

BUREAU OF INDIAN STANDARDS

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भारतीय मानक मसौदा

ब्रोमिन — सुरक्षा संहिता

(IS 6953 पहला पुनरीक्षण)

Draft Indian Standard

Bromine — Code of Safety

(First Revision of IS 6953)

ICS 71.060.10

Chemical Hazards Sectional Committee, CHD 07

Last date for Comments: 20.03.2025

FOREWORD

(Formal clause to be added later)

Bromine as a liquid or as a vapour is highly irritating to skin, mucous membranes, eyes and respiratory tract. Being a powerful oxidizing agent, it also constitutes a fire hazard.

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 bromine, a knowledge of effects of hazardous substances on biological systems is desirable. This code of safety recommends practices to be followed to ensure safety of personnel engaged in industries where bromine is produced, stored, handled or used.

The properties of bromine listed in Clause 4 have been taken from literature and have been included for information only. Moreover, these properties pertain to bromine. BIS has published a separate standard IS 2142 : 2023 on the requirements and the methods of sampling and test for bromine intended for industrial purposes.

The Standard was originally published in 1973. 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.

There is no ISO standard on this subject.

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 bromine, the nature of hazards associated with it and essential information on storage, handling, packing, labelling, disposal of waste, cleaning and repair of containers, selection and training of personnel, protective equipment and first-aid.

1.2 This code 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

4.1 General Information

Bromine is a heavy, reddish-brown liquid that gives off a red vapour at room temperature. It is only non-metallic element that is liquid at room temperature.

4.1.1 *Chemical Name* — Bromine

4.1.2 *Common Name & Synonyms* — Diatomic bromide, Dibromine, elemental bromine and molecular bromine

4.1.3 *Uses*

Bromine serves as a starting material for a variety of products that are the building blocks for highly complex organic molecules that meet specific performance, environmental, and quality requirements. Bromine is utilized in many applications including flame retardants, agrochemicals, pharmaceuticals, fine chemicals, high performance rubber, polymers, biocides and energy storage, as well as in chemicals used by the oil and gas industries in completion fluids, and inorganic bromides for mercury control.

4.2 Identification

4.2.1 *Formula* — Br₂

4.2.2 *CAS Number* — 7726-95-6

4.2.3 *UN No.* — 1744

4.2.4 *UN Class* — 8 (6.1)

4.3 Physical Properties

4.3.1 *General*

4.3.2 *Molecular mass* — 159.81 g/mol.

4.3.3 *Physical State* — Liquid or dense fuming liquid, bromine is liquid at ordinary temperature.

- 4.3.4 Colour of liquid/Vapour** — Heavy reddish-brown.
- 4.3.5 Odour** — Sharp, pungent, suffocating (strong).
- 4.3.6 Boiling Point** — 58.8 °C.
- 4.3.7 Melting Point** — (-) 7.2 °C.
- 4.3.8 Freezing Point** — (-) 7.3 °C.
- 4.3.9 Vapour density** — 7.1 (air = 1)
- 4.3.10 Relative vapour density** — 5.52 at 15 °C (air = 1)
- 4.3.11 Specific Gravity Liquid (water = 1)** — 3.12 g/ml at 20°C
- 4.3.12 Viscosity at 20 °C** — 1.02 mPa.s
- 4.3.13 Vapour Pressure** — 175 mm Hg at 20 °C
- 4.3.14 Density** — 3.12 at 20 °C and 2.928 at 59 °C
- 4.3.15 Solubility of water** — 3.3 g/100 ml at 20 °C
- 4.3.16 Solubility in other solvents**

Bromine is easily soluble in diethyl ether, slightly soluble in water, and freely soluble in alcohol, chloroform, carbon disulfide, carbon tetrachloride, concentrated hydrochloric acid, and aqueous solution of bromides.

