

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

(Not to be reproduced without permission of BIS or used as an Indian Standard)

Draft Indian Standard

Code of Safety for Cryogenic liquid

Part 6 Liquid Krypton

(First Revision of IS 5931)

भारतीय मानक मसौदा

क्रायोजेनिक तरल के लिए सुरक्षा संहिता

भाग 6 तरल क्रीप्टोन

(पहला पुनरीक्षण)

(ICS 71.100.20)

Chemical Hazards Sectional Committee, CHD 07

Last Date of Comment: 21.07.2024

FOREWORD

(Formal clause to be added later)

Handling liquid krypton safely is largely a matter of knowing their properties and using suitable procedures based on that knowledge. There are a number of general precautions and safe practices which shall have to be observed because of extremely low temperatures and high rates of conversion into gas of the liquid krypton mentioned in this standard. There are also certain specific precautions which shall have to be followed where a particular liquid may react with contaminants or may present a hazard to life.

The elimination of accidents is vital to public interest. Accidents produce social and economic 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. Apart from general precautions, some typical precautions are required to be taken during manufacture, storage and handling of liquid krypton. The standard also prescribes safety measures for controlling hazards and essential

information on symptoms of poisoning, first-aid, medical treatment, storage, handling, labelling and employee safety. This standard is intended to guide the users in the recognition of these hazards and in establishing safe handling procedures.

BIS has published a standard IS 5931: 1970 'Code of Safety for Handling of Cryogenic Liquids'. During the revision, considering the bulkiness of the standard, and recognizing the need for clarity, the committee decided to restructure it by splitting into various parts based on type of cryogenic liquids.

This (Part 6) prescribes a code of safety concerning hazards relating to liquid krypton. It describes the properties and essential information for the safe handling and use of liquid krypton, safety measures for controlling hazards and essential information on symptoms of poisoning, first-aid, medical treatment, storage, handling, labelling and employee safety.

The other parts of this standard are as following:

Part 1 Liquid Oxygen (*first revision*)

Part 2 Liquid Nitrogen (*first revision*)

Part 3 Liquid Argon (*first revision*)

Part 4 Liquid Helium (*first revision*)

Part 5 Liquid Hydrogen (*first revision*)

Part 7 Liquid Neon (*first revision*)

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

SCOPE

1.1 This code describes the properties of krypton, the nature of hazards associated with it and the essential information on storage, handling, packing, labelling, and disposal of waste, cleaning and repair of containers, training of personnel, selection of personal protective equipment and first aid.

1.2 This code does not deal with the specifications for design of buildings, chemical engineering plants, storage vessels and equipment for operations control and waste disposal.

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, 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 standards given at below:

| <i>IS No.</i> | <i>Title</i> |
|---------------|--------------|
| | |

| | |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| IS 1260 (Part 1): 1973 | Pictorial marking for handling and labelling of goods: Part 1 Dangerous Goods |
| 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 8520: 2023 | Guide for selection of industrial safety equipment for eye, face and ear protection |
| IS 15298 (Part 2) : 2016/ISO 20345: 2011 | Personal protective equipment: Part 2 safety footwear (<i>second revision</i>) |

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 4155 shall apply.

4 PROPERTIES

4.1 General Information

4.1.1 Krypton is a colorless and odorless inert gas and make up to 1 ppm of the earth's atmosphere. It offers longer life spans and greater illumination for lighting in halogen bulbs. It is used as measurement tool using a radioactive isotope to determine decay rates.

4.1.2 *Chemical Name* - Krypton

4.1.3 *Common Name & Synonyms* - Kr

4.1.4 *Uses*

Krypton is most commonly used in its gaseous state. Krypton is a colorless and odorless inert gas and make up to 1 ppm of the earth's atmosphere. It offers longer life spans and greater illumination for lighting in halogen bulbs. It is used as measurement tool using a radioactive isotope to determine decay rates.

4.2 Identification

4.2.1 *Formula* – Kr

4.2.2 *CAS Number* - 7439-90-9

4.2.3 *UN Number* - 1056

4.2.4 *UN Class* - 2.2

4.3 Physical Properties

4.3.1 *General*

Krypton is colorless, odorless, non-flammable, oxidizing and extremely cold.

4.3.2 Molecular Mass — 83.798 gm/mol

4.3.3 Physical State — gas

4.3.4 Colour — colorless

4.3.5 Odour — odorless

4.3.6 Boiling Point — (-) 153.4 °C

4.3.7 Melting Point — (-) 157.2 °C

4.3.8 Gas Density (Air=1) — 2.9 (air = 1) Heavier than air.

4.3.9 Solubility in Water — 221 mg/l.

4.4 Chemical Properties

4.4.1 Reactivity

Krypton is highly chemically unreactive gas but reacts violently with fluorine.

