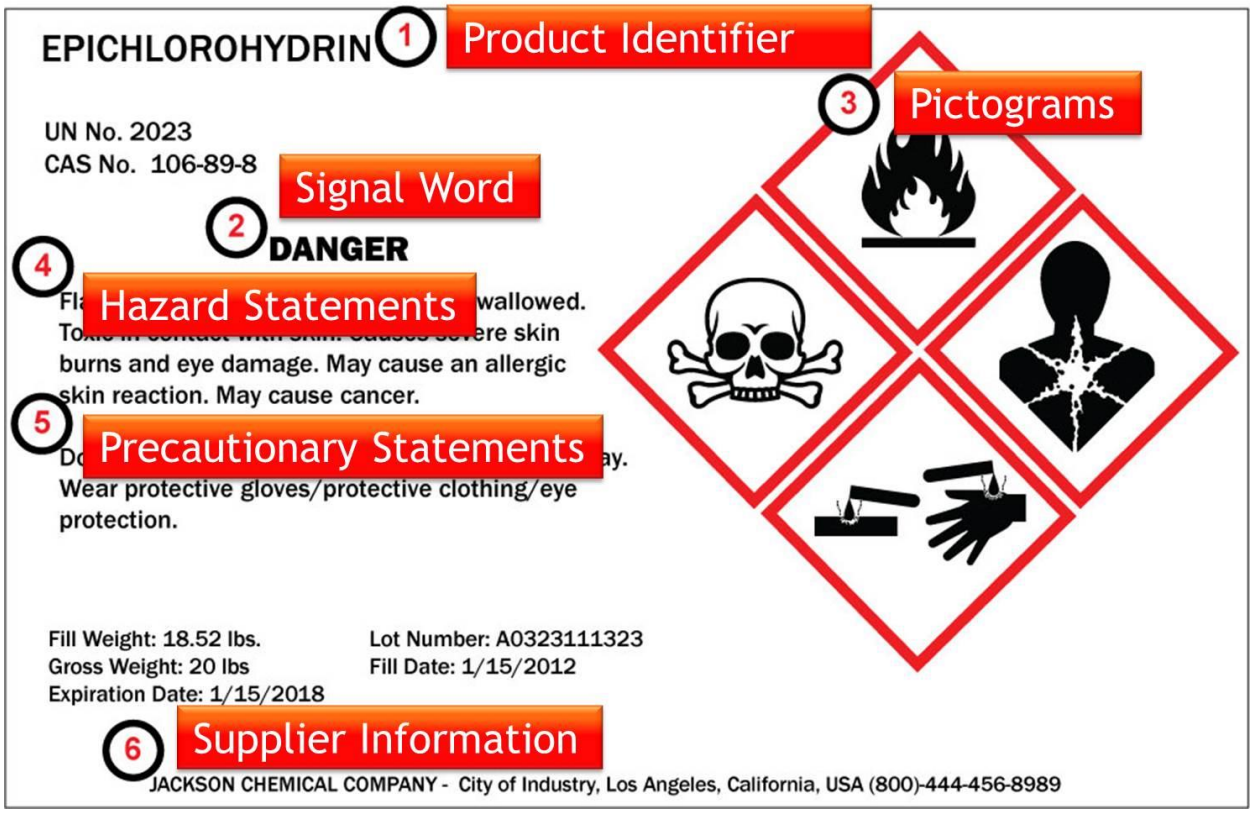
  “Keep away from heat”

  “If inhaled: Immediately call a poison center or doctor/physician”

Further Information may be obtained form from link:

http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html

An **example** of a GHS label for a chemical is given found below:



Sample GHS Label

GHS Hazard Pictograms

The nine hazard pictograms that are representative of the physical, health and/or environmental hazards are shown below:

Pictogram	**Hazard**
	- Explosive
Exploding bomb	
	- Flammability
Flame	
	- Oxidising
Flame over circle	
	- Chronic Health hazards
Health hazard	
	- Environmental hazard
Environment	

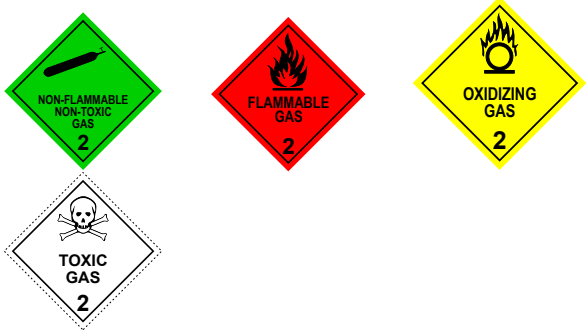
Pictogram	**Hazard**
	- Gases under pressure
Gas cylinder	
	- Corrosive
Corrosion	
	- Acute toxicity
Skull and crossbones	
	- Certain health Hazards (e.g. sensitisers)
Exclamation mark	

Chronic health hazards include carcinogens, reproductive toxins, mutagens, specific target organ toxicants, and aspiration toxicants.

Comparison of Hazard Pictograms with TDG Code Class Labels

The table below compares hazard pictograms from the GHS with the corresponding UN TDG Code class labels.

Hazard Pictograms	GHS Hazard	Dangerous Goods class labels (pictograms)	Dangerous goods classes
	Explosives Self-reactives Organic peroxides	   	Explosive
	Flammables Self-reactives Pyrophorics Self-heating Emits flammable gas in contact with water Organic peroxides	     	• Flammability (Liquid, Solid or Gas) • Pyrophoric, • Emits Flammable Gas • Organic Peroxide
	Oxidisers	 	• Oxidiser • Oxidising gas

	Gases under pressure		Non-toxic non-flammable gas, flammable gas, oxidising gas, toxic gas
	Acute toxicity		• Acute toxicity • Acute Toxic gas
	Acute toxicity Skin irritants Eye irritants Skin sensitisers	No equivalent	
	Carcinogens Respiratory sensitisers Reproductive toxicants Target organ toxicants Germ cell mutagens	No equivalent	
	Eye corrosion Skin corrosion Corrosive to metal		Corrosive to metals

	Aquatic toxicity. Not covered within the scope of workplace hazardous chemicals requirements		Environmental hazard
No equivalent hazard pictogram			Miscellaneous dangerous goods
Not covered within the scope of workplace hazardous chemicals requirements			Infectious
Not covered within the scope of workplace hazardous chemicals requirements			Radioactive

Annexure-5: Example hazardous materials inventory

Hazardous Material	Hazardous characteristics	UN GHS or local classification	UN GHS or local hazardous code	Physical State	Primary use	Volume stored on site (m^3 or litres)	Reporting threshold (m^3 or litres)	Location of MSDS
e.g. Diesel	*e.g. flammable, toxic, carcinogenic*	*e.g. code, class, division*		*e.g. liquid*	*e.g. fuel*			*EHS Manager office*

Annexure-6: MSDS / SDS HEADER CHECKLIST

This checklist provides a summary of the key information contained in MSDS or SDS. It is not a comprehensive list of information required on the MSDS. Refer to the relevant standard for detailed instructions.