4.4 Chemical Properties

4.4.1 Reactivity

Bromine is incompatible with organic compounds containing active hydrogen atoms adjacent to the carbonyl group (aldehydes, ketones, carboxylic acids). They may react violently in unmoderated contact with bromine. It is also incompatible with diethyl zinc, potassium, germanium, rubidium, aluminum, mercury, titanium, liquid halogen, silane, acetylene, acrylonitrile, ammonia, dimethyl formamide, ethyl phosphine, hydrogen, isobutyrophenone, nickel carbonyl, nitrogen triiodide, ozone, oxygen difluoride, phosphorous, potassium, silver azide, sodium, sodium carbide, alkali hydroxides, arsenites, ferrous, mercurous salts, hypophosphites, and other oxidizable materials, saw dust, antimony, tin, boron, cesium acetylene carbide, chlorotrifluoroethylene, copper hydride, cuprous, acetylide, fluorine, lithium carbide, magnesium phosphide, phosphine, phosphorous oxide, phosphorus trioxide, rubidium acetylene carbide, rubidium carbide, sodium acetylene carbide, strontium phosphide, zirconium dicarbide, wood, cotton, straw. Bromine reacts violently in contact with natural rubber, but more slowly with some synthetic rubbers. Aluminum, mercury, or titanium react violently with dry bromine.

4.4.2 Polymerisation — No data available

4.4.3 Allotrope formation — No data available

4.4.4 Corrosion properties

Bromine is very corrosive to metals and tissue, and it can cause severe corrosion problems in stainless steel

4.5 Fire and Explosive Hazard Properties

4.5.1 Ignition Temperature — No data available

4.5.2 Auto Ignition Temperature — No data available

4.5.3 Flash Point — No data available

4.5.4 Upper Explosive Limit — No data available

4.5.5 Lower Explosive Limit — No data available

4.5.6 Fire Risk

4.5.6.1 Bromine itself is not combustible but enhances combustion of the other substances. Many reaction may cause fire or explosion. Bromine in its liquid or vapour form may react exothermically with reducing agents and organic matter such as wood, sawdust, cotton, straw, leading to fire or violent reaction.

4.5.6.2 Bromine may react violently with antimony, boron, cesium, acetylene, carbide, chloro-fluoro-ethylene, copper hydride, cuprous acetylide, fluorine, germanium, lithium carbide, carbide magnesium phosphide, phosphine, phosphorus, phosphorus oxide, phosphorus trioxide, rubidium, acetylene carbide, rubidium carbide and sodium acetylene carbide, strontium phosphide and zirconium di-carbide leading to fire or explosion.

4.5.6.3 It combines readily with potassium, phosphorus and tin, and reaction may be accompanied by spontaneous ignition.

4.5.6.4 *Special remarks on explosion hazards*

4.5.6.4.1 It reacts explosively with acetylene, acrylonitrile, ammonia, dimethyl formamide, ethyl formamide, ethyl phosphine, hydrogen, iso-butyrophenone, nickel carbonyl, nitrogen tri-iodide, ozone, oxygen difluoride, phosphorus, potassium, silver azide, sodium and sodium carbide.

4.5.6.4.2 Lithium is stable in contact with dry bromine, but heavy impact will initiate explosion, while sodium in contact with bromine needs only moderate impact for initiation. Potassium ignites in bromine vapor and explodes violently in contact with liquid bromine and rubidium ignites in bromine vapor. During preparation of praseodymium bromide, accidental contact of liquid bromine with small particles of praseodymium led to a violent explosion.

5 HAZARDS ASSOCIATED WITH BROMINE

5.1 General Information

5.2 Routes of Entry

5.2.1 Skin

Bromine is highly corrosive in nature. It may be fatal upon contact with the skin. Corrosive materials can cause severe burns, blisters, ulcers, and permanent scarring, depending on the concentration of the solution and the duration of exposure. If skin exposure is not immediately treated, it can lead to tissue destruction and slow-healing ulcerations. Direct contact with the skin results in pain, redness, and skin burns.

5.2.2 Eyes

Bromine is highly corrosive. Even low concentrations of its vapor (less than 1 ppm) are very irritating to the eyes, causing inflammation and lachrymation. Corrosive materials can produce severe eye burns and permanent damage, including blindness, depending on the concentration of the solution and the duration of exposure.

5.2.3 Ingestion

In the unlikely event of bromine ingestion, it can cause severe and permanent damage to the digestive tract, including gastrointestinal burns. It may also lead to liver and kidney damage, perforation of the digestive tract, and cardiac disturbances. Additionally, it may affect the central nervous system and cause systemic effects. Symptoms may include nausea, vomiting, diarrhea (possibly with blood), and other complications.