4.4.2 Polymerization – Under normal conditions of storage and use, hazardous decomposition products are not produced.

4.4.5 Incompatible Materials — No data available.

4.5 Fire and Explosion Hazard Properties

4.5.1 Ignition Temperature – Not Available

4.5.2 Auto Ignition Temperature – Not Available

4.5.3 Flash Point – Not Available

4.5.4 Upper Explosive Limit - Not Available

4.5.5 Lower Explosive Limit - Not Available

4.5.6 Fire Risk — Not Available

5 HEALTH HAZARD & TOXICITY INFORMATION

5.1 General Information

5.2 Routes of entry

5.2.1 Skin

No potential harm to skin. On contact with the expanding gas may cause frostbite to unprotected skin. It can asphyxiate by displacement of air

5.2.2 Eyes

On exposure to krypton there is no harmful impact on eyes. On contact with rapidly expanding gas may cause burns or frostbite.

5.2.3 Ingestion

An unlikely route of exposure.

5.2.4 Inhalation

Asphyxiation due to lack of oxygen. Moderate concentration may cause headache, drowsiness, dizziness, excitation, excess salivation, vomiting, and unconsciousness. Lack of oxygen can kill.

5.4 Antidote

No antidote for krypton poisoning. Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been inhaled.

6 PERSONAL PROTECTIVE EQUIPMENT

6.1 Availability and Use

While personal protective equipment is not an adequate substitute for good, safe working conditions, adequate ventilation and intelligent conduct on the part of employees working with krypton 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 maybe exposed to danger.

6.2 Non-Respiratory Equipment

6.2.1 Eye and face Protection

Eyes are most sensitive to the rapidly expanding krypton and its vapors. The recommended personal protective equipment when handling or using krypton is a full face shield over safety goggles (*see* IS 8520) necessary to avoid exposure to liquid splashes, mists, gases or dusts.

6.2.2 Head Protection

Safety helmet with face shield is recommended while handling the krypton (*see* IS 2925).

6.2.3 Foot and leg Protection

Safety shoes are recommended when handling cylinders (*see* IS 15298 (Part 2)).

6.2.4 Body, Skin and Hand Protection

6.2.4.1 Wear work gloves when handling gas containers. If the operation involves possible exposure to a cryogenic liquid, wear loose fitting thermal insulated or cryo-gloves.

6.2.4.2 Never allow any unprotected part of the body to touch uninsulated pipes or vessels which contain cryogenic fluids. The extremely cold metal will cause the flesh to stick fast and tear when one attempts to withdraw from it. Safety shoes are recommended when handling cylinders

6.3 Respiratory Equipment

Severe exposure to krypton may occur in tanks during equipment cleaning and repairs, during decontamination of areas following spills, or in case of failure of piping or equipment. Employees who may be subject to such exposures should be provided with proper respiratory protection.

7 STORAGE, HANDLING, LABELLING AND TRANSPORT

7.1 General

Krypton should be stored away from the direct sunlight in a dry, cool and well-ventilated area away from the incompatible material.

7.2 Storage

7.2.1 Do not change or force fit connections.

7.2.2 Always keep container in upright position.

7.2.3 Close valve after each use and when empty.

7.2.4 Use insulated hose and piping to prevent condensation of oxygen-rich liquid air. Use a back flow preventative device in the piping.

7.2.5 Do not allow storage temperature to exceed 52 °C (125 °F). Containers should be stored in a purpose build compound which should be well ventilated, preferably in the open air.

7.2.6 Full containers should be stored so that oldest stock is used first. Do not store in a confined space. Full and empty cylinders should be segregated. Store containers in location free from fire risk and away from sources of heat and ignition.

7.2.7 Return empty containers in a timely manner. Stored containers should be periodically checked for general condition and leakage. Protect containers stored in the open against rusting and extremes of weather.

7.2.8 Containers should not be stored in conditions likely to encourage corrosion. Cryogenic containers are equipped with pressure relief devices to control internal pressure. Under normal conditions these containers will periodically vent product. All vents should be piped to the exterior of the building. Observe all regulations and local requirements regarding storage of containers.

7.3 Handling

7.3.1 Krypton shall be stored and used only in a well-ventilated place. If enough krypton gas evaporates from the liquid in an unventilated space, the percentage of oxygen in the air may become dangerously low making anybody present there, symptoms, such as dizziness,

unconscious without any warning. Remaining in this atmosphere long enough may become fatal.

7.3.2 Krypton build-up is most likely to occur when a room is closed, overnight for example. If there is any doubt about the amount of oxygen in a room, the room shall be ventilated completely before entering it. Waste krypton shall not be disposed of in a confined area or a place where someone else may enter.

