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भारतीय मानक मसौदा

क्लोरीन — सुरक्षा संहिता

(*IS 4263 पहला पुनरीक्षण*)

Draft Indian Standard

Chlorine — Code of Safety

(*First Revision of IS 4263*)

ICS 71.060.10

Chemical Hazards Sectional Committee, CHD 07

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FOREWORD

(*Formal clause to be added later*)

One of the greatest hazards associated with the use of chlorine is that, in becoming a familiar part of a process, it is often forgotten that it is potentially dangerous. The shipment of liquid chlorine in bulk from manufacturer to consumer involves various handling operations, in which the principal risks are common. These are attributable to its toxicological character, physical properties, and chemical reactivity.

It is important that personnel, engaged in chlorine plant or in any activity involving handling of chlorine, should understand the hazardous properties of chlorine and should have a good grasp of the basis of preventive measures. This will make them more conscious about safety which would not be achieved if they are trained to follow certain instructions mechanically.

The elimination of accidents is vital to public interest. Accidents produce economic and social loss, and impair individual or group productivity. Realization of this loss has led the authorities to devote a good deal of attention to safety education. In any programme of safety education, preparation of code of safety is an essential part. Apart from general precautions, some typical precautions are required to be taken and this code of safety lays special emphasis

on these points. For, proper utilization of the code of safety for chlorine, knowledge of the effects of hazardous substances on biological systems are desirable. This code of safety recommends practices to be followed to ensure safety of personnel engaged in industries where chlorine is produced, stored, handled or used.

The properties of chlorine listed in Clause **4** have been taken from literature and have been included for information only. BIS has published a separate standard IS 646: 2020 on the requirements and the methods of sampling and test for chlorine intended for industrial purposes.

The Standard was originally published in 1967. The Committee felt a need to revise this standard with a view to update the standard based on the experience of last five decades and on the currently available data. In this revision general properties have been incorporated, and modifications have been made to update safety measures for controlling hazards and essential information on symptoms of poisoning, first-aid, medical treatment, storage, handling, labelling and employee safety.

In India, chlorine is deemed to be an explosive, when contained in any metal container in a compressed or liquefied state, within the meaning of the *Indian Explosives Act*, 1884. The filling, possession, transport and importation is governed by the *Gas Cylinder Rules*, 2016.

There is no standard on this subject published by ISO. This standard has been prepared indigenously based on the available data and information.

The various clauses of the standard have been aligned with the format being applied for all Indian Standards on code of safety of chemicals.

1 SCOPE

1.1 This standard prescribes general properties of chlorine, and the nature of hazards associated with it.

1.2 This standard also covers other essential information such as information on storage, handling, packing, labelling, disposal of waste, cleaning and repair of containers, selection and training of personnel, protective equipment and first-aid.

1.3 This standard does not deal with specification for design of buildings, chemical engineering plants, storage vessels, equipment for operations control and waste disposal.

2 REFERENCE

The standards listed in **Annex A** contain provisions which through reference in this text, constitute provisions of this standard. At the time of publications, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purpose of this code, the definitions given in IS 4155 and IS 4167 shall apply.

4 PROPERTIES OF CHLORINE

4.1 General Information

Chlorine (Cl) is a poisonous, greenish-yellow gas with a strong, choking odor. A highly reactive halogen, it is never found in its pure form in nature but occurs as sodium chloride in seawater and minerals like halite, carnallite, and sylvite. It is more than twice as dense as air and dissolves in water, becoming highly reactive in the presence of moisture. Although chlorine does not burn, it readily combines with many elements and acts as a strong oxidizing agent, often removing hydrogen from compounds to form hydrogen chloride.

4.1.1 *Chemical Name* — Chlorine (gas or liquid)

4.1.2 *Common Name & Synonyms* — Chlorine, dichlorine, chlorinum,.

4.1.3 *Uses*

Chlorine also has a multitude of industrial uses. It is used as a bleaching agent in paper and cloth industry. It also used as water and wastewater disinfectant .

4.2 Identification

4.2.1 *Formula* — Cl_2

4.2.2 *CAS Number* — 7782-50-5

4.2.3 *UN Number* — 1017

4.2.4 *UN Class* — 2.3

4.2.5 *UN Subsidiary Hazard Class* — 5.1 and 8

4.3 Physical Properties

4.3.1 *General*

Chlorine is a greenish-yellow gas with a strong, pungent, and suffocating odor. It has a molecular mass of 70.90 g/mol and a boiling point of (-) 34.6 ℃, while its melting point is (-) 101 ℃. Chlorine is 2.5 times heavier than air, with a density of 2.898 kg/m^3 at 20 ℃ at standard conditions. It is slightly soluble in water (0.7 g/100 ml at 20 ℃), forming a weak acidic solution. Chlorine is also soluble in organic solvents such as carbon tetrachloride, chloroform, benzene, and carbon disulfide. In its liquid state, chlorine has a viscosity of 0.134 mPa.s at 20 ℃. It is a strong oxidizing agent and can react vigorously with various substances, requiring careful handling and storage.

4.3.2 *Molecular Mass* — 70.90 g/mol.

4.3.3 *Physical State* — greenish-yellow compressed liquefied gas

4.3.4 *Colour* — Greenish yellow (gas)

4.3.5 *Odour* — Pungent, irritating, suffocating.

4.3.6 *Boiling Point (liquefying)* — (-) 34.6 ℃

4.3.7 *Melting Point* — (-) 101 ℃

4.3.8 *Freezing Point* — (-) 101 ℃

4.3.9 *Vapour density* — 35.5 (ratio of its atomic mass to that of hydrogen)

4.3.10 *Relative vapour density* — 2.5 (air = 1)

4.3.11 *Specific Gravity Liquid* (*water* = 1) — 1.424 g/ml at 15 ℃

4.3.12 *Viscosity at* 20 °C — 0.134 mPa.s

4.3.13 *Vapour Pressure* — 673 mm Hg at 20 ℃

4.3.14 *Density* — 2.898 kg/m^3 at 20 ℃

4.3.15 *Solubility in Water* — 0.7 g/100ml at 20 ℃

Chlorine is only slightly soluble in water, approximately 1 percent at 9.4 ℃. Above this its solubility decreases with rise in temperature up to the boiling point of water at which it is completely insoluble. Below 9.4 ℃ chlorine hydrate known as ‘chlorine-ice’ ($C1_2.8H_2O$), may crystallize.

4.3.16 *Solubility in Other Solvents*

Chlorine is moderately soluble in organic solvents and dissolves well in carbon tetrachloride, chloroform, benzene, and carbon disulfide.

4.4 Chemical Properties

4.4.1 *Reactivity*

4.4.1.1 Chlorine is an extremely reactive and strong oxidizing agent that can ignite or explode upon contact with metals like sodium, potassium, and aluminum, as well as non-metals such as phosphorus and boron. It forms explosive compounds with ammonia, hydrocarbons, and alcohols, and can initiate combustion in organic materials, including rubber and wax. Chlorine has a strong affinity for hydrogen, resulting in removal of chlorine from compounds by forming hydrochloric acid. Moist chlorine is highly corrosive, reacting aggressively with metals like mercury, while dry chlorine is less reactive but can still ignite steel at high temperatures. Due to its hazardous nature, chlorine must be carefully handled in compatible materials such as stainless steel, platinum, and tantalum.