5.2.4 Inhalation

Bromine is highly corrosive and toxic and may be fatal if inhaled. The concentration of bromine ≥ 10 ppm can cause severe respiratory irritation with mucous secretion in upper airways, coughing, nosebleeds, respiratory difficulties, dizziness, and headache. Prolonged or high exposure to vapours may cause respiratory failure, pulmonary edema, and pneumonia. Bromine is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Bromine exposure may result in spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis and pulmonary edema. Low concentrations of bromine vapor cause irritation, tearing, and inflammation of the eyes.

5.2.5 Long term effects

Long term exposure may have negative effects on the respiratory and male reproductive systems.

5.3 Toxicity Information

- a) Threshold Limit Value (TLV) — 0.1 ppm
- b) Short Term Exposure Limit (STEL) — 0.2 ppm

- c) Immediately Dangerous to life or Health (IDLH) — 3 ppm
- d) Lethal Dose LD₅₀ (Rat) Oral — 2.600 mg/kg
- e) Lethal Dose LD₅₀ (adult) Oral — 1 ml
- f) Inhalation (Female Mouse) Lethal Concentration — 0.1427 duration 4 h

5.4 Antidote

There is no specific antidote for bromine. Treatment of bromine poisoning is symptomatic and supportive. Only specific symptomatic treatment is required, such as 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

Bromine in its both as a liquid or as a vapour, acts as a local irritant and corrosive, it is very hazardous in case of skin contact (corrosive). Hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of ingestion, of inhalation.

5.5.1 Signs and Symptoms

Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist 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

Bromine has excellent warning properties and systemic intoxication is unlikely. Lachrymation is caused by concentrations less than 1 ppm, while 10 ppm concentration would cause extreme upper respiratory irritation which will not be voluntarily borne. Concentrations of 40 ppm to 60 ppm are dangerous to life on exposure for 0.5 h to 1 h, those of 500 ppm to 1 000 ppm are rapidly fatal to short exposure. If bromine vapours are present in a confined space, severe respiratory tract injury may result followed by pulmonary edema, pneumonia and respiratory failure.

5.5.2.2 Local effects

Liquid bromine produces a mild cooling sensation on first contact with the skin. This is followed by sensation of heat. If bromine is not removed immediately the skin becomes red and finally brown. Such a contact will result in destruction of the skin area involved and development of an indolent, slow healing ulcer. Bromine is especially hazardous to the tissues of the eyes, severely painful and destructive burns may result from contact with either liquid or concentrated vapour.

5.5.3 Chronic Toxicity

Because of the extremely irritating nature and intolerability to body tissues, chronic systemic poisoning or local effects are unlikely.

6 PERSONAL PROTECTIVE EQUIPMENT (PPE)

6.1 Availability and Use

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 bromine, 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.

6.2 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 bromine coming in contact with the eyes. Goggles should be carefully fitted (*see* IS 8520).

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 bromine 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 bromine is needed.

6.2.2 *Head Protection*

'Hard' hats should be worn where there is danger from falling objects. If hard hats are not considered necessary, soft-brimmed hats or caps may be worn to give protection against overhead leaks. Safety helmets (*see* IS 2925) should be worn where there is danger from falling objects.

6.2.3 *Foot and leg Protection*

Leather or rubber safety shoes with built-in steel toe caps are recommended. Rubbers may be worn over leather safety shoes. Leather shoes should be discarded after any contact with bromine (*see* IS 10667). PVC blend boots or safety footwear [IS 15298 (Part 2)] should be used while handling bromine.

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. The suitable body protective gear for handling bromine are given in IS 2925.

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 bromine.

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 bromine.

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 bromine. It should be thoroughly decontaminated and cleaned before re-use.

6.3 *Respiratory Equipment*

Severe exposure to bromine 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, inspected, cleaned and sterilized at regular intervals, and always before and after use by another person.

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 10254 (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 provided 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, vapours, 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 Air-Line Masks [*see* IS 10254 (Part 3)]

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.

6.3.4 Industrial Canister Type gas masks

Equipped with full face pieces fitted with the proper canister for absorbing bromine vapour. 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 vapour concentration is unknown and also an oxygen deficiency may exist. The wearer must be warned to leave the contaminated area immediately on detecting the odour of a harmful vapour. This may indicate that the mask is not functioning properly, that the vapour concentration is too high, that the canister is exhausted or that the mask is not properly fitted.