Section	Headers
1. Product identifier & identity for the chemical	☐ Product Identifier ☐ Other means of identification ☐ Recommended use of the chemical and restrictions on use ☐ Suppliers name, address and phone number ☐ Emergency phone number
2. Hazard Identification	☐ Classification of the hazardous chemical ☐ Label elements, including precautionary statements ☐ Other hazards which do not result in classification
3. Composition/information on ingredients	☐ Identity of chemical ingredients ☐ CAS number and other unique identifiers ☐ Concentration of ingredients
4. First Aid Measures	☐ Description of necessary first aid measures ☐ Symptoms caused by exposure ☐ Medical Attention and Special Treatment
5. Fire Fighting Measures	☐ Suitable extinguishing media ☐ Specific hazards arising from the chemical ☐ Special protective equipment and precautions for fire fighters
6. Accidental release measures	☐ Personal precautions, protective equipment and emergency procedures ☐ Environmental precautions ☐ Methods and materials for containment and cleaning up
7. Handling and Storage	☐ Precautions for safe handling ☐ Conditions for safe storage, including any incompatibilities
8. Exposure controls/personal protection	☐ Control parameters – exposure standards, biological monitoring

Section	Headers
	☐ Appropriate engineering controls ☐ Personal protective equipment (PPE)
9. Physical and chemical properties	☐ Appearance ☐ Odour ☐ Odour threshold ☐ pH ☐ Melting point/freezing point ☐ Boiling point and boiling range ☐ Flash point ☐ Evaporation rate ☐ Flammability ☐ Upper/lower flammability or explosive limits ☐ Vapour pressure ☐ Vapour density ☐ Relative density ☐ Solubility(ies) ☐ Partition coefficient: n-octanol/water ☐ Auto-ignition temperature ☐ Decomposition temperature ☐ Viscosity ☐ Specific heat value ☐ Particle size ☐ Volatile organic compounds content ☐ % volatile ☐ Saturated vapour concentration ☐ Release of invisible flammable vapours and gases
Additional parameters	☐ Shape and aspect ratio ☐ Crystallinity ☐ Dustiness ☐ Surface area ☐ Degree of aggregation or agglomeration ☐ Ionisation (redox potential)

Section	Headers
	☐ Biodurability or biopersistence
10. Stability and Reactivity	☐ Reactivity ☐ Chemical stability ☐ Conditions to avoid ☐ Incompatible materials and possible hazardous reactions ☐ Hazardous decomposition products
11. Toxicological information	☐ Information on routes of exposure ☐ Symptoms related to exposure ☐ Numerical measures of toxicity ☐ Immediate, delayed and chronic health effects from exposure ☐ Exposure Levels ☐ Interactive effects ☐ Data limitations
12. Ecological information	☐ Ecotoxicity ☐ Persistence and degradability ☐ Bioaccumulative potential ☐ Mobility in soil ☐ Other adverse effects
13. Disposal considerations	☐ Safe handling and disposal methods ☐ Disposal of any contaminated packaging ☐ Environmental regulations
14. Transport information	☐ UN number ☐ Proper shipping name ☐ Transport hazard class(es) ☐ Packing group ☐ Environmental hazards ☐ Special precautions during transport ☐ Hazchem Code
15. Regulatory information	☐ Safety, health and environmental regulations specific for the product in question ☐ Poisons Schedule number

Section	Headers
16. Other information	☐ Date of preparation or review ☐ Key abbreviations or acronyms used

Annexure 7: Checklist for identifying hazards from MSDS

Sites should prepare separate checklist for each hazardous chemical or group of hazardous chemicals with similar properties.

Detail of Hazardous Chemical

Name of the chemical	
Class & Primary Risk	
Subsidiary Risk(s)	
UN Number	
CAS Number	
Chemical Formula	
Ingredients	
Proportion	

Identification of Associated Hazards

Property	Value if applicable	Potential Hazards
A. Physical Properties		
Compressed gas		
Gas dissolved under pressure		
Liquefied gas		
Cryogenic liquid		
Mobile liquid		
Viscous liquid		
Volatile liquid		
Liquid with solids in solution or suspension		
Liquid with solids in solution or suspension		
Finely divided solid		
Granular / flaked solid		
Caked or undivided solid		
Physical state as stored / handled if different from above		
Solubility in water		

Boiling point / range		
Melting point / range		
Odour		
Electrical conductivity / resistance		
Relative density at 20 °C		
Relative density at relevant temperature		
Pressure as packed		
Vapour pressure at 20 °C		
Vapour pressure at other relevant temperature		
Polarity		
pH as stored and handled		
pH of 1% solution		
B. Flammability		
Flashpoint (closed cup)		
Flashpoint (open cup)		
Sustains flame?		
Auto ignition temperature		
Flammability range LEL UEL		
Evolves / produces hazardous combustion products		
Explosion potential		
C. Biological Hazards		
Exposure limits		
Toxicity		
Irritant		
Carcinogen (known / suspected)		
Mutagen		
Sensitiser		
Biologically active		
D. Corrosivity		
Skin		
Metals		
Other materials		
E. Reactivity		
With air		
With water		
With other materials (details)		
Self reactive		
Decomposition conditions		
Hazardous decomposition effects		

Hazardous decomposition products		
Polymerisation potential		
Hazardous polymerisation effects		
Inhibitor required		
Phlegmatiser required		
Blanketing material required		
Self Accelerating Decomposition Temperature (S.A.D.T.)		
Control temperature		
Other special controls required		
F. Sensitivity		
To shock		
To heat		
To radiation		
To moisture		
To contamination with:		
E. Environmental		
Atmospheric pollutant		
Ozone depleter		
Odorous		
Visual pollutant		
Marine pollutant		
Ground water pollutant		
Soil pollutant		
Relevant half life information		
Special neutralising / absorbent material requirements		