4.4.1.2 *With metals*

4.4.1.2.1 Dry chlorine reacts with aluminium, arsenic, gold, mercury, selenium, tellurium, tin and titanium. At certain temperatures potassium and sodium burn in dry chlorine. Carbon steel ignites at temperatures above 250 °C.

4.4.1.2.2 Dry chlorine, both gaseous and liquid, may be handled safely in equipment fabricated from iron, steel, 04Cr19Ni9 and 07Cr19 Ni9Mo2Ti28 stainless steels, Hastelloy ‘C’, Monel, nickel, copper, brass, silver, lead and platinum below 110 °C (at temperatures above 65 °C, chlorine reacts with steel at an accelerated rate). However, this temperature is considerably lower if the metal or alloy is in finely divided, sponge, or wire form.

4.4.1.2.3 Titanium, platinum, gold, and silver are resistant to wet chlorine. Tantalum is resistant to both wet and dry chlorine at temperatures below 149°C. Moist chlorine readily reacts with mercury. At low pressure, wet chlorine may be handled in equipment made of glass, porcelain, and chemical stoneware. Gaseous chlorine, wet or dry, may be used with hard rubber equipment at normal temperatures and pressures. However, neither soft nor hard rubber can be used with liquid chlorine.

4.4.1.3 *With other elements*

Chlorine reacts with most elements under specified conditions. Mixtures of chlorine and hydrogen composed of more than 5 percent of either component may react with explosive violence. It reacts with ammonia, alkalis and alkaline earth metal hydroxides.

4.4.1.4 *With inorganic compounds*

Chlorine has great affinity for hydrogen and as such, removes hydrogen from some inorganic compounds to form hydrochloric acid. It reacts with ammonia and ammonium compounds to form various mixtures of chloramines and under proper conditions nitrogen trichloride which is explosive. Chlorine reacts readily with lime and caustic soda to form hypo chlorites which are well-known bleaching agents.

4.4.1.5 With organic compounds

Chlorine reacts with organic compounds to form chlorinated derivatives and hydrogen chloride. Some of these reactions, particularly those with hydrocarbons, alcohols and ethers may become explosive.

4.4.2 *Polymerisation* — No information available

4.4.3 *Allotrope formation* — No information available

4.4.4 *Corrosion properties*

Chlorine is highly corrosive, especially in the presence of moisture, forming hydrochloric acid and hypochlorous acid, which aggressively attack metals like iron, steel, and copper. Dry chlorine is less reactive but can still cause oxidation, especially at high temperatures. Corrosion-resistant materials like titanium, platinum, and certain alloys are used in industries to prevent damage.

4.5 Fire and Explosion Hazard Properties

4.5.1 *Ignition Temperature* — Not applicable

4.5.2 *Auto Ignition Temperature* — Not applicable

4.5.3 *Flash Point* — Not applicable

4.5.4 *Upper Explosive Limit* — Not applicable

4.5.5 *Lower Explosive Limit* — Not applicable

4.5.6 *Fire Risk*

Neither liquid nor gaseous chlorine is explosive or flammable, but both react readily with many organic substances, usually with the evolution of heat and, in some cases, resulting in explosion. Chlorine is not combustible and does not burn, but it can support combustion by reacting with various substances. While neither liquid nor gaseous chlorine is explosive or flammable on its own, it reacts vigorously with organic materials, often releasing heat and, in some cases, causing explosions. Chlorine can also act as an oxidizer, allowing certain materials to burn in its presence.

5 HAZARDS ASSOCIATED WITH CHLORINE

5.1 General Information

Chlorine gas is primarily a respiratory irritant. The characteristic penetrating odor of chlorine gas usually gives warning of its presence. At higher concentration it is visible as greenish yellow gas.

5.2 Routes of entry

5.2.1 *Skin*

Chlorine is highly corrosive in nature, even at a low concentration of 1 ppm, when comes in contact with skin. It can cause severe irritation and damage, depending on the exposure level and duration. It may cause mild irritation, redness, and dryness. Repeated exposure can lead to more severe effects such as chemical burns, blisters, and inflammation. Liquid chlorine is more hazardous and can cause severe burns, tissue damage, and even frostbite due to its rapid evaporation and cooling effect.

5.2.2 *Eyes*

Chlorine may cause irritation and can damage the eyes due to its highly corrosive nature. . Low concentrations may lead to redness, burning, and excessive tearing (lachrymation). Higher concentrations or prolonged exposure can result in swelling, blurred vision, and chemical burns. In severe cases, exposure to chlorine gas or liquid chlorine can cause corneal damage, leading to long-term vision problems or even blindness.

5.2.3 *Ingestion*

Swallowing of chlorine is extremely hazardous and potentially fatal. Symptoms of ingestion include severe abdominal pain, burns of the oesophagus, vomiting, vomiting blood, and blood in the stool. Additional effects may include burning sensations in the eyes, nose, and throat, chest discomfort, coughing, wheezing, nausea, and skin burns. In severe cases, it can cause rapid fluctuations in blood pressure.

5.2.4 *Inhalation*

Inhalation of chlorine causes severe health hazard and exposure to concentrations in excess of 10 ppm may cause death. The inhalation exposure can lead to bronchiolitis obliterans and lung fibrosis. It is highly toxic to the respiratory system, causing symptoms such as coughing, wheezing, chest tightness, shortness of breath, and a burning sensation in the nose and throat. Prolonged or high-dose exposure may result in pulmonary edema, severe breathing difficulties, and fluid buildup in the lungs. In extreme cases, chlorine inhalation can cause irreversible lung damage, respiratory failure, or death.

5.2.5 *Long term effects*

Prolonged exposure to atmospheric chlorine concentration may result in death.

5.3 Toxicity Information

a) Threshold Limit Value (TLV) — 0.1 ppm

b) Short Term Exposure Limit (STEL) — 0.4 ppm

c) Immediately Dangerous to life or Health (IDLH) — 10 ppm

d) Lethal Dose LD_{50} (Rat) Oral — Not available

e) Lethal Dose LD_{50} (adult) Oral —Not available

5.4 Antidote

There is no specific antidote for chlorine poisoning, so treatment focuses on removing exposure and managing symptoms. The affected person should be moved to fresh air immediately, and oxygen may be provided if required. Monitoring of ECG and vitals should be continued. It is not recommended to use neutralizing compound. Investigations such as endoscopy, chest x-ray, and abdominal barium x-rays are recommended A medical specialist should be concerned at once in all cases. After initial first aid measures are completed, keep the person quiet, warm, and upright.

5.5 Health Hazards

Chlorine gas is a strong respiratory irritant, detectable by smell from 0.2 ppm onwards. It has a TLV of 0.1 ppm. Exposure can cause tachycardia, blood pressure fluctuations, pulmonary edema, and pneumonia, along with burning eyes, throat irritation, coughing, dizziness, nausea, and vomiting. Skin contact may lead to pain, blisters, and chemical burns, especially with liquid chlorine.