7.3.3 Krypton is colder than liquid oxygen. Therefore, if it is exposed to the air, oxygen from the air may condense into the liquid krypton. If this is allowed to continue for any length of time, the oxygen content of the krypton may become appreciable and the liquid will require the same precautions as for handling liquid krypton. However, most liquid krypton containers are entirely closed except for a small neck area and the krypton gas issuing from the surface of the liquid forms a barrier which keeps air away from the liquid and prevents oxygen contamination.

7.3.4 Before entering any large liquid krypton storage tank, it shall be made sure that all pipes to the tank are blanked or positively closed off. The tank shall then be purged with air. If a check with instruments shows that the atmosphere normal air, it shall be safe to enter. Unless all lines are physically isolated, inside atmosphere shall be checked frequently with instruments during work. If, for any reason, the supply of fresh air in the tank is doubtful, breathing apparatus shall be used with its own supply of oxygen or air. Whenever anybody enters a tank, he should make sure that he is equipped with a life line and that an observer is stationed outside to check on his reactions while working. It is a good practice to have the ventilating equipment rapidly changing the air in tanks at all times when personnel are working inside them.

7.3.5 Only experienced and properly instructed persons should handle compressed gases/cryogenic liquids.

7.3.6 Do not remove or deface labels provided by the supplier for the identification of the cylinder contents.

7.3.7 Before connecting the container, check the complete gas system for suitability, particularly for pressure rating and materials.

7.3.8 Before connecting the container for use, ensure that back feed from the system into the container is prevented. Close container valve after each use and when empty, even if still connected to equipment. Never attempt to repair or modify container valves or safety relief devices. Damaged valves should be reported immediately to the supplier.

7.3.9 If user experiences any difficulty operating cylinder valve discontinue use and contact supplier. Do not remove or interchange connections. Ensure the complete gas system has been checked for leaks before use. Prevent entrapment of cryogenic liquid in closed systems not protected with relief device. A small quantity of liquid produces large volumes of vaporized gas at atmospheric pressure.

7.3.10 Containers used in shipment, storage, and transfer of cryogenic liquid are specially designed, well-insulated containers equipped with a pressure relief device and valves to control pressure. Under normal conditions, these containers will periodically vent product to limit pressure buildup. Ensure that the container is in a well-ventilated area to avoid creating an oxygen-deficient atmosphere.

7.3.11 Use adequate pressure relief in systems and piping to prevent pressure buildup; liquid in a closed container can generate extremely high pressures when vaporized by warming. Employ suitable pressure regulating devices on all containers when the gas is being emitted to systems with lower pressure rating than that of the container. Only transfer lines designed for cryogenic liquids shall be used.

7.3.12 Do not subject containers to abnormal mechanical shock. When moving cylinders, even for short distances, use a cart (trolley, hand truck, etc.) designed to transport cylinders. When doubt exists as to the correct handling procedure for a particular gas, contact the supplier.

7.3.13 Krypton is extremely cold. Cryogenic liquids and their vapours can rapidly freeze human tissue and can cause many common materials such as carbon steel, rubber, and plastics to become brittle or even break under stress.

7.3.14 Krypton is extremely cold. Cryogenic liquids and their vapours can rapidly freeze human tissue and can cause many common materials such as carbon steel, rubber, and plastics to become brittle or even break under stress.

7.3.15 All cryogenic liquids produce large volumes of gas when they vaporize. A cryogenic liquid cannot be indefinitely maintained as a liquid, even in well-insulated containers.

7.3.16 Always handle cryogenic liquids carefully. Their extremely low temperatures can produce cryogenic burns of the skin and freeze underlying tissue.

7.3.17 When spilled on a surface, they tend to spread as far as the quantity of liquid spilled and the physical confines of the area permit.

7.3.18 They can cool large areas. The vapors coming from these liquids are also extremely cold and can produce burns.

7.4 Labelling

7.4.1 Each container (including tankers) should carry an identifying label or stencil as depicted in Fig. 2 in IS 1260 (Part 1). The storage containers shall be labelled or marked to identify as follows:

- a) Contents of the container;
- b) Name and address of the manufacturer or importer of the hazardous chemical; and
- c) 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 Manufacturers name with label warnings required by regulations or ordinances form part of the label or placard.

7.5 Transport

7.5.1 The vessel for transporting shall always be fitted with adequate relief devices. General precautions to be observed for both full and empty vessels are as follows:

- a) Container shall be kept vertical.