Other Important hazard information to be noted from the MSDS

Hazard classification	Classification including primary and subsidiary risk(s)
The route of entry	This information is important to assess the health risks. Routes of entry can include inhalation (breathing it in), skin contact, ingestion (swallowing it), eye contact and injection through high pressure equipment. Depending on the substance, the severity of the harm could range from minor to major, for example, from minor skin irritation to chronic respiratory disease. Some chemicals may not be hazardous by all routes of entry. For example, silica is hazardous only by inhalation so the risk assessment needs to consider how inhalation could occur.
Advice or warnings for at-risk workers	Advice or warnings for people that might be at risk, such as • people who are sensitised to particular chemicals • warnings for pregnant women • people with existing medical conditions such as asthma.
Instructions on storage	This may include advice on not to store with certain incompatible materials, or advice on potential hazardous degradation products.
Use situations that may generate hazardous chemicals	Examples may include: • use of welding rods which may liberate hazardous fumes and vapours • directions for use of chlorine bleach, warning that harmful levels of chlorine gas may be generated if the substance is mixed with incompatible chemicals • warnings that some metals, including alkali metals, in contact with water or acids, liberate flammable gas • information on by-products or breakdown products like formation of explosive peroxides in ether

Annexure-7: Incompatibilities by hazard class

Incompatibilities by Hazard Class

	Acids, Inorganic	Acids, Oxidizing	Acids, Organic	Alkalis (Bases)	Oxidizers	Poisons, Inorganic	Poisons, Organic	Water-Reactives	Organic Solvents
Acids, inorganic			X	X		X	X	X	X
Acids, oxidizing			X	X		X	X	X	X
Acids, organic	X	X		X	X	X	X	X	
Alkalis (bases)	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons, inorganic	X	X	X				X	X	X
Poisons, organic	X	X	X	X	X	X			
Water-reactives	X	X	X	X	X	X			
Organic solvents	X	X		X	X	X			

X indicates incompatibility between two chemical product groups. Incompatible products should not be stored in close proximity.

Annexure-8: Partial list of incompatible chemicals

The following list of chemicals in the left-hand column should be transported, stored, used, and disposed of in such a manner that they do not accidentally come in contact with the corresponding chemicals in the right–hand column. These chemicals could react violently if allowed to come in accidental contact with each other, resulting in an explosion, or may produce highly toxic and/or flammable gases or vapors. However, it should be remembered that this list is not in any way complete but is to serve only as a guide for the commonly used chemicals.

Primary Chemical	Incompatible with
Acetic acid	Chromic acid, ethylene glycol, hydroxyl-containing compounds, nitric acid, perchloric acid, permanganates and peroxides.
Acetone	Bromine, chlorine, nitric acid, and sulfuric acid.
Acetylene	Bromine, chlorine, copper, mercury, and silver.
Alkaline and alkaline earth metals such as calcium, cesium, lithium, magnesium, potassium and sodium.	Carbon dioxide, chlorinated hydrocarbons, and water.
Aluminum and its alloys (as powders)	Acid or alkaline solutions, ammonium persulfate and water, chlorates, chlorinated compounds, nitrates, and organic compounds in nitrate/nitrite salt baths.
Ammonia (anhydrous)	Bromine, calcium hypochlorite, chlorine, hydrofluoric acid, iodine, mercury, and silver.
Ammonium perchlorate, permanganate, or persulfate.	Combustible materials, oxidizing materials such as acids, chlorates, and nitrates.
Ammonium nitrate	Acids, chlorates, lead, metallic nitrates, metal powders, finely divided organics or combustibles, sulfur and zinc.
Aniline	Hydrogen peroxide or nitric acid.
Barium peroxide	Combustible organics, oxidizable materials, and water.
Barium rhodanide	Sodium nitrate.
Bismuth and its alloys	Perchloric acid
Bromine	Acetone, acetylene, ammonia, benzene, butadiene, butane and other petroleum gases, hydrogen, metal powders, sodium carbide, and turpentine.
Calcium or sodium carbide	Moisture (in air) or water.
Calcium hypochlorite	Ammonia or carbon (Activated)
Chlorates or perchlorates	Acids, aluminum, ammonium salts, cyanides, phosphorous, metal powders, oxidizable organics or other combustibles,

Primary Chemical	Incompatible with
	sugar, sulfides and sulfur.
Chlorine	Acetone, acetylene, ammonia, benzene, butadiene, butane and other petroleum gases, hydrogen, metal powders, sodium carbide, and turpentine.
Chlorine dioxide	Ammonia, hydrogen sulfide, methane, and phosphine.
Chromic acid	Acetic acid (glacial), acetic anhydride, alcohols, combustible materials, flammable liquids, glycerine, naphthalene, nitric acid, sulfur, and turpentine.
Cumene Hydroperoxide	Acids (mineral or organic).
Cyanides	Acids or alkalines.
Fluorine	Most materials.
Hydrocarbons such as benzene, butane, gasoline, propane, turpentine, etc.	Bromine, chlorine, chromic acid, fluorine, hydrogen peroxide, and sodium peroxide.
Hydrofluoric acid or anhydrous hydrogen fluoride	Ammonia (anhydrous or aqueous).
Hydrocyanic acid or hydrogen cyanide	Alkalies and nitric acid.
Hydrogen peroxide, 3%	Chromium, copper, iron, most metals or their salts.
Hydrogen peroxide, 30% to 90%	Same as Hydrogen peroxide 3% (above), plus aniline, any flammable liquids, combustible materials, nitromethane, and all other organic matter.
Hydrogen sulfide	Fuming nitric acid or oxidizing gases.
Iodine	Acetylene, ammonia, (anhydrous or aqueous), and hydrogen.
Lithium	Acids, moisture in air, and water.
Lithium aluminum hydride	Air, chlorinated hydrocarbons, carbon dioxide, ethyl acetate, and water.
Magnesium (particularly powder)	Carbonates, chlorates, heavy metal oxylates or oxides, nitrates, perchlorates, peroxides, phosphates, and sulfates.
Mercuric oxide	Sulfur
Mercury	Acetylene, alkali metals, ammonia, nitric acid with ethanol, and oxalic acid.
Nitrates	Combustible materials, esters, phosphorous, sodium acetate, stannous chloride, water, and zinc powder.
Nitric Acid (Conc.)	Acetic acid, aniline, chromic acid, flammable gases and liquids, hydrocyanic acid, hydrogen sulfide, and nitratable substances.
Nitric acid	Alcohols, and other oxidizable organic material, hydiodic acid (hydrogen iodide), magnesium or other metals, phosphorous, and thiophene.
Nitrites	Potassium or sodium cyanide.