5.5.1 *Signs and Symptoms*

Chlorine gas is a strong irritant to mucous membranes, eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death.

5.5.2 *Acute Toxicity*

5.5.2.1 *Systemic effects*

Chlorine gas is extremely irritating to the mucous membranes, the eyes and the respiratory tract. If the duration of exposure or the concentration of chlorine is excessive, it will cause restlessness, throat irritation, sneezing and copious salivation. In extreme cases, lung tissues may be attacked resulting in pulmonary edema. Systemic effects of chlorine primarily involve the respiratory system and can range from mild irritation to severe, life-threatening conditions. Concentration of 5 ppm makes breathing difficult. Higher concentrations, such as 15 ppm to 30 ppm, lead to throat irritation, coughing, and severe discomfort. At 40 ppm to 60 ppm, exposure for 30 min to 1 h becomes dangerous, while 1 000 ppm is rapidly fatal. The effects of liquid chlorine absorption through the skin, lungs, or digestion remain unclear, but it quickly vaporizes into a gas that can cause severe health issues.

5.5.2.2 *Local effects*

Short-duration exposures of skin to high concentrations of chlorine gas is not much irritating or corrosive. But this effect is perceptible only when prolonged exposure is tolerated by the use of respiratory protection. Splashes of liquid chlorine on the eyes, skin, and clothing may cause immediate irritation and chemical burns, and severe damage to body tissues. When comes in contact, chlorine causes irritation and burns at the site of contact - be it skin, mucous membrane, eyes or respiratory tract. It is very corrosive to tissues. While brief skin contact with chlorine gas is mild, prolonged or liquid exposure causes severe tissue damage. Liquid chlorine evaporates rapidly

5.5.3 *Chronic Toxicity*

5.5.3.1 Chlorine exposure can affect the respiratory tract and lungs, leading to chronic inflammation and impaired function. Prolonged exposure to chlorine concentrations above 5 ppm may lead to bronchial disease and increased susceptibility to tuberculosis, while 0.8 ppm to 1 ppm can cause permanent lung damage. Tooth enamel erosion is also a concern. Even low, undetectable levels can cause slight irritation, making leak detection essential, especially in confined areas. Aqueous ammonia is an effective method, as it produces white fumes upon contact with chlorine.

5.5.3.2 It should be noted here that several hours exposure in the atmosphere containing chlorine at a concentration below that which can be detected by smell or sight may produce slight irritation. Therefore, suitable means of leak

detection should be employed for the protection of persona continuously exposed to chlorine handling operations, especially in confined areas. One of the most effective way of leak detection is the use of aqueous ammonia solution, which produces white fumes in the presence of even slight quantities of chlorine.

5.5.4 *Long term effects*

Long term exposure have severe effects on the respiratory effects, eyes, throat and lungs and may be fatal.

6 PERSONAL PROTECTIVE EQUPMENT (PPE)

6.1 Availability and Use

6.1.1 While personal protective equipment is not an adequate substitute for safe working conditions, adequate ventilation and intelligent conduct on the part of employees working with chlorine, it is in many instances, the only practical means of protecting the worker, particularly in emergency situations. Personal protective equipment protects only the worker wearing it, and other unprotected workers in the area may be exposed to danger.

6.1.2 The correct usage of personal protective equipment requires the education of the worker in proper employment of the equipment available to personnel.

6.1.3 Under conditions which are sufficiently hazardous to require personal protective equipment, its use should be supervised and the type of protective equipment selected should be capable of control over any potential hazard.

6.2 Non-Respiratory Equipment

The following personal protective equipment should be used when indicated:

6.2.1 *Eye and Face Protection*

6.2.1.1 *Chemical safety goggles*

Cup type or rubber framed goggles equipped with approved impact glass or plastic lenses should be worn, whenever there is danger of chlorine coming in contact with the eyes. Goggles (*see* IS 8520) should be carefully fitted.

6.2.1.2 *Face shields*

Plastic shields (full length, 20 cm minimum) with forehead protection may be worn in addition to chemical safety goggles where complete face protection is desirable. Chemical safety goggles should always be worn as added protection where there is danger of chlorine striking the eyes from underneath or around the sides of the face shield (*see* IS 8520).

6.2.1.3 *Spectacle-type safety goggles*

Metal or plastic rim safety spectacles with side shields which can be obtained with prescription safety lenses or suitable all-plastic safety goggles may be used where continuous eye protection is desirable.

NOTE — These types, however, should not be used where complete eye protection against chlorine is needed.

6.2.2 *Head Protection*

Soft-brimmed hats or caps may be worn to give protection against overhead leaks. Hard hats or Safety Helmets (*see* IS 2925) should be worn where there is danger from falling objects.

6.2.3 *Foot and Leg Protection*

PVC rubber or nitrile safety shoes with built-in steel toe caps are recommended. Rubbers may be worn over leather safety shoes. PVC blend boots or safety footwear [IS 15298 (Part 2)] should be used while handling chlorine.

6.2.4 *Body, Skin and Hand Protection*

6.2.4.1 Suits made of polyvinyl chloride and neoprene rubber or suitable protective material and properly designed, should be used wherever complete body protection (*see* IS 8519) is necessary.

6.2.4.2 Aprons made of rubber or other suitable protective material should be used for protection against accidental contact.

6.2.4.3 Neoprene/nitrile gloves should be worn to protect the hands from chlorine.

6.2.4.4 Sleeves made of suitable protective materials should be worn when the need for complete arm protection is indicated.

6.2.4.5 When cleaning, inspecting, or repairing tanks, safety equipment, such as safety belts, rescue harness, life-line, protective clothing and gas masks should be worn as required by the specific nature of the work and the hazards involved.

6.2.4.6 Frequent inspections and necessary repairs should be made of all personal protective equipment so that the wearer will be adequately protected. Rubber and other impervious apparel must be checked frequently for signs of deterioration due to exposure to chlorine.

6.2.4.7 All contaminated clothing, including gloves, shoes, coveralls, etc., should be removed as soon as possible after exposure to avoid prolonged contact with chlorine. It should be thoroughly decontaminated and cleaned before re-use.

6.3 Respiratory Equipment

6.3.1 Severe exposure to chlorine may occur in tanks during equipment cleaning and repairs, when decontaminating areas following spills, or in case of failure of piping or equipment. Employees who may be subject to such exposure should be provided with proper respiratory protection and trained in its use and care. Available types are described in **6.3.1** to **6.3.5**.

NOTE — Respiratory protective equipment shall be carefully maintained, protected with paraffined paper or polyethylene bags. Inspection and cleaning should be done by a competent person after each use and at least once a month and sterilized at regular intervals, always before and after use by another person. Protective gear should be comfortable and workers should never enter contaminated areas alone, ensuring an observer is present for emergencies.

6.3.1 *Self-Contained Breathing Apparatus*

Permitting the wearer to carry a supply of oxygen or air compressed in the cylinder [*see* IS 10245 (Part 1)] and [IS 10245 (Part 2)] and the self-generating type which produces oxygen chemically (*see* IS 15803). These allow considerable mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air, oxygen or regenerating material carried. Compressed oxygen should not be used where there is danger of contact with flammable liquids, vapors, or sources of ignition, especially in confined spaces, such as tanks or pits.

