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भाग 1 तरल ऑक्सीजन

(पहला पुनरीक्षण)

Cryogenic Liquid — Code of Safety

Part 1 Liquid Oxygen

(First Revision)

ICS 71.100.20

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FOREWORD

This Indian Standard (Part 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Water Quality Sectional Committee had been approved by the Chemical Division Council.

Handling liquid oxygen safely is largely a matter of knowing its properties and using suitable procedures based on that knowledge. There are 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 oxygen mentioned in this standard. There are also certain specific precautions which shall have to be followed where liquid oxygen 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 oxygen. 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. In this first revision title of standard has also been revised.

Under general title 'Cryogenic liquid — Code of safety' this standard is being published in several other parts. The other parts of this series are:

- 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 6 Liquid krypton (*first revision*)
- Part 7 Liquid neon (*first revision*)

This (Part 1) prescribes a code of safety concerning hazards relating to liquid oxygen. It describes the properties and essential information for the safe handling and use of liquid oxygen, safety measures for controlling hazards and essential information on symptoms of poisoning, first-aid, medical treatment, storage, handling, labelling and employee safety.

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

The composition of the Committee responsible for the formulation of this standard is given in [Annex A](#).

Indian Standard

CRYOGENIC LIQUID — CODE OF SAFETY

PART 1 LIQUID OXYGEN

*(First Revision)***1 SCOPE**

1.1 This standard (Part 1) describes the properties of liquid oxygen, 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 provision 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 these 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 8520 : 2023/ ISO 19734 : 2021	Eye and face protection — Guidance on selection, use, and maintenance (<i>first revision</i>)
IS 10245 (Part 2) : 2023	Respiratory protective devices — Specification: Part 2 Self-contained open circuit breathing apparatus (<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 Liquid oxygen is pale blue and extremely cold. Although non-flammable, oxygen is a strong oxidizer. Liquid oxygen is a cryogenic liquid. Cryogenic liquids are liquefied gases that have a normal boiling point below (–) 130 °F (– 90 °C). Liquid oxygen has a boiling point of (–) 297 °F (– 183 °C).

4.1.2 Oxygen is the second largest component of the atmosphere, comprising 20.8 percent by volume. Oxygen is necessary to support life. Oxygen will react with nearly all organic materials and metals, usually forming an oxide. Materials that burn in air will burn more vigorously in oxygen. The temperature difference between the liquid oxygen and the oxygen in surrounding environment is substantial, it requires special equipment for handling and storage.

4.1.3 Chemical Name — O₂

4.1.4 Common Name and Synonyms — Oxygen (refrigerated), Oxygen USP, LOX, Cryogenic Liquid Oxygen

4.1.5 Uses

Oxygen is most commonly used in its gaseous state. For its life sustaining properties oxygen is used in health and medical applications. Oxygen is widely applied in metal industries for its strong oxidizing properties. Steel and iron manufacturers extensively use oxygen to affect chemical refining and heating associated with carbon removal and other oxidation reactions to get benefit of fuel and energy savings plus to lower total emission volumes. In the chemical and petroleum industries, oxygen is used as a feed component to react with hydrocarbon building blocks to produce chemicals such as alcohols and aldehydes. The pulp and paper industry uses oxygen as a bleaching and oxidizing agent. Similarly, oxygen enhances the combustion process in industries that manufacture glass, aluminium, copper, gold, lead, and cement, or that are involved in waste incineration or remediation. Liquid oxygen is used as an oxidant for liquid fuels in the propellant systems of missiles and rockets.

To access Indian Standards click on the link below:

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/knownyourstandards/Indian_standards/isdetails/

4.2 Identification

4.2.1 *Formula* — O₂

4.2.2 *CAS Number* — 7782-44-7

4.2.3 *UN Number* — 1073

4.2.4 *UN Class* — 2.2

4.3 Physical Properties

4.3.1 *General*

Liquid Oxygen is tasteless, odourless, non-flammable, oxidizing, and extremely cold.

4.3.2 *Molecular Mass* — 32 g/mol

4.3.3 *Physical State* — Liquefied gas.

4.3.4 *Colour* — Pale blue.

4.3.5 *Odour* — No odour warning properties.

4.3.6 *Boiling Point* — -130 °F (-90 °C)

4.3.7 *Melting Point* — -297 °F (-183 °C)

4.3.8 *Vapour Density* (Air = 1) — 1.105 (air = 1)
Heavier than air.