Primary Chemical	Incompatible with
Nitro paraffins	Inorganic alkalies.
Oxalic acid	Mercury or silver.
Oxygen (liquid or enriched air)	Flammable gases, liquids or solids such as acetone, acetylene, grease, hydrogen, oils, and phosphorous.
Perchloric acid	Acetic anhydride, alcohols, bismuth and its alloys, grease, oils, or any organic materials, and reducing agents.
Peroxides (organic)	Acids (mineral or organic).
Phosphorous	Chlorates and perchlorates, nitrates and nitric acid.
Phosphorous pentoxide	Organic compounds or water.
Phosphorous (Red)	Oxidizing materials.
Phosphorous (White)	Air (oxygen) or other oxidizing materials.
Picric acid	Ammonia heated with oxides or salts of heavy metals and friction with oxidizing agents.
Potassium	Air (moisture and/or oxygen) or water.
Potassium chlorate or perchlorate	Acids or their vapors, combustible materials, especially organic solvents, phosphorous, and sulfur.
Potassium permanganate	Benzaldehyde, ethylene glycol, glycerin, and sulfuric acid.
Silver	Acetylene, ammonium compounds, nitric acid with ethanol, oxalic acid, and tartaric acid.
Sodium amide	Air (moisture and oxygen) or water.
Sodium chlorate	Acids, ammonium salts, oxidizable materials and sulfur.
Sodium hydrosulfite	Air (moisture) or combustible materials.
Sodium nitrite	Ammonia compounds, ammonium nitrate, or other ammonium salts.
Sodium peroxide	Acetic acid (glacial), acetic anhydride, alcohols, benzaldehyde, carbon disulfide, ethyl acetate, ethylene glycol, furfural, glycerine, methyl acetate, and other oxidizable substances.
Sulfur	Any oxidizable substance.
Sulfuric acid	Chlorates, perchlorates, and permanganates.
Water	Acetyl chloride, alkaline and alkaline earth metals, their hydrides and oxides, barium peroxide, carbides, chromic acid, phosphorous oxychloride, phosphorous pentachloride, phosphorous pentoxide, sulfuric acid, and sulfur trioxide, etc.
Zinc chlorate	Acids or organic materials.

Annexure-9: PPE selection guide

This table is a guide for the selection of PPEs. The MSDS review and risk assessment will provide more information which should be used in the decision making process.

PPE	Application	Limitations	PPE Requirements	Where/When to Use	Issue
Apron[1]	Protects the front of the body from splashes.	Won't protect the back of the body, the lower legs or the arms.	Must be suitable for the chemical being handled – Refer MSDS	• Open handling of liquids that can splash and can quickly damage your skin (materials the MSDS says can cause "skin corrosion", "skin burns"). • Open handling of powders where there is potential for high exposure and the powder can quickly damage your skin (materials the MSDS says can cause "skin corrosion", "skin burns" and/or are "harmful if absorbed through intact skin"). • When handling very hot materials.	**S**
Chemical suit	Protects the whole body except face, hands, and feet from chemicals.	Chemical suits are made of different materials. They don't all protect the body from the same chemicals.	Check Compatibility with chemicals handled	In situations where a hazardous material can come in contact with the body in quantities too large for other PPE to protect. Normally used for emergency response.	**S**
Dust mask[2]	Protects the lungs, nose, throat from dusts by filtering the air you breathe.	Won't protect you from vapors.	Use correct dust masks for toxic dusts. Make sure mask fits the face properly.	In situations where dust (nuisance or hazardous) can be above exposure limits.	**P**
Face shield	Protects your face from liquid splashes and from flying particles and objects.	Will not protect eyes, since particles or liquids can come around the shield if it does not form a tight seal around the eyes.	Compatibility with head protection and chemicals used. Must meet IS - standard or equivalent.	• Use (with goggles) in any situation where you can potentially see a liquid that can quickly damage the skin (liquids the MSDS says can cause "skin corrosion" or "skin burns"). .	**S**

[1] For example, PVC

[2]For example, 3M #8710 disposable dust mask

PPE	Application	Limitations	PPE Requirements	Where/When to Use	Issue
		Will not protect the face from powders or dusts.			
Gloves[3]	Protects hands and fingers from chemicals, hot materials, rough or sharp materials. Available in different sizes so a good fit can be obtained. Long gloves also protect the lower arms.	There are gloves made from many different materials. They don't all protect hands from the same chemicals. All gloves can be permeated and should not be used indefinitely.	Must protect from the chemicals handled (refer to ABGCB PPE Corporate Guidelines").	Use each time you handle a material that is hazardous to the skin (materials the MSDS says "severe irritation", "can be absorbed by the skin", "skin sensitizer"). Use when repeatedly handling a material that the MSDS says can "irritate the skin" (mild effects).	**P**
Safety Helmet	Protect your head from injury (for example from falling objects and low obstructions). Also protect against liquids falling from above.	Won't work when a large object or very heavy weight falls on your head. Safety helmet are certified with a 3.6kg weight dropped from 1.5m (5 feet).	Safety helmet must meet local standard or IS – standard	Use when working in an area where there is potential for falling objects.	**P**
Hearing protection	Ear plugs or ear muffs protect the ears from noise by reducing the amount of noise the ear receives.	Ear plugs must be correctly inserted into ears to work.	Must provide correct protection for the noise levels encountered.	Use when exposed to noise levels in excess of the 85 dB exposure limit.	**P**
Metatarsal guard	Protects the metatarsus (between toes and ankle) from impact and high pressure water jet.	Does not protect toes. Must be worn in combination with safety shoes or boots.	Must withstand at least 75 foot pounds of impact.	Use when manually using high pressure water blaster (with pressures above 3,000psi).	**S**

3 For example, PVC

PPE	Application	Limitations	PPE Requirements	Where/When to Use	Issue
Respiratory protection	Many types available (canister, air supply, full-face, half-mask).	Refer to ABGCB Corporate PPE guidelines	No beards, employee should be clean shaven See "Respiratory Protection" guidelines from manufacturer.	• Use when handling materials that can produce air concentrations above exposure limits. • Use when air monitoring data is not available for the open handling of materials. • Full face respirator also provides eye protection.	**S***
Rubber Shoes	Protect the feet from chemicals.		Must be compatible with the chemicals handled.	Use when working with liquids on the floor, for example spill cleanup.	**P**
Safety glasses	Protect your eyes from impacts with flying particles. Provides limited protection from chemical splashes.	Won't protect eyes from splashes of hazardous materials.	Must have side shields. Must meet IS - standard or equivalent.	Wear in areas where liquids are handled (unless goggles are specified). Wear in areas where flying particles can be present.	**P**
Safety shoes	Protect your toes from objects that can crush, penetrate or injure them on impact.	Most safety shoes only provide protection over your toes (not the whole foot).	Must have steel toe for impact protection, must be made of leather or other tough material.	Wear when handling equipment or load, object that can damage the foot if dropped, or can roll over the feet.	**P**
Splash goggles	Protect your eyes from dusts and chemical splashes.	Will fog if not kept clean and coated with anti-fog.	Must form a seal all around the face. Must fit different shaped faces. Must be capable of fitting over prescription lenses for those people who wear them. Must meet IS-standard or equivalent.	• In any operation where you can potentially see* a liquid the MSDS says can cause "severe eye irritation", "corrosion to eyes", "injury to eyes". Open handling of powders where there is potential for dust (for example no local exhaust ventilation) and the MSDS says can cause "severe eye irritation" or "injury to eyes".	**P**

PPE	Application	Limitations	PPE Requirements	Where/When to Use	Issue
Welding goggles	Protects the eyes from uv radiation, and sparks.	Must be of correct tint to protect the eyes.	Must meet a local standard. Must select correct lens tint based on type of welding. Must meet IS - standard or equivalent.	Wear when welding or using a gas torch.	**S**
Welding helmet	Protects the eyes and face from uv radiation, sparks and metal chips.	Does not protect the lungs or eyes from fumes. Must be of correct tint to protect the eyes.	Must meet local standard. Must select the correct lens tint based on type of welding. Must meet IS - standard or equivalent.	Wear when welding.	**S**

Issue:

P = Personal issue which is not shared.