6.3.2 *Positive Pressure Hose Masks*

The air shall be supplied by blowers requiring no internal lubrication. The wearer shall be able to use the same route for exit as for entrance and shall take precautions to keep the hose line free of entanglement. The air blower shall be placed in an area free of contaminants.

6.3.3 *Demand Type Hose Masks*

It supplies air to the facepiece only during inhalation, using compressed air cylinders or a compressor. Combination units consist of a self-contained air supply with a reinforced high-pressure hose connected to remote air sources.

6.3.4 *Air-Line Masks*

Supplied with clean compressed air. These are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. These masks are usually supplied with air piped to the area from a compressor. It is extremely important that the air supply is taken from a safe source and that it is not contaminated by oil decomposition from inadequate cooling at the compressor. The safer method is to use a separate compressor of the type not requiring internal lubrication. Pressure reducing and relief valves as well as suitable traps and filters must be installed at all mask stations. An alternative arrangement frequently used is high pressure breathing air from cylinders, with demand-type valve and face piece [*see* IS 10245 (Part 3)].

6.3.5 *Industrial Canister Type Gas Masks*

It is equipped with full face pieces fitted with the proper canister for absorbing chlorine vapor. These will afford protection against concentrations not exceeding 1 percent by volume when used in accordance with manufacturer's instructions. The oxygen content of the air must not be less than 16 percent by volume. The masks should be used for relatively short periods only. They may not be suitable for use in an emergency since, at that time, the actual vapor concentration is unknown and also an oxygen deficiency may exit. The wearer must leave the contaminated area immediately on detecting the odour of a harmful vapor. This may indicate that the mask is not functioning properly, that the vapor concentration is too high, that the canister is exhausted or that the mask is not properly fitted.

6.3.6 *Chemical Cartridge Respirators*

May be used to avoid inhaling disagreeable concentrations of chlorine vapor. These respirators, however, are not recommended for protection where toxic quantities may be encountered.

7 STORAGE, HANDLING, LABELLING AND TRANSPORT

7.1 General

7.1.1 All personal handling chlorine should use proper personal protective equipment. Appropriate firefighting equipment should be available in the vicinity while handling chlorine. Persons handling nitrobenzene should have adequate training in use of firefighting equipment.

> NOTE — The storage shall be as per the criteria given in the relevant schedule of the *manufacture, storage and import of Hazardous Chemicals Rules,* 1989 and *Indian Explosives Act*, 1884. While referring to the statutes, the stipulations given in the latest amendments of those statutes shall be taken into account.

7.1.2 The manufacturer/producer of chlorine shall issue material safety datasheet (MSDS) for all its user for comprehensive safety details. The MSDS shall be in format as prescribed in IS 17889. MSDS translation in local languages may be provided as required.

7.1.3 Chlorine should be stored in fireproof buildings, away from food and drains, in a cool, dry, and well-ventilated area to prevent hazardous buildup. Exposure to chlorine gas can cause severe respiratory and skin irritation, requiring emergency eye wash stations and safety showers nearby. Cylinders must be handled with care, using proper carts for transportation, and never lifted by the cap. Protective measures, including respiratory equipment and leak detection, are essential to ensure safe handling and storage.

7.2 Storage

7.2.1 For authorized containers, an outage (vacant space over liquid) of not less than 10 percent of the capacity of the container is required.

7.2.2 Chlorine should be stored in a well-ventilated area to prevent hazardous buildup and avoid direct sunlight.

7.2.3 Chlorine cylinders should be stored in dry areas, away from salt, corrosive chemicals, fumes, heat, and weather exposure. They must be kept separate from reactive substances like acetylene, ether, turpentine, ammonia, natural gas, hydrogen, and finely divided metals to prevent hazardous reactions.

7.2.4 Chlorine from reaction vessels or storage tanks should be vented through an alkali absorber preferably kept under constant pressure.

7.2.5 Electrical fittings in area should be made from corrosion-resistant materials like PVC conduit. Chlorine can severely damage standard metal fittings, making durable alternatives essential. Always refer to local electrical codes and manufacturer guidelines to ensure proper selection and safety.

7.2.6 Piping for chlorine should be made from materials like carbon steel, stainless steel, PVC, PTFE, and Monel. The choice of material depends on factors such as pressure, temperature, and the state of chlorine (dry or gaseous) to ensure safe and efficient handling.

7.2.7 Cylinders should always be stored in an upright position and securely fastened to prevent them from falling. Full and empty cylinders must be stored separately to avoid confusion and potential hazards. Ton containers should be placed on their sides and must not be stacked or racked more than one high to ensure stability and safety during storage.

7.2.8 Storage tanks should be located in concrete paved and diked areas so that any leak or spill can be contained.

7.2.9 Storage areas should be remote from elevators gangways or ventilating systems because, in the event of a chlorine leak, dangerous concentrations of chlorine may spread rapidly.

7.2.10 The storage area should be separate from that in which other compressed gas containers are stored, and should contain no turpentine, ether, anhydrous ammonia, finely divided metals or other inflammable material. The storage area should be dry, well-ventilated, clean of trash, and protected from external heat sources (steam pipes, etc.). Sub-surface areas should be avoided for storing chlorine cylinders.

7.2.11 The valves on cylinders and ton containers should be protected by a stout metal cap securely attached to the cylinder body. This cap should always be kept in place on all containers in storage and at all times except during evacuation of chlorine.

7.2.12 Protect storage tanks from moisture or humid air, as chlorine can react with water to form corrosive acids that may damage the storage system.

7.2.13 The amount of chlorine in storage should be kept to a minimum. The separation distance between the storage area and the site boundary shall be determined by local regulations.

7.2.14 The storage area should be on low ground to minimize the dispersal of chlorine vapors. The minimum diked volume should be equivalent to the largest storage tank plus 10 percent.

7.2.15 The diked area should not have a sewer connection or near to it. The adequate size sump should be provided near dike area for collecting chlorine spills and pump away collected rainwater and fire-fighting water. The fire-fighting water should be prevented from contaminating water sources.

7.2.16 The outside shaded or a separate building containing no incompatible materials and located away from all other structures should be preferred.

7.2.17 The fire-fighting installation and hydrants should be distributed around the area. The drainage should be adequate to prevent flooding of any point on the site and particularly flooding of outside storage areas or around the entrances to, or emergency exits from, warehouses. Fire-fighting water run-off should be prevented from polluting water sources.

7.2.18 Storage areas with a noncombustible wall at least 5 feet high and a fire resistance rating of at least 30 minutes can be used to separate gases of different hazard classes when stored close together.

7.2.19 Cylinders must be stored at least 20 feet away from all flammable, combustible, or incompatible substances to ensure safety.

7.2.20 In the event of a major loss of containment of one or more of the chemicals on site, there should be provisions for quickly closing off storm water drains to prevent entry of chemicals. The construction of floor should be of impervious, may be of concrete.