4.3.9 *Specific Gravity for Liquid* (Water = 1) at 20 °C, 1 atm — 1.14

4.3.10 *Viscosity* at 30 °C — No data available

4.3.11 *Vapour Pressure* at 118 °C — 5 080 kPa

4.3.12 *Heat of Combustion* — No data available

4.3.13 *Refractive Index* at 25 °C — No data available

4.3.14 *Solubility in Water* at 25 °C, 101.325 kPa — 3.1 percent by volume

4.3.15 *Solubility in Other Solvents* — No data available

4.3.16 *Light Sensitivity* — No data available

4.4 Chemical Properties

4.4.1 *Reactivity*

Violently oxidizes organic material. May react violently with combustible materials. May react violently with reducing agents.

4.4.2 *Polymerization* — Oxygen can both initiate and inhibit polymerization process.

4.4.3 *Allotrope Formation* — O₃

4.4.4 *Corrosion Properties* — Can speed up corrosion due to rapid rate of oxidation.

4.4.5 *Incompatible Materials*

Cryogenic liquids can cause embrittlement of some metals and alter the physical properties of other materials. Keep equipment free from oil and grease. Consider the potential toxicity hazard due to the presence of chlorinated or fluorinated polymers in high pressure (> 30 bar) oxygen lines and equipment in case of combustion.

4.5 Fire and Explosion Hazard Properties

4.5.1 *Ignition Temperature* — No data available

4.5.2 *Auto Ignition Temperature* — No data available

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* — Oxygen can react explosively with oil and grease

5 HEALTH HAZARD AND TOXICITY INFORMATION

5.1 General Information

Normally, air contains 21 percent oxygen, and oxygen is essentially non-toxic. No health effects have been observed in people exposed to concentrations up to 50 percent at 101.325 kPa for 24 h or longer.

5.2 Routes of entry

5.2.1 *Skin*

Oxygen itself is not harmful when in its gaseous form and is essential for human respiration. However, when oxygen is cooled and liquefied, it becomes extremely cold, with a boiling point of -183 °C (-297 °F). This extreme cold temperature can cause severe frostbite and tissue damage upon contact with skin.

5.2.2 *Eyes*

Exposure of the eyes to liquid oxygen can cause immediate and severe injury such as frostbite due to the extreme cold temperatures of the liquid. The severity of the frostbite depends on the duration of exposure and the amount of liquid oxygen that comes into contact with the eyes.

5.2.3 *Ingestion*

Ingestion is not considered a potential route of exposure.

5.2.4 Inhalation

The inhalation at 1 atm of 80 percent oxygen for more than 12 h can cause irritation of the respiratory tract, progressive decrease in vital capacity, coughing, nasal stuffiness, sore throat, and chest pain, followed by trachea-bronchitis and later by pulmonary congestion and/or edema. Inhalation of pure oxygen at atmospheric pressure or less can cause pulmonary irritation and edema after 24 h. Respiratory symptoms can occur in 2 h to 6 h at pressures above 1 atm. Breathing 75 percent or more oxygen at atmospheric pressure for more than a few hours may cause nasal stuffiness, cough, sore throat, chest pain and breathing difficulty. Breathing pure oxygen under pressure may cause lung damage and can also affect central nervous system. One of the earliest responses of the lung is accumulation of water in its interstitial spaces and within the pulmonary cells. This can cause reduced lung function, which is the earliest measurable sign of toxicity. Other symptoms include fever and sinus and eye irritation. One of the earliest responses of the lung is accumulation of water in its interstitial spaces and within the pulmonary cells. This can cause reduced lung function, which is the earliest measurable sign of toxicity. Other symptoms include fever and sinus and eye irritation. When pure oxygen is inhaled at pressures greater than 202.65 kPa or 303.975 kPa, a characteristic neurological syndrome can be observed. Signs and symptoms include nausea, dizziness, vomiting, tiredness, light-headedness, mood changes, euphoria, confusion, incoordination, muscular twitching, burning/tingling sensations (particularly of the fingers and toes), and loss of consciousness. Characteristic epileptic-like convulsions, which may be preceded by visual disturbances such as loss of peripheral vision, also occur. Continued exposure can cause severe convulsions that can lead to death.

5.3 Toxicity Information

5.3.1 Time Weighted Average (TWA) — No data available

5.3.2 Short Term Exposure Limit (STEL) — No data available

5.3.3 Immediately Dangerous to Life and Health (IDLH) — No data available

5.3.4 Lethal Dose (LD₅₀) — No data available

5.3.5 Inhalation (Rat) Lethal Concentration (LC₅₀) — No data available