S = shared

S* = shared but cleaned, checked and sanitized after each person has used equipment.

Annexure-10: Selection of respiratory PPEs for different types of hazards

		Air-supplied respirators				*Power air-purifying respirators*			*Air Purifying respirators*		*Escape only*
	Self-contained breathing apparatus[1]	*Full-face mask w/ escape cylinder* [2]	*Full-face mask* [2]	*Hood or suit*	*Loose - fitting face-pieces*	*Full-face mask* [2,3]	*Hood* [3]	*Loose -fitting face-pieces* [3]	*Full-face mask* [2,3,4]	*Half-mask* [2,3,4]	*Approved escape respirator*
Assigned protection factor	1,000+	1,000	1,000	1,000	25	1,000	1,000	25	10 100 [5]	10	NA
Hazard / Exposure											
Firefighting[6]	X										
IDLH[6]	X	X									
Oxygen deficient[6]	X	X									
Escape	X	X									X
Exposure >1,000 x OEL	X										
Exposure up to 1,000 x OEL[7]	X	X	X	X		X	X				
Exposure up to 100 x OEL	X	X	X	X		X	X		X		
Exposure up to 25 x OEL	X	X	X	X	X	X	X	X	X		
Exposure up to 10 x OEL	X	X	X	X	X	X	X	X	X	X	

[1]Refers to a 30-minute or longer pressure-demand (i.e., positive-pressure) unit.

[2]*A fit test shall be performed.*

[3]*Proper cartridges/filters must be used for the hazard (i.e., gas, vapor, aerosol, or combination); a scheduled cartridge change program or end-of-service- life indicator is required if hazard is a gas or vapor.*

[4]*Full-face mask shall be used if hazard is toxic or irritating to the eyes.*

[5]*A quantitative fit test shall be performed if a protection factor greater than 10 is indicated.* An assigned protection factor of 100 may be used only if a quantitative fit test is performed that demonstrates a fit factor of greater than 1,000.

[6]*Standby personnel/rescue provisions shall be in place.*

[7]OEL = pertinent occupational exposure limit.

X = designates permissible respirators for hazard/exposure.

Assigned protection factor (APF)*— the expected workplace level of respiratory protection that would be provided by a properly functioning respirator or class of respirators to properly fitted and trained users (e.g., 10 times the OEL for a negative-pressure half mask).*

Annexure-9: Sample sealed source physical inventory/audit checklist and survey form

A. Sealed source physical inventory/audit checklist

Sealed Source Information

Manufacturer		Radioisotope	
Model No.		Original Activity, mCi	
Serial No.		Type of Device	

Sealed Source Location

Business Unit	
Building	
Room	

Sealed Source Custodian Information

Custodian Name	
Building/Room	
Phone	

☐ Physical Inventory Only (Stored Sealed Sources) ☐ Physical Inventory and Leak Test

Sealed Source Semi-annual Audit

Item	Yes	No	N/A
Is the source holder/instrument housing labeled with a conventional radiation symbol?	☐	☐	☐
Door(s) or area, if feasible, is posted with a radioactive material sign indicating the radioisotope and radioactivity (mCi)?	☐	☐	☐
Is the custodian for the source identified, if feasible, on the door(s) to the room where the source is located?	☐	☐	☐
Is there an on/off shutter mechanism?	☐	☐	☐
If so, is it functional?	☐	☐	☐
Is shielding adequate to control the dose rate below 2 millirems/hour (0.02 mSv/hr)?	☐	☐	☐
If dose of >10 millirems/week or 2 millirems/hour (0.02 mSv/hr) is possible, are area personnel badged?	☐	☐	☐
Is the area protected by a sprinkler system?	☐	☐	☐
Have all users attended sealed source training (initial and refresher)?	☐	☐	☐

Survey Meter

Manufacturer: _____ Date of Calibration: _____

Meter Model No.: _____ Meter Serial No.: _____

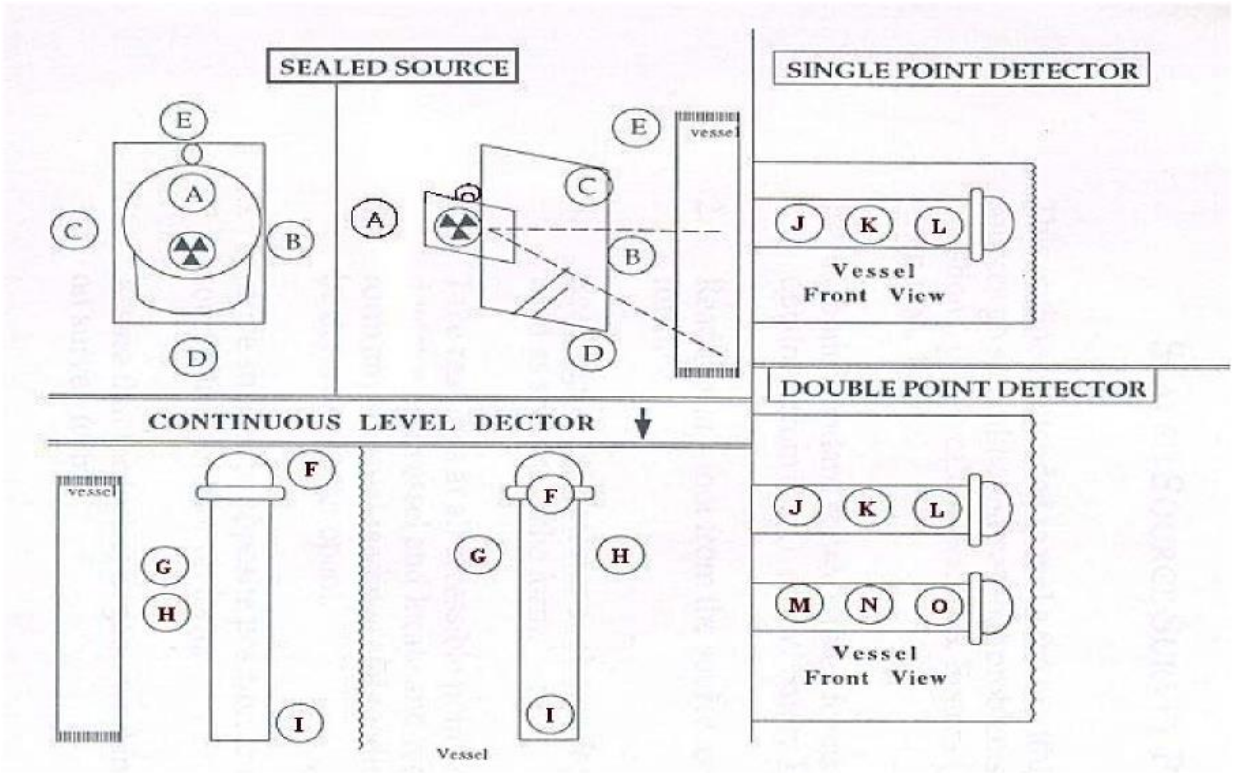
Probe Type: _____ Probe Model and Serial No.: _____