6.3.5 Chemical Cartridge Respirators

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

7 STORAGE, HANDLING, LABELLING AND TRANSPORT

7.1 General

7.2 Storage

Bromine is usually stored in lead lined steel containers and nickel drums or in glass bottles. Earthenware, stoneware and Monel metal containers may also be used for storage of bromine.

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 Bromine should be stored in a cool well-ventilated area avoiding direct sunlight. The temperature of storage area should not go below — 7 °C to prevent freezing.

7.2.3 Bromine should be stored away from other chemicals and organic chemicals.

7.2.4 Bromine vapours from reaction vessels or storage tanks should be vented through an alkali absorber preferably kept under constant pressure. The vent line should be purged with dry air.

7.2.5 Electrical fittings in area where bromine vapours are likely to be present should be able to withstand the corrosive effect and should be of vapour proof construction, wiring being in tight, rigid metal conduits.

7.2.6 Glass or porcelain piping, free from stresses or strains, is highly satisfactory with polytetrafluoroethylene (PTFE) and asbestos sheathed gaskets on flange joints.

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

7.2.8 Store drum, tank truck or ISO quantities of bromine in lead or lead-lined steel tanks, which feed to the process or reaction. For larger storage vessels where bottom outlets cannot be used, pump bromine out of the tank with nickel or plastic pumps. Contact your supplier representative for specific recommendations.

7.2.9 Protect storage tanks from moisture or humid air as bromine will absorb moisture from the air. When exposed to air having a normal summer dew point of 5 °C to 10 °C (40 °F to 50 °F), bromine will equilibrate at about 70 – 80 ppm water. Bromine this wet can cause severe corrosion of many metals. Keep a slight positive pressure (0.1 inch of H₂O) on the storage tanks by purging with dry (-40 °C/ -40 °F dew point) air or nitrogen into the tank.

7.2.10 The amount of bromine 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.

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

7.2.12 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 bromine spills and pump away collected rainwater and fire-fighting water. The fire-fighting water should be prevented from contaminating water sources.

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

7.2.14 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.

7.2.15 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.

7.2.16 The bromine ISO tanks should not be stored within 10 m from human or animal foodstuffs. The explosives and flammable substances should not be stored in vicinity of bromine.

7.2.17 Full bromine ISO tanks may be stacked 2 high in such a manner that each receptacle can be inspected without having to move other receptacles. Empty ISO tanks may be stacked 3 high.

7.2.18 The concrete surface under the ISO tank storage positions should have a slope running to a drain channel located at the side of the storage area.

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

7.2.20 The external storage should be concreted. The concrete should be of adequate thickness to withstand the use of lifting equipment and capable of bearing the point loading from the stock.

7.2.21 Storage bays should be clearly marked and either remote from vehicle access routes or protected from vehicular impact by walls or crash barriers. The storage arrangement should comply with relevant local regulations if applicable.

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

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

7.2.24 There should be not confined spaces in the vicinity of the storage facility or bromine handling units, to avoid accumulation of bromine and bromine vapour in them.

7.2.25 The bromine should be stored under dry nitrogen or dry air to prevent moisture being absorbed, and to prevent corrosion. Suitable material for handling bromine are glass, lead for moist bromine and nickel and its alloy for dry bromine. Mild steel and stainless steel are not recommended for bromine handling as they are prone to corrosion.

7.2.26 The bromine tank should be cleaned periodically with nitrogen.

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 bromine and of appropriate first-aid measures.

7.3.1.2 Exhaust hoods and ventilation should be adequate to maintain the concentration of bromine vapour in the work area below 0.1 ppm. Air analyses will be necessary for proper control.

7.3.1.3 Safety showers and eye-wash fountains 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 bromine without available assistance in the area.

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

7.3.1.6 Storage and operations should be over drip pans draining to a sump.

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 vapours into inhabited areas.

7.4 Labelling

7.4.1 Each container (including tankers) shall carry an identifying label or stencil as specified in Fig. 9 and Fig. 15 of IS 1260 (Part 1) or **Label Model 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.