- b) Containers are not to be rolled-on a tilted axis (milk churning).
- c) Sudden mechanical shocks shall be avoided.
- d) Immediately before transport, it should be made sure that the vents are free from blockage and that the relief devices are in working order.
- e) If the container is of the type which requires liquid nitrogen shielding, it should be ensured that the liquid nitrogen reservoir is full.
- f) It should be ensured that gas is following from the vent immediately after the filled vessels are received and daily thereafter.
- g) With containers of the liquid nitrogen jacketed type, liquid nitrogen reservoir is to be topped up daily.
- h) Proper filling and transfer tube equipment shall be used.
- i) A brass or copper rod shall be kept available for freeing any solid gas blockage. To use, slide the rod gently down to the plugged area, exerting only sufficient force to free the obstruction.
- j) Recipients of krypton should designate staff familiar with liquid handling techniques to be responsible for ensuring that correct handling procedures are adopted.
- k) In any unusual emergency, the krypton suppliers shall be contacted immediately.

7.5.2 Driver

Only driver trained in handling should be employed for transportation of krypton. Driver should carry TREM card, material Safety Data Sheet and other legal documents for safety needs when vehicle is on road.

8 SPILLAGE, LEAKAGE AND WASTE DISPOSAL

8.1 General

All personnel attending to spill/leak should use proper personal protective equipment and firefighting equipment while handling.

8.2 Spillage

8.2.1 Evacuate personnel to safe areas. Ventilate the area. Monitor oxygen level. Wear self-contained breathing apparatus when entering area unless atmosphere is proved to be safe.

8.2.2 Prevent further leakage or spillage. Prevent from entering sewers, basements and work-pits, or any place where its accumulation can be dangerous. Do not discharge into any place where its accumulation could be dangerous.

8.2.3 Ventilate the area.

8.2.4 If possible, stop flow of product. Increase ventilation to the release area and monitor oxygen level. Vapor cloud may obscure visibility. Do not spray water directly at leak. If leak is from cylinder or cylinder valve, call the emergency telephone number. If the leak is in the user's system, close the cylinder valve and safely vent the pressure before attempting repairs.

8.3 Waste Disposal

8.3.1 Return unused product in original cylinder to supplier. Contact supplier if guidance is required.

8.3.2 Small amounts may be allowed to evaporate into the atmosphere. In case of large spills consult an expert and allow evaporation. Large amounts should only be handled by gas supplier.

9 FIRE PREVENTION AND FIRE FIGHTING

9.1 Krypton is non-flammable.

9.2 Krypton cannot catch fire. Use appropriate media for arresting fire.

9.3 Evacuate all personnel from danger area. Immediately de-lunge cylinders with water from maximum distance until cool, then move them away from fire area, if without any risk. Self-contained breathing apparatus may be required by rescue workers.

9.4 Krypton cannot catch fire. Heat of fire can build pressure in cylinder and cause it to rupture. No part of cylinder should be subjected to a temperature higher than 52 °C. Krypton cylinders are equipped with a pressure relief device.

10 TRAINING

10.1 All personnel directly involved in the commissioning, operation and maintenance of krypton storage systems shall be fully informed regarding the hazards associated with helium and oxygen deficient and be properly trained, as applicable, to operate or maintain the equipment. Training shall be arranged to cover those aspects and potential hazards that the particular operator is likely to encounter.

10.2 Training shall cover, but not necessarily be confined to, the following subjects:

- a) Potential hazards of krypton;
- b) Site safety regulations;
- c) Emergency procedures;
- d) Use of firefighting equipment;
- e) Use of protective clothing/apparatus including breathing sets where applicable; and
- f) First aid treatment for cryogenic burns.

10.3 In addition, individuals shall receive specific training in the activities for which they are employed.

10.4 It is recommended that the training be carried out under a formalized system and that records be kept of the training given and where possible, some indication of the results obtained, in order to show where further training is required.

10.5 The training programme should make provision for refresher courses on a periodic basis and for changes of site personnel.

10.6 Safety in handling krypton 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 safeguards provided for them is a responsibility of supervisor. Employee education and training should emphasize the need of safely handling

krypton according to the methods outlined in the manual, in order to avoid spilling or splashing, leaks, burns, inhalation of the vapor of burning material, or ingestion. Unauthorized and untrained employees should not be permitted in areas where krypton is being handled.

10.7 Before being placed on the job, all new employees should be instructed and trained to maintain a high degree of safety in handling procedures. Older employees should be re-instructed and trained periodically.

11 HEALTH MANAGEMENT, FIRST-AID AND MEDICAL TREATMENT

11.1 First Aid

11.1.1 *Contact with Skin*

Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

11.1.2 *Contact with Eyes*

Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 min. Get medical attention if irritation occurs.

11.1.3 *Ingestion*

An unlikely route of exposure. This product is a gas at normal temperature.

11.1.4 *Inhalation*

Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.