Reading at source, mR/hr: _____

Radiation Safety Office representative (Printed Name)	Radiation Safety Office representative (Initials)	Date

Sample sealed source physical inventory/audit checklist and survey form (continued)

B. Sealed source survey form



Shutter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Vessel Empty FULL
Open																High Reading: Detector High Reading: Source
Closed																(with shutter open)

Annexure-10: AERB specifications for radiation symbol and warning sign

1. The radiation symbol for radioactive sources other than medical diagnostic and industrial x-ray radiography equipment shall confirm to the specifications given hereunder;

   (a) The relative dimensions of the trefoils and the central circle shall be as shown in Fig.1.
   (b) The trefoils and the circle shall be of magenta colour.
   (c) The background of the above symbol shall be yellow.
   (d) The symbol should be accompanied by appropriate legend in English, Hindi and local language indicating radiation hazard and restricted entry, e.g. CAUTION – RADIOACTIVITY.
   (e) Small objects, containing radioactive material may, however, have on them only the aforesaid trefoil symbol engraved in a conspicuous colour when their dimensions do not permit compliance with (d) above.

2. The radiation symbol for radiation generating equipment such as medical diagnostic x-ray equipment, industrial x-ray radiography equipment and accelerators shall have a warning sign as illustrated in Fig.2 and the warning sign shall conform to the specifications given hereunder;
   (a) The triangle shall be equilateral.
   (b) The ratio of the outer to the inner sides of the triangle shall be 1.5.
   (c) The area between the outer and inner triangle shall be in yellow colour on white background.
   (d) The printing on the area between the outer and inner triangle and figure inside the inner triangle shall be bold, proportional and red in colour.
   (e) The area between the outer and inner triangle should be accompanied by appropriate legend in English, Hindi and local language indicating radiation hazard and restricted entry.

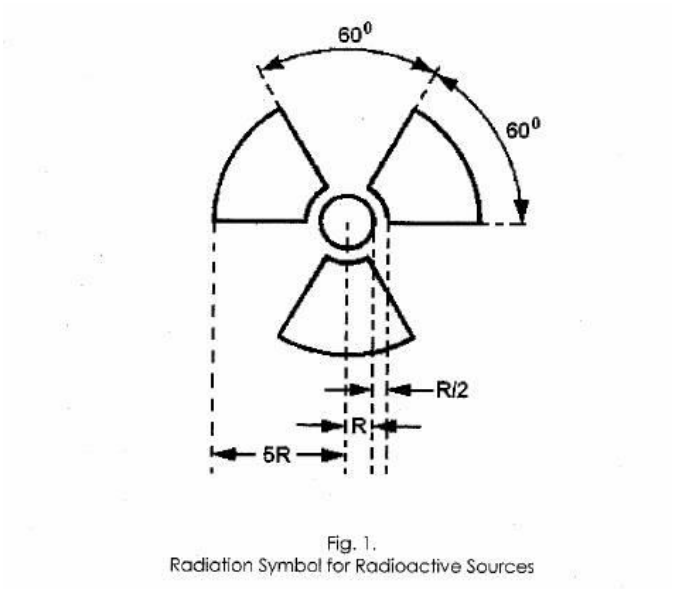


Fig. 1.
Radiation Symbol for Radioactive Sources

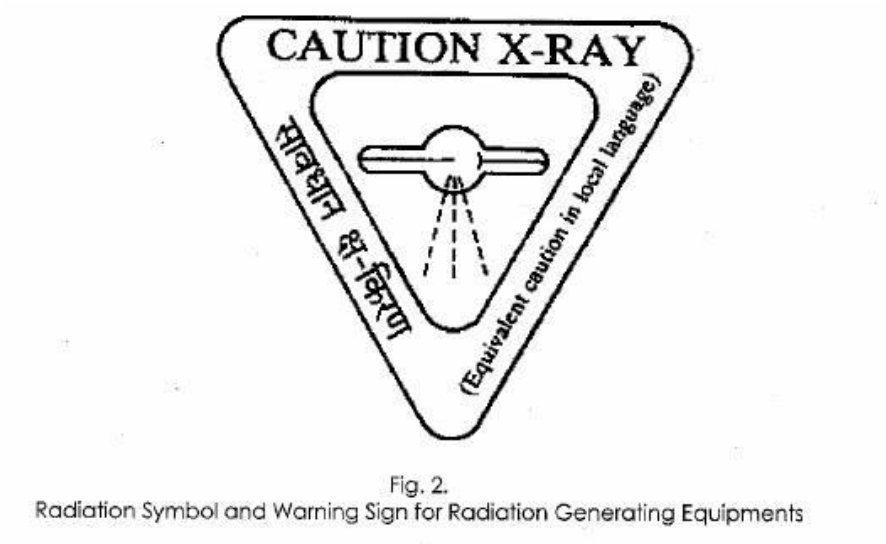
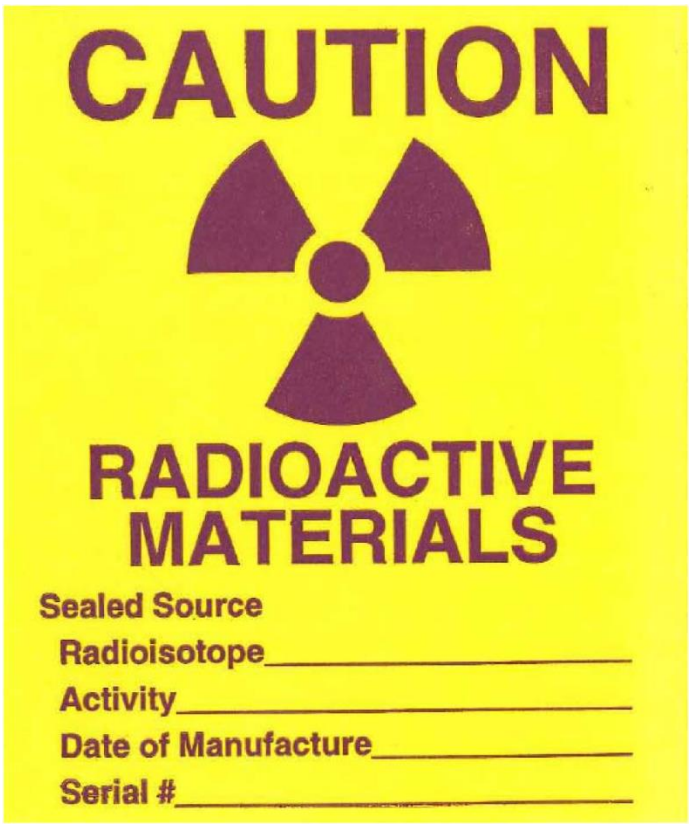