Corrosive Handle with Care

7.5 Transport

7.5.1 Unloading Tank

7.5.1.1 When connecting, disconnecting or inspecting the receptacle flanges, a full-face gas mask should be worn together with other protective equipment such as polyvinyl chloride (PVC) gauntlets and apron. There should be another personnel to observe the activity from a safe remote location to call for assistance, in case of emergency.

7.5.1.2 The cleaning of bromine-spotted receptacles should not be done with quick drying organic solvents.

7.5.1.3 In case bromine receptacles are not in use, the valves should be closed, and the gaskets and blind flanges should be replaced. The valve dome cover should be closed and pinned to prevent accidental opening.

7.5.1.4 Ensure that road or rail vehicles cannot be moved during a transfer operation.

7.5.1.5 An elevated unloading platform can be provided which will give protected access to ISO tank unloading valves during the unloading operation.

7.5.1.6 Provide handling devices to assist in the manipulation of unloading arms or hoses.

7.5.1.7 Bromine tanks can be unloaded under pressure, by vacuum, or with unloading pumps.

7.5.1.8 If the installation has three connecting lines, one for the transfer of the liquid bromine, one for use as a pressurizing connection and one to be used as a vent connection, then the three ISO tank valves are connected as indicated.

7.5.1.9 The vent connections and the pressurizing valve with its piping should be bromine resistant to prevent corrosion by diffusion of bromine back into the pressurizing or venting systems.

7.5.1.10 The use of nitrogen as the padding medium may lead to frothing when the gas comes out of solution. At 1 bar gauge nitrogen pressure, approximately one volume of nitrogen gas dissolves in one volume of liquid bromine.

7.5.1.11 For unloading under vacuum, the liquid bromine unloading line and the bromine receiving tank are put under vacuum. Then the bromine is siphoned over. This alleviates the necessity of pressurizing and its possible dangers.

7.5.1.12 A sight glass in the liquid bromine unloading line is helpful to observe that liquid flow is taking place. No flow indication is a sign that the unloading has been completed or that there is some difficulty that has to be corrected.

7.5.1.13 The bromine should be filled into tanks at 88 percent to 92 percent of the tank volume, as bromine is heavy in nature. This is to prevent the bromine from surging and causing the unit to become unstable.

7.5.1.14 The transport of bromine is only allowed via approved pre-determined routes. These routes should be notified to the emergency services in that area for emergency response/training purposes.

7.5.1.15 Major truck roads are to be used apart from collection/delivery points and avoid urban or densely populated areas if possible by use of by-passes or ring roads (beltways). 'Black-spots' should be avoided wherever possible and avoid peak times where volume of traffic causes congestion.

7.5.3 Driver

7.5.3.1 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.

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

7.5.3.3 Driver should carry TREM card when vehicle is on road.

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

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

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

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

NOTE — If transport of the hazardous chemical is involved it shall be carried out in accordance with the *Central Motor Vehicles Rules, 1989*. 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 General

8.2 Spillage

8.2.1 General Information

8.2.1.1 In the case of bromine spillage, ammonia gas vapours should be released to the area from a safe distance.

CAUTION — Only anhydrous ammonia gas should be used for vapor decontamination. Violent reaction may follow the mixing of aqueous ammonia and liquid bromine.

8.2.1.2 Hypo solution, lime water slurry, or soda ash solution may be poured over a liquid bromine spill on the floor. The bromine and neutralizer should be washed to the sump or sewer with a cold-water hose. (Hypo solution is prepared by dissolving 220 g of technical sodium thiosulphate in a litre of water and adding 100 g of soda ash. The solution will remain stable for four to six weeks.)

8.2.1.3 Until decontamination is complete, a mild ammonia atmosphere should be maintained. Doors and windows may be opened to remove the white clouds of ammonium bromide formed.

8.2.2 Glass Bottles

Hermetically-sealed glass containers should be first cooled and then opened with extreme caution.

8.2.2.1 The lead cap should be loosened cautiously and taken off the bottle. Mechanical means of siphoning instead of mouth suction should be used to siphon bromine from the bottle.