7.2.21 Moderate amounts can be stored in high-strength tanks as liquefied gas under pressure.

7.2.22 There should be a strengthened approach way for emergency vehicles on two sides of the installation.

7.2.23 A flexible connection should be used between the container and piping. Annealed copper tubing (9.5 mm outer diameter × 0.889 mm wall) suitable for 35.2 kg/cm² service is recommended. A clamp and adapter connector is preferred, and if a union connector is used, the threads must match the valve outlet. A new lead gasket should be used when making the connection.

7.2.24 Avoid using PTFE tape or any sealing material to tighten the seal. The seal should be achieved through metal-to-metal contact; otherwise, the valve or regulator must be replaced.

7.2.25 Small quantities of chlorine are stored and transported as liquefied gas under pressure in 45.4 kg, 68 kg, and 909 kg steel cylinders, equipped with fusible plug relief devices.

7.2.26 The storage facility should be away from residential or working areas to avoid the prevailing winds blow chlorine vapors towards inhabited areas, offices, workshops, or other employee concentration areas.

7.2.27 The storage site should be more than 25 m away from a public road or main rail line to minimize the risk of damage in case of an accident.

7.2.28 There should not be any confined spaces in the vicinity of the storage facility or chlorine handling units, to avoid accumulation of chlorine.

7.2.29 The chlorine should be stored in areas where there is no contact with incompatible material.

7.2.30 The valve on cylinders and ton containers should be protected by a stout metal cap securely attached to the cylinder body. This cap should always be kept in place on all the containers in storage and at all times except during use of chlorine.

7.2.31 The storage area should be dry, well-ventilated, clean of trash, and protected from external heat sources (steam pipes, etc). Sub-surface areas should be avoided for storing chlorine cylinders.

7.3 Handling

7.3.1 General

The general handling practices given in **7.3.1.1** to **7.3.1.7** should be followed.

7.3.1.1 All handlers should be aware of the potential hazards of chlorine and of appropriate first-aid measures.

7.3.1.2 Cylinders should not be lifted by the metal cap, and methods like rope slings, chains, or magnetic devices should be avoided. Unloading platforms should be at the same level as the truck or car bed. Ton containers should be handled with a suitable cradle and chain slings, using a hoist or crane with a minimum capacity of 2 metric tonnes.

7.3.1.3 Safety showers and eyewash fountains as specified in IS 10592 should be immediately at hand where contact is at all likely.

7.3.1.4 If there is significant risk of exposure an operator should not handle chlorine without available assistance in the area.

7.3.1.5 Chlorine, in any breakable package or line, should be kept at as low a level as possible above protection pans.

7.3.1.6 When chlorine is absorbed in a liquid, precautions must be taken to prevent the liquid from being sucked back into the container due to a partial vacuum. This can be prevented by using a barometric leg, vacuum-breaking device, or both.

7.3.1.7 Sumps should be sufficiently large to prevent general contamination in case of spills and shall be ventilated to prevent escape of vapors into inhabited areas.

7.3.1.8 Cylinders and ton containers being trucked should be carefully checked, clamped, or otherwise suitably supported to prevent shifting and rolling. They should not be permitted to drop, and no object should be allowed to strike them with force. They should not project beyond the sides or ends of the vehicles in which they are transported.

7.3.1.9 Cylinders normally should be emptied in the gas phase, standing secured in an upright position. Ifit is necessary to empty them in the liquid phase, they should be partially inverted and clamped securely on a rack set at an angle of above 60 º to the horizontal. Connection of containers discharging liquid to a manifold is not recommended.

7.3.1.10 Ton-containers set in a horizontal position, with the valves in a vertical plane, deliver gas from the upper valve and liquid from the lower valve. be used.

7.3.1.11 The flow of chlorine-gas from any chlorine container depends on the internal pressure which in turn depends on the temperature of the liquid chlorine. Discharge rates may, however, be increased by forced circulation of room-temperature air around the container.

7.3.1.12 If the gas discharge rate from a single container will not meet demand requirements, two or more may be connected to a manifold and discharged simultaneously, or a vaporizer may be used. When discharging through a manifold, care shall be taken that all containers are at the same temperature, particularly when connecting a new container to the manifold. If there is a difference in the temperature of the liquid chlorine, it will be transferred by distillation from the warm to the cool container, and the cooler container may become completely filled with liquid. If this should occur. and the container valve remains closed, hydrostatic pressure may cause bursting. For this reason, extra precautions shall 'be 'observed when closing valves of containers connected to a manifold. Connection of cylinders or ton containers discharging liquid chlorine to a manifold is not recommended.

7.3.1.13 Tonner/cylinder valves should not be used as controlling valve for flow of liquid/gas. Separate valve should be provided at the source of consumption for regulating the flow.

7.3.1.14 Inspection of the chlorine tanks shall be done as per Static and Mobile Pressure Vessel Rules, 2016 before loading can begin. While referring to the statutes, the stipulations given in the subsequent amendments of those statutes shall be taken into account.

7.4 Labelling

7.4.1 Each container (including tankers) shall carry an identifying label or stencil as specified in Fig. 3, Fig. 9, Fig. 15, and Fig. 24 of IS 1260 (Part 1) or Label Model No. 2.3, No. 5.1, and No. 8 of Annex B of IS 18149. The storage containers shall be labelled or marked to identify as follows:

a) Name of the material;
b) Indication of the source of manufacture;
c) Net mass;
d) Batch number or lot number in code or otherwise; and
e) Physical, chemical and toxicological data as per the criteria given in the relevant schedule of the *manufacture, storage and import of Hazardous Chemicals Rules*, 1989. While referring to the statutes, the stipulations given in the subsequent amendments of those statutes shall be taken into account.

7.4.2 The container shall carry the following label and this label may be used with any other illustration/descriptions.

Warning! CHLORINE!
Corrosive Handle with Care

1. Do not change the colour of this cylinder.
2. This cylinder may not be filled with any gas other than chlorine.
3. This cylinder should be kept cool. It should not be placed near a stove or any other source of heat, nor be exposed to the sun.
4. No oil or similar lubricant should be used on the valves or other fittings of this cylinder.

7.5 Transport

7.5.1 Loading of the chlorine tonners should be done under the supervision of experienced and trained persons.

7.5.2 Filled chlorine tonners should be placed horizontally in a single layer with valves of all tonners facing in the same direction.

7.5.3 In order to, prevent the tonner from falling during transportation, they should be supported with wooden wedges

7.5.4 The loading of all the tonners in the truck/vehicle should always be within its loading capacity. It should also be noted that no tonners or any part of it should dangle out of the truck.

7.5.6 It should be ensured that neither any other goods should be loaded in the truck along with chlorine nor any passenger should be transported in the truck loaded with chlorine tonner.

7.5.7 The vehicle on route if required to be parked then it should be parked in an open the place should be shadowed, windy and open area. Vehicle should not be parked under direct sunlight.

7.5.8 Ascertain in advance, availability of safe & proper parking places en route or at customers place so that in case or emergency the vehicle can be park in such sate place.

7.5.9 After the chlorine tonner reaches at the customer end, always use mechanical or electrical devices for unloading the tonner. Magnet or Sling should never be used for unloading the same.