Fig. 2.
Radiation Symbol and Warning Sign for Radiation Generating Equipments

Sample label for areas or equipment containing a sealed source



Annexure-11: Sample Loose Source Use/Storage Area Wipe Test Form

Monthly Radiation Safety Audit & Wipe Test

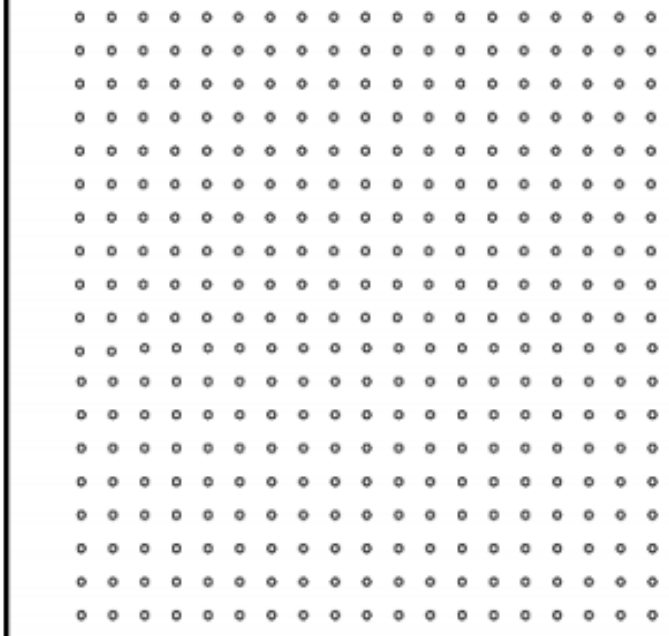
ENTER SITE/FACILITY NAME HERE

Area ALARA Classification 1 _ 2 _ 3

Building _____ Room Number _____

Principal Investigator _____ Name _____ Phone No. _____ Date (Month/Day/Year) _____

Surveyor _____ Name _____ Phone No. _____ Counter Used _____



Isotopes Checked

- ☐ H-3
- ☐ C-14
- ☐ S-35
- ☐ P-32
- ☐ P-33
- ☐ I-125
- ☐ Other _____
- ☐ Other _____

Location	Isotope 1	Isotope 2	Isotope 3
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Wipe Tests ☐ •Current •<200 DPM •DPM Noted	**Personnel** ☐ •Trained •Registered
Material in Use ☐ •Labeled •Attended/Secured	**Radiation Level** ☐ •<2mr/hr •ALARA
Survey Meter ☐ •Sticker Current •Batteries OK	**Signs** ☐ •Posted •Current
Material in Storage ☐ •Labeled •Secured	**Work Area** ☐ •Marked •Segregated
Inventory Record ☐ •Current •Available	**Badges** ☐ •Used •Current
Maximum Expected Quantity (MEQ) ☐ •Posted •Current	☐ _____

Attach counter printout to this form.
If not displayed in DPM, show efficiency

USE COMPLIANCE SELF AUDIT CODE:

OK= In Compliance **CO**= Corrective Action completed
NA= Not Applicable **CA**= Corrective Action in progress (Describe in "Remarks")

Remarks: (See Over)

Annexure-12– Sample Radiography Inspection Permit

HZL Radiography Safety Permit

1.0 Radiography Event Information

Date of Radiography Event: _____

Time of Radiography Event: _____

Location of Radiography Event: _____

2.0 Contract Administration Information

Name of Contract Administrator: _____

Office phone No.: _____

Cell phone No.: _____

Pager No.: _____

3.0 Radiographer Information

Company name: _____

Company address: _____

_____

Company phone No.: _____

License Number: _____

License Expiration Date: _____

3.1 Radiographer #1

Printed Name: _____

Title: _____

Certification Date: _____

3.2 Radiographer #2

Printed Name: _____

Title: _____

Certification Date: _____

4.0 Radiography Source Information:

Radioisotope: _____

Activity: _____ Curies on _____ (date)

Activity at time of use: _____ Curies x 1000 = _____ millicuries

5.0 Survey Instrumentation (minimum of two, operable instruments required)

5.1 Survey Instrument #1

Manufacturer: _____

Model No.: _____

Serial No.: _____

Calibration due date: _____

Range of meter 2.0 mR/hr to 1000 mR/hr? ☐ Yes ☐ No

5.2 Survey Instrument #2

Manufacturer: _____

Model No.: _____

Serial No.: _____

Calibration due date: _____

Range of meter 2.0 mR/hr to 1000 mR/hr? ☐ Yes ☐ No

6.0 Radiography Documentation

The following **must** be at job site and available for inspection.	Yes	No	N/A
• Current copy of applicable license(s)?			
• Operating and Emergency procedures?			
• Latest instrument calibration and leak test records for devices on current job?			

All "No" responses require follow-up and resolution PRIOR to start-up. All "N/A" responses require supporting written documentation.

7.0 Exposure Monitoring

The following **must** be at job site for each person on the radiographic team.	Yes	No	N/A
• Whole-body personal monitors (film badge, TLD, OSL) with current month's date?			
• Personal pocket dosimeter, zeroed at start of shift?			
• Operable, audible rate meter calibrated within the past year?			

All "No" responses require follow-up and resolution PRIOR to start-up. All "N/A" responses require supporting written documentation.

8.0 Boundary Control

The following **must** be in place at the job site prior to start-up.	Yes	No	N/A
• Barrier ropes and signs set up at appropriate distances and locations?			