8.2.3 *Land Spill (Spill on land)*

8.2.3.1 The materials like clay, sand, or soil should be used to confine bromine to the already contaminated area.

8.2.3.2 Do not use spill pillows or other fibrous materials for containment as they may increase the potential for fire.

8.2.3.3 The pooled bromine should be gently covered with a thin layer of water to minimize bromine vapor emission. While adding water, do not agitate the bromine pool as this will cause excessive vapor.

8.2.3.4 The thick covering of hydrated limewater slurry should be placed over the bromine which will slowly neutralize the bromine and stop vapor emissions.

8.2.3.5 If the soil has already absorbed the bromine, work lime deep into the ground with water. For large spills, earth moving equipment may be required.

8.2.3.6 If there has been a bromine spillage, wash it off the ISO-container with plenty of water to prevent corrosion. Small bromine spills on the ground may be neutralized with a clear soda ash or a sodium thiosulphate solution. Then dispose of it in a manner approved by the local authorities.

8.2.3.7 When handling a leaking bottle, drum, or cylinder of bromine, personal protective clothing, goggles, and equivalent approved self-contained breathing equipment should be worn.

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

8.2.3.9 The slight ammonia atmosphere should be used throughout the cleanup. Carefully release anhydrous ammonia gas to neutralize bromine vapor, but do not over apply anhydrous ammonia.

8.2.3.10 Using cold water, wash neutralized bromine into a sump for transfer to an approved waste disposal facility where the waste can be processed.

8.2.3.11 Ventilate the area to remove the ammonium bromide and any bromine fumes.

8.3 **Leakages**

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

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

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

8.3.4 The properly protected and trained personnel should attempt to stop the leak, using emergency repair materials (i.e. wooden cones, lead wool, etc.), or by freezing the bromine at the escape opening.

8.3.5 If the bromine is leaking out from between flanges, the personnel should follow the troubleshooting recommendations in section to contain a bromine spill on the ground, earth or sandbag dams should be built around the spill and the contained bromine neutralized with dry soda ash or a slaked lime $\text{Ca}(\text{OH})_2$ water slurry.

8.4 **Tank Cleaning and Repairs**

8.4.1 The hazardous nature of tank inspection, cleaning or repairs requires that the foreman and crew be selected and trained carefully. They should be thoroughly familiar with the hazards, and safeguards necessary for the safe performance of the work. Written approval should be secured from the plant supervisor before the work is started. All tank work should be done under direct supervision.

8.4.2 Pipelines into or out of the tank or other equipment should be shut off, disconnected, and a blank flange should be installed for protection against leaks and errors. Valves and cocks in the pipe line should not be relied upon.

8.4.3 Lock electrical switches in the off position, remove drive belts, and otherwise completely safeguard against accidentally starting the agitating equipment or other moving parts located inside the tank or adjacent to the entrance.

8.4.4 Before entering a tank and during the work, tests should be made by a qualified person to determine that no further washing is necessary, that no oxygen deficiency exists, and that no harmful gas or vapour is present. The tank should be purged continuously with an air stream during all work within the tank.

8.4.5 Proper personal protective equipment should be worn by anyone entering a tank for inspection, cleaning, or repairs.

8.4.6 One man on the outside of the tank should keep the men in the tank under constant observation and at least two other men should be available to aid in the rescue, if any, of those in the tank are overcome.

8.4.7 A hose mask, an airline mask or self-contained breathing apparatus together with rescue harness and life line should be located outside the tank entrance.

8.4.8 The portable electric lights and power tools should be of the three wire, grounded type.

8.4.9 Additional precautions are recommended as follows:

- a) Neutralize the bromine within the tank with Sodium thiosulfite or Soda solution,
- b) Drain tank as completely as possible,
- c) Wash thoroughly with large quantities of water, and
- d) Dry completely tank by blowing with warm dry air.

8.5 Waste Disposal

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

8.5.2 Dilute and neutralize before disposal as indicated in **8.5.2.1** to **8.5.2.6**.

8.5.2.1 In the case of bromine spillage, ammonia gas vapours should be released to the area from a safe distance.

CAUTION: Only anhydrous ammonia gas to be used for vapour decontamination. Violent reaction may follow the mixing of aqueous ammonia and liquid bromine.

8.5.2.2 Hypo solution and a lime and water slurry or soda ash solution may be poured over a liquid bromine spill on the floor. The bromine and neutralizer should be washed to the sump or sewer with a cold water hose.

8.5.2.3 Until decontamination is complete a mild ammonia atmosphere should be maintained. Doors and windows may be opened to remove the white clouds of ammonium bromide formed.

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

8.5.2.5 Brominated hazardous waste shall be collected and temporarily stored in non-reactive drums/bags under the dedicated hazardous waste storage area and be sent to authorized facility within 90 days from generation of the waste in accordance with the authorization issued by the concerned SPCB.

8.5.2.6 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

Good ventilation should be maintained at all times in all locations where bromine 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 the threshold limit of one-tenth (0.1) ppm, which is considered safe for repeated 8 h exposures.

9.2 Fire Fighting

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

10 TRAINING

10.1 Safety in handling bromine 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 bromine 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 bromine is being handled.

10.2 Before being placed on the job, all new employees should be instructed thoroughly for the proper handling of bromine. 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.

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 bromine.

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 know what to do in emergency and the first-aid measures and should realize the necessity for the prompt application of first-aid in case of contact with bromine or exposure to the vapours of the burning material.

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 bromine liquid or vapours. 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 bromine 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

Diseases of the heart or lungs should exclude an employee from working with bromine.

11.2 First Aid

11.2.1 General

11.2.1.1 If bromine is accidentally spilled on skin, the area should be promptly washed, if necessary, under safety shower and a paste of sodium bicarbonate may be applied to the affected area.

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

11.2.1.3 In case of inhalation, the person should be removed from the toxic atmosphere promptly to open air and all constricting cloth about neck should be loosened. The patient should be kept warm and oxygen administered.

11.2.1.4 A medical specialist should be summoned at once in all cases.

11.2.2 Contact with Skin

In case of contact, immediately flush skin with plenty of water. Get medical attention. Flood skin with the water, directing a stream of water under the clothing while they are being removed. Wash skin with mild soap and plenty of water for at least 15 min. Get medical attention immediately. No decontamination other than water should be used on humans. Avoid reusing contaminated clothing.

11.2.3 Contact with Eyes

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 min and get medical attention immediately.

11.2.4 Ingestion

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

11.2.5 Inhalation

Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing. Get medical attention immediately.

11.2.6 First-Aid Kit

There is no specific antidote for bromine. Treatment is symptomatic and supportive. Only specific symptomatic treatment is required, monitoring of ECG and vitals should be continued. No neutralizing compound recommended. Investigations such as endoscopy, chest x-ray, and abdominal barium x-rays are recommended. A medical specialist should be summoned at once in all cases. After initial first aid measures are completed, keep the person quiet, warm, and upright. Provide emergency personnel with information about all materials used by the person, appropriate information about bromine and first aid procedures.

ANNEX A

(Clause 2)

LIST OF REFERRED STANDARDS

<i>IS No.</i>	<i>Title</i>
IS 1260 (Part 1) : 1973	Pictorial markings for handling and labelling of goods Part 1 Dangerous goods (<i>first revision</i>)
IS 2925 : 1984	Specification for industrial safety helmets (<i>second revision</i>)
IS 4155: 2023	Glossary of terms relating to chemical and radiation hazards and hazardous chemicals (<i>first revision</i>)
IS 4167: 2020	Glossary of terms relating to air pollution (<i>second revision</i>)
IS 8519 : 2024	Guide for selection of occupational protective clothing — Body protection (selection, care, and maintenance) (<i>first revision</i>)
IS 8520 : 2023/ ISO 19734 : 2021	Eye and face protection — Guidance on selection, use, and maintenance (<i>first revision</i>)
IS 10245 (Part 1) : 1996	Breathing apparatus Part 1 Closed circuit breathing apparatus (compressed oxygen cylinder) — Specification (<i>first revision</i>)
IS 10245 (Part 1) : 2023	Respiratory Protective Devices - Specification : Part 2 self-contained open circuit breathing apparatus (<i>second revision</i>)
IS 10667 : 1983	Guide for selection of industrial safety equipment for protection of foot and leg
IS 15803 : 2008	Respiratory protective devices — Self-contained closed circuit breathing apparatus chemical oxygen (KO ₂) type, self-generating, self-rescuers — Specification
IS 18149: 2023	Transportation of dangerous goods – Guidelines