7.5.10 Tonners should never be thrown directly on the floor.

7.5.11 *Driver*

7.5.11.1 Driver should be aware about the travel route before start of journey. Shortcuts should not be permitted.

7.5.11.2 The driver should be familiar with the truck and the ISO-container; it's length, width, maximum speed, height, braking, turning circle etc.

7.5.11.3 Driver should carry TREM card when vehicle is on road. Drivers are to be provided with written instructions regarding hazardous nature of chlorine being transported by him and also the precaution to be taken during transportation.

7.5.11.4 The driver should not board the passengers in transport units carrying dangerous goods.

7.5.11.5 The Driver and his crew should be aware about the necessary requirements for fire-fighting.

7.5.11.6 The drivers should be prohibited from opening the packages containing dangerous goods.

7.5.11.7 The engine shall be shut off during loading and unloading operations.

7.5.11.8 Driver remembers the preventive measures required to be taken during adverse weather condition.

7.5.11.9 Vehicle driver should be aware of the potential hazards of the load and should know standard procedure (do's and don'ts) in the event of an accident or an emergency.

7.5.11.10 The driver should always keep a bottle of dilute Ammonia in the cabin. In case of smell or doubt of chlorine leakage, wet a cloth tied on wooden baton with Ammonia solution an take it near each end of the container, white fumes indicate chlorine leak.

NOTE — If transport of the hazardous chemical is involved it shall be carried out in accordance with the *Central Motor Vehicles Rules*, 1989 and Gas Cylinder Rule, 2016. While referring to the statutes, the stipulations given in the subsequent amendments of those statutes shall be taken into account.

8 SPILLAGE, LEAKAGE AND WASTE DISPOSAL

8.1 Spillage

8.1.1 *General Information*

Wherever chlorine is handled a potential risk is involved and a serious emergency might suddenly and unexpectedly occur. Emergency situations should be anticipated, plans established and persons trained to counteract them. In the event of a chlorine spill, stop the leak, isolate the area, and ensure no water comes into contact with the spill.

8.1.1.1 When chlorine spills, chlorine gas (Cl_2) is released, which is a yellowish-green gas with a strong, irritating odor. It is highly dangerous when inhaled and can cause significant respiratory irritation.

CAUTION — Avoid the contact with water it may cause large amounts of chlorine gas, posing significant health hazards, when chlorine spilled in water.

8.1.1.2 Decontamination from chlorine exposure involves removing contaminated clothing, rinsing with water, and seeking medical help immediately.

8.1.2 *Land Spill (Spill on land)*

8.1.3.1 The material like activated carbon, polyurethane, polyolefin, Dowex 1 should be used to the contaminated area.

8.1.3.2 Do not use hydrocarbons, cleaning solvents, paints& thinners, oil, grease, as they may increase the potential for fire.

8.1.3.3 Water should never be used on a chlorine leak as it worsens the situation due to chlorine's corrosive effect. Even cold water causes the liquid chlorine to evaporate faster, exacerbating the leak. Containers should not be immersed in water, as the leak will worsen and the container may float, allowing gas to escape.

8.1.3.4 If a chlorine leak occurs during transit in a populated area, and the leak is minor, use large quantities of lime to neutralize the chlorine with calcium carbonate, hydroxide, oxide, sodium hydroxide, limestone.

8.1.3.5 If the soil is contaminated by the chlorine isolate the area by 100m then use reducing agent like calcium sulfite, lignite filtrate, or cellulose sulfite liquor.

8.1.3.6 Use water spray to reduce vapors or direct vapor cloud drift, avoiding runoff contact with the spill.

8.1.3.7 When handling a leaking drums or tonners, cylinders containing chlorine, personal protective equipment as mentioned in **6** should be worn.

8.1.3.8 The contaminated area should be cleaned for non-essential personnel.

8.1.3.9 Contact emergency personnel immediately and use spark-proof, explosion-proof equipment.

8.1.3.10 Use water spray to reduce vapors or direct vapor cloud drift, avoiding runoff contact with the spill.

8.1.3.11 Ventilate the area to remove the chlorine fumes.

8.2 Leakages

8.2.1 The driver of a vehicle with leaking chlorine should try to get the vehicle to an unpopulated area, put on escape gas mask, take all the shipping documents, and get to a safe spot upwind and higher than the vehicle.

8.2.2 The personnel not properly equipped should be kept out of the area.

8.2.3 In any chlorine road transport emergency, contact details of EMERGENCY CONTACT that should be clearly marked on the shipping papers and labels.

8.2.4 When moving cylinders, even over short distances, use a cart (trolley, hand truck, etc.) designed for cylinders. Never insert objects (e.g., wrench, screwdriver) into cap openings, as this can damage the valve and cause a leak. Use an adjustable strap wrench to remove over-tight or rusted caps.

8.2.5 Leaks around valve stems can usually be stopped by tightening the packing nut or gland. If ineffective, close the corner valve and dispose of the chlorine in the outlet piping. For a valve leak on a ton-container, roll the container to position the leaking valve at the top in a vertical plane.

8.2.6 Chlorine leaks always get worse unless they are corrected promptly. Chlorine leaks should be investigated by authorized, trained personnel equipped with suitable gas masks. If the leak is extensive an effort should be made to warn all persons in the path of the gas. Chlorine is heavier than air, therefore persons should be instructed to keep above and upwind of the leak.

8.2.7 If a leak occurs in equipment in which chlorine is being used, the supply of chlorine shall be shut off and chlorine which is under pressure at the leak shall be disposed off safely.

8.2.8 If practical, the pressure in the container should be reduced by removing the chlorine as gas (not as liquid) to process or a disposal system. In some cases it may be desirable to move the container to an isolated spot where it will do the least harm.

8.2.9 In case of chlorine leaks, while seeking an escape, or while respiratory equipment is being secured and adjusted, short, shallow breaths should be taken and eyes should be closed as much as possible. It is important to keep above and to the windward side of escaping chlorine gas. All exhaust mechanisms should be turned on immediately. The leaks should be investigated at once by authorized, trained personnel equipped with suitable respiratory protection.

8.2.10 All other personnel should be kept away from the area, until the cause of the leak is discovered and the difficulty corrected. Respiratory protective devices should be located outside the probable area of contamination so that it will be possible to reach them in emergency.

8.2.11 If a chlorine leak develops in transit in a populated area and if the magnitude of the leakage is minor, and no emergency kits are available, ,excessive quantities of lime should be used to arrest leaking chlorine. If the leakage is extensive, it is advisable to dump the leaking cylinder in a nearby water stream or river or, alternatively, to keep the transporting vehicle moving until open country is reached in order to minimize the hazards. Appropriate emergency measure, as given above, should then be taken as quickly as possible.

8.2.12 As a regular part of chlorine storage and use, provisions shall be made for emergency disposal of chlorine from leaking cylinders or ton-containers. Chlorine may be absorbed in solutions of caustic soda or soda ash, or in agitated hydrated-lime slurries. Caustic soda is recommended as it absorbs chlorine more readily.

8.3 Waste Disposal

8.3.1 The waste shall be disposed off as per *Central Pollution Control Board* (CPCB) and the respective *State Pollution Control Board* (SPCB) guidelines.

8.3.2 Dilute and neutralize before disposal as indicated in **8.3.2.1** to **8.2.2.6**.

8.3.2.1 When chlorine spills, chlorine gas (Cl_2) is released, which is a yellowish-green gas with a strong, irritating odor. It is highly dangerous when inhaled and can cause significant respiratory irritation if exposed to large amounts.

CAUTION — Avoid the contact with water it may cause large amounts of chlorine gas, posing significant health hazards, when chlorine spilled in water.

8.3.2.2 Surplus and non-recyclable products should be disposed of by a licensed waste disposal contractor. Waste must not be discharged untreated into sewers unless fully in compliance with relevant regulatory requirements. Empty pressure vessels should be returned to the manufacturer.

8.3.2.3 Chlorine can be absorbed in solutions of caustic soda, soda ash, or agitated hydrated-lime slurries, with caustic soda being the preferred option due to its greater absorption efficiency. To neutralize 45 kg of chlorine, different neutralizing agents require varying amounts. Caustic soda and water should be used in a weight/volume ratio of 58 to 182. Soda ash and water require a ratio between 136 and 450, while hydrated lime and water need a ratio ranging from 58 to 566. These agents help effectively neutralize chlorine when used in appropriate proportions.

8.3.2.4 A suitable tank for holding the solution should be placed in a convenient location, and chlorine gas should be introduced into the solution via an iron pipe or rubber hose, properly weighted to keep it submerged; the container should not be immersed.

8.3.2.5 The waste water generated from spillages shall be treated physio-chemically in an effluent treatment plant (ETP).

8.3.2.6 During the process of utilization and handling of hazardous waste, the unit shall comply with the requirements in accordance with the *Public Liability Insurance Act*, 1991 as amended, wherever applicable.

9 FIRE PREVENTION AND FIRE FIGHTING

9.1 General

9.1.1 Good ventilation should be maintained at all times in all locations where chlorine is stored or handled. Local exhaust ventilation may at times be required where higher concentrations may occur. At all times ventilation should be sufficient to keep exposure at or below one-tenth (0.1) ppm of the threshold limit.

9.1.2 In the event of fire, chlorine containers should be moved from the fire zone immediately. If chlorine containers cannot be moved, water should be applied to cool them provided no chlorine is escaping.

9.2 Fire Fighting

Firefighters should wear self-contained breathing apparatus and full protective gear while fire-fighting.

9.3 Explosion Hazard

9.3.1 Chlorine reacts with hydrogen slowly in the dark but explosively in sunlight or at high temperatures, forming hydrogen chloride. The reaction rate significantly increases in the presence of oxygen, making it crucial to take precautions during chlorine manufacturing by electrolysis to prevent dangerous hydrogen-chlorine mixing, which could lead to fires or explosions. Regular analysis of chlorine for hydrogen content is essential for safety. The lower explosive limit of hydrogen-chlorine mixtures varies between 3.1 % and 8.1 %, depending on pressure and other factors.

9.3.2 Hot chlorine gas from electrolytic cells can crystallize as chlorine octahydrate ($Cl_2.8H_2O$) due to sudden cooling, leading to pipeline blockages and gas buildup in the system. This back pressure inside the cells may cause chlorine to escape into the air or the hydrogen chamber, potentially resulting in an explosion.

9.3.3 Liquid chlorine expands significantly when it evaporates, which can lead to hydrostatic rupture in containers, pipelines, and other equipment due to excessive pressure buildup. This risk is especially critical in heated cylinders, where pressure accumulation may result in an explosion.

10 TRAINING

10.1 Safety in handling chlorine depends upon the effectiveness of employee education, training and supervision. The education and training of employees to work safely and to use the personal protective equipment and other safe guards provided for them is a responsibility of supervision. Employee education and training should emphasize the need of handling chlorine according to the methods outlined in the manual, in order to avoid spilling or splashing, leaks, burns, inhalation of the vapour of burning material, or ingestion. Unauthorised and untrained employees should not be permitted in areas where chlorine is being handled. The work permit shall be issued as per format prescribed in IS 17893.

10.2 Before being placed on the job, all new employees should be instructed thoroughly for the proper handling of chlorine. Older employees should be re-instructed periodically.

10.3 Each employee should know the location, purpose and maintenance of personal protective equipment (PPEs) and be thoroughly trained when and how to use it. Each employee should know the location of safety showers, fountains for flushing the eyes, and hose lines. There should be periodic drill and instruction time to time.

10.4 Only reliable, dependable and properly trained employees should be given the responsibility of all operations involving storage, handling, transport and emergency management involving chlorine.

10.5 Employee should be trained to report to the proper authority about all suspected leaks or equipment failure.

10.6 They should be instructed to inform to supervisors any signs of illness or skin related problems.

10.7 Each employee should be aware of emergency procedures and the first-aid measures and should take prompt action regarding first-aid in case of contact or exposure to chlorine.

10.8 All workers should be instructed and trained to, adopt preventive measures in case of emergency. Such training should include knowledge of emergency, firefighting equipment, fire alarms, crash shut-down procedures for valves and switches, steps to be taken before starting repairs anywhere in the plant, use of personal protective equipment and first-aid. Regular and surprise drills for the above should be conducted to improve further the training in preventive and emergency aspects.

11 HEALTH MANAGEMENT, FIRST-AID AND MEDICAL TREATMENT

11.1 Health Monitoring

11.1.1 *Personal Hygiene*

Workers should be thoroughly instructed and supervised in proper operating procedures to avoid exposure to chlorine vapor. Where exposure is possible, personal protective equipment should be used.

11.1.1.1 All contaminated clothing, including gloves, shoes, overalls, etc., should be removed immediately to avoid prolonged contact with chlorine and should be thoroughly decontaminated and cleaned before re-use.

11.1.1.2 Working areas, storage rooms and unloading areas should be well equipped with safety showers, readily accessible and plainly marked. Eye washing fountains or running tap water, such as a bubbler drinking fountain or a hose should be available for eye irrigation. The location of such equipment should be inspected and tested at fixed intervals to make sure that it is in good working condition at all times.

11.1.2 *Physical Examination*

A physical examination should focus on the eyes, cardiac health, dental condition, and skin for chronic disorders. Olfactory function should be assessed, and respiratory tests (FVC, FEV1) conducted. A chest X-ray (14" × 17") is required only if pulmonary tests or symptoms indicate respiratory issues.

11.1.3 *Pre-placement Examinations*

Preplacement examination including a chest X-ray is recommended for all new employees and follow up medical examinations at suitable intervals for all the workers handling chlorine.

11.2 First Aid

11.2.1 *General*

11.2.1.1 If chlorine is accidentally spilled on skin, the area should be promptly washed and take medical advice.

11.2.1.2 In case of contact with eyes, they should be irrigated for at least 15 min with clean and lukewarm water.

11.2.1.3 In case of inhalation, ensure fresh air and rest, keeping the patient in a half-upright position. Assess vital signs, including pulse and respiratory rate, and check for any trauma. If no pulse is detected, initiate CPR. If the patient is not breathing, provide artificial respiration. If breathing is labored, administer oxygen or other respiratory support.

11.2.1.4 Clear notices about first-aid measures should be placed in accessible locations. Emphasis must be placed on the urgency of first-aid response while minimizing patient shock. Employees should promptly report minor injuries and any work-related illnesses for immediate treatment. Anyone severely exposed to chlorine gas must be moved to a safe, uncontaminated area without delay.

11.2.2 *Contact with Skin*

If case of chlorine or chlorinated water comes into contact with skin or clothing, use the emergency shower immediately. Wash the affected skin areas with large amounts of soap and water. Do not attempt to neutralize chlorine with chemicals, and avoid applying ointments for 24 h. Remove contaminated clothing immediately.

11.2.3 *Contact with Eyes*

If the eyes are exposed to liquid chlorine or high concentrations of chlorine gas, flush them immediately with running water for at least 15 min. Do not attempt to neutralize with chemicals. After flushing, instill 2 drop or 3 drop of a 0.5 percent solution of pontocaine or a similarly effective topical anesthetic. Avoid using oils or oily ointments unless prescribed by an eye specialist.

11.2.4 *Ingestion*

Swallowing of liquid chlorine is highly unlikely, but if it occurs and the person is conscious, they should immediately drink large amounts of lime water, milk of magnesia, or fresh water if the others are unavailable. Do not administer sodium bicarbonate. The person may vomit spontaneously, but do not attempt to induce vomiting or use a stomach tube. Seek immediate medical attention from a physician.

11.2.5 *Inhalation*

11.2.5.1 If breathing has not stopped, the patient should be laid on their back with their head and back elevated. Keep them warm with blankets if needed. Rest is crucial for recovery.

11.2.5.2 If breathing has stopped, artificial respiration should be initiated immediately using the 'Nielson arm lift-back pressure' method. A physician must be contacted right away. If oxygen-inhalation equipment is available, oxygen should be administered by a person authorized by a physician.

11.2.5.3 Stimulants are rarely needed when adequate oxygenation is maintained, and any shock treatment drugs should only be administered by a physician. In mild cases, milk may be given to alleviate throat irritation. Nothing should be given by mouth to an unconscious patient.

11.2.6 *First-Aid Kit*

11.2.6.1 *General*

All employees should receive thorough instructions on how to use first-aid equipment, including the items listed below and any additional equipment provided by the authorities.

11.2.6.2 Emergency showers and eye baths should be appropriately designed, provided in accessible locations, and regularly maintained.

11.2.6.3 Oxygen administration equipment should be available in the plant's first-aid, ambulance room, or medical dispensary, and should be managed by a trained individual. Large-scale manufacturers and consumers should ensure multiple personnel are trained in the use of the apparatus and have a trained person on-site at all times.

11.2.7 Boxes or Cupboards

First-aid kits, clearly marked with the words "First-Aid," should be placed in easily accessible locations. These kits should only contain the prescribed medical supplies, with a list of contents displayed inside. A sufficient number of individuals should receive effective first-aid training.

11.3 Medical treatment

Treatment consists of removing the chlorine from the body as soon as possible and providing supportive medical care. Symptoms can be treated in a hospital setting or by trained emergency personnel.

12 ADDITIONAL INFORMATION

12.1 Emergency Kits

Most chlorine suppliers provide emergency kits and skilled technicians to use them. These kits can typically stop most leaks in chlorine cylinders or ton containers and can usually be delivered to consumer plants within a few hours during an emergency. However, it is recommended that consumers purchase their own kits and train employees in their use.

12.2 The fundamental steps for safe working conditions in a plant or area where chlorine is produced, stored or processed are:

a) designing of layout of area with due consideration for adequate natural or mechanical ventilation;

b) use of properly selected material for construction of plant and equipment for handling of chlorine;

c) preventive maintenance of all equipment in proper working condition; and

d) availability and use of adequate and suitable personal protective equipment at all times.

12.3 Tank Cleaning and Repairs

12.3.1 Equipment and tank cleaning and repairs must be supervised by properly trained personnel.

12.3.2 Workers should never attempt to repair chlorine equipment while it is in operation or when the piping system is active.

12.3.3 Welding, cutting, or any work involving flame or sparks should only be performed on chlorine lines or containers after they have been purged with steam and hot-air-dried. Alternatively, carbon dioxide may be used to fill the lines if equipped with a low-pressure safety valve.

12.3.4 When removing pipe sections and opening flanges, loosen the lower bolts first. Even if the lines have been purged, care should be taken to avoid contact with any residual material that may drip from the equipment.

12.3.5 If water is accidentally introduced into a chlorine pipeline or container, or it is opened for repairs or cleaning, immediate drying is essential to prevent corrosion.

12.3.6 Workers entering tanks must wear appropriate personal protective equipment, such as a self-contained breathing apparatus. Canister masks should only be used if the oxygen level is verified to be adequate. At least one person must observe the operation from outside the tank.

12.3.7 Under no circumstances should a rescuer enter a tank to remove a victim of overexposure without proper respiratory protection, a safety harness, and an attached lifeline. Another attendant should always be present, and the rescuer must remain in view or maintain constant communication with the outside attendant.

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 1260 (Part 1) : 1973	Pictorial markings for handling and labelling of goods Part 1 Dangerous goods (*first revision*)
IS 2925 : 1984	Specification for industrial safety helmets (*second revision*)
IS 4155: 2023	Glossary of terms relating to chemical and radiation hazards and hazardous chemicals (*first revision*)
IS 4167: 2020	Glossary of terms relating to air pollution (*second revision*)
IS 8519 : 2024	Guide for selection of occupational protective clothing — Body protection (selection, care, and maintenance) (*first revision*)
IS 8520 : 2023/ ISO 19734 : 2021	Eye and face protection — Guidance on selection, use, and maintenance (*first revision*)
IS 10245 (Part 1) : 1996	Breathing apparatus Part 1 Closed circuit breathing apparatus (compressed oxygen cylinder) — Specification (*first revision*)
IS 10245 (Part 2) : 2023	Respiratory protective devices — Specification Part 2 Self-contained open circuit breathing apparatus (*second revision*)
IS 10245 (Part 3) : 1999	Breathing apparatus Part 3 Fresh air hose and compressed air line breathing apparatus — Specification (*first revision*)

IS 10592 : 2018	Industrial emergency showers, eye and face fountains and combination units — Specification (*first revision*)
IS 10667 : 2025	Selection of industrial safety equipment for protection of foot and leg — Guide (*first revision*)
IS 15298 (Part 2) : 2024	Personal protective equipment Part 2 Safety footwear (*third revision*)
IS 15803 : 2008	Respiratory protective devices — Self-contained closed circuit breathing apparatus chemical oxygen (KO_2) type, self-generating, self-rescuers — Specification
IS 17889: 2022	Material Safety Data Sheets- Guidelines
IS17893: 2023	Work Permit System - Code of Practice
IS 18149: 2023	Transportation of dangerous goods — Guidelines