• Restricted Areas (2 millirems/hr) are posted?			
• Restricted Areas are adequately controlled to prevent entry?			
• Radiation and High Radiation Areas are established?			
• Radio contact, or equivalent, is established between radiographer and area personnel?			

All "No" responses require follow-up and resolution PRIOR to start-up. All "N/A" responses require supporting written documentation.

9.0 Radiation Survey

The following **must** be completed during and following radiography.	Yes	No	N/A
• Complete area and perimeter survey conducted during first exposure?			
• Camera locked after each exposure?			
• Camera locked out and key removed before moving camera?			
• Lock out survey made of camera in shielded position before securing source?			

All "No" responses require follow-up and resolution PRIOR to start-up. All "N/A" responses require supporting written documentation.

10.0 Exposure Information

Number of exposures performed: _____

Time per exposure: _____

Maximum exposure time (min) in 60 minutes: _____

Total exposure time: _____

11.0 Barricade Distance Calculations

11.1 Restricted Area (2 millirem/hr boundary)

$$d = \sqrt{\frac{Rodo^2 \; x \; Ci \; \frac{Total\ Exposure\ Time\ (\text{min})}{60\ \text{min}}}{2}}$$

where: $Rodo^2$ (mR per hour per curie at one foot) = 14,080 for Cobalt-60
3,440 for Cesium-137
5,910 for Iridium-192

Ci = number of Curies in the source

Total exposure time (min) = summation of actual individual exposure times

12.0 Barricade Sketch

Include information on basic work area configuration, area landmarks, location of exposure(s), and location of barricades and signs.

13.0 Signatures

Signatures of the involved principles must be obtained **prior** to start-up.

Principle Radiographer, Printed Name

Date

Principle Radiographer, Signature

Contract Administrator, Printed Name

Date

Contract Administrator, Signature

Area Operations Manager, Printed Name

Date

Area Operations Manager, Signature

Radiation Safety Officer, Printed Name

Date

Radiation Safety Officer, Signature

Annexure-13: Common secondary containment options for drums and IBCs

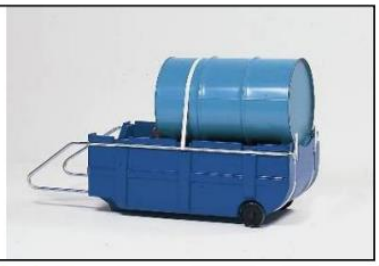
From HSE UK Pollution Prevention Guidelines PPG26

Drip Tray

- A simple tray placed under storage containers to collect minor leaks and spills.
- Suitable for use with a single drum or a few small containers.
- Ideal for small containers or drums in storage or at their point of use.
- If you store oil on a drip tray in drums, the tray must be able to contain at least 25% of the total drum volume.

Dispensing sump trolley

- Proprietary system used for transporting and then dispensing a single drum or small container.
- Not suitable for use with IBCs due to their weight when full.
- Good where products need to be stored next to their point of use. Fully bunded when in horizontal position.



Sump pallets

- Pallets to hold containers with a sump to contain spills.
- Suitable for use with small containers, two, four or eight drums, or up to four IBCs.
- Containers are kept off the ground and containment is provided.

Bunded dispensing station

- Designed to allow drums or IBCs to be stored safely and collect any drips or spills while they're in use.
- Still providing secondary containment volume but with extra space to allow small containers to be filled over the secondary containment.

Decking

- Decking units allow containers, of any size, to stand off the ground on a grid while providing containment underneath.
- Proprietary units can be added to cover the floor area required, either in the area of use or in a dedicated store.

Drum racking, indoor storage

- Racks specifically for storing drums, either vertically or horizontally. They may have facilities that allow you to dispense from the drums.
- They are stored off the ground with integral bunding or can be used in dedicated stores.
- Drums stored horizontally would ideally be turned so both outlets are horizontal with each other (i.e. at 3 and 9 o'clock) this means not all the product will be lost if there's a leak.

Racking, external storage

- Similar to drum racking but designed for use outside.
- Manufactured with a roof and doors to keep rainwater off the drums or IBCs and the integrated sump.
- Drums stored horizontally should be turned as above.
- You need to consider the security of the area to reduce the risk of vandalism.

Dedicated internal store

- Purpose-built or adapted store room/area.
- Can be built to be suitable for any size container or a mix of containers.
- Ideal where substantial storage capacity is required.
- Containment can be provided using stepped or ramped access, kerbing, bund walls, sloping floors or use of a proprietary system.

Dedicated external store

- Purpose-built, or adapted, external storage area, for any storage container, incorporating containment design features, for example ramped access.
- Useful for storing large quantities of materials, particularly where ventilation is important.
- Containment provided as above. In addition, containers should be protected from the elements by roofing (which will also prevent rainwater accumulating) and be stored off the ground. Consider the need for fencing for security and to prevent containers being ejected in the case of fire.

Annexure-14: Examples of safe handling and storage of portable containers and gas cylinders

Fig: 1: **U – shaped double platform provided with double looped strap for easy loading (Tough polyethylene construction, rust free and corrosion free)**

Fig 2: **Spill scooter with handle**

- The Spill Scooter Provides secondary containment for incidental spills and drips which often occur during vertical dispensing applications.
- Incidental spills and drips are contained in the well, with a spout for easy draining.
- The Spill Scooter fits all drums up to 55 gallons.
- Made of 100% polyethylene, the Spill Scooter will not rust or corrode

Fig 3: **Poly-spillcart**

- Poly-Spillcart eliminates the risk of spills during transport with its 57-gallon sump capacity.
- Poly-Spillcart's caster wheels let the person move around freely, while its ergonomically designed handle makes maneuvering a breeze.
- A tray for tool storage keeps tools clean and handy.
- Structural foam grate removes for easy cleaning and drain plug lets you drain the sump without effort.

Fig: 4 **The poly-rack system for 6 drums consisting of 1 poly-racker; 2 poly-stacker;**

- **Poly-Racker Features:**
  The centerpiece of the Poly-Rack System is the Poly-Racker, a unique, one-piece polyethylene rack that holds two 55-gallon drums securely in place.
- **Poly-Stacker Features:**
  Each Poly-Stacker holds two 55-gallon drums and can be quickly be stacked with a forklift.
- **Poly-Shelf Features:**
  It easily attaches to a Poly-Stacker and allows simultaneous dispensing from all drums.

Fig: 5 **Multi-purpose work Ramp**

Fig: 6 **Dual cylinder dolly**

Fig: 7 **Single cylinder Dolly**

Fig: 8 **Four Cylinder poly- stand**

Fig: 9 **Poly cylinder bumper bracket**

Figure 10: High Pressure Cylinder Storage, a fully enclosed design for added safety and security, optional provision for forklift bottoms and fiberglass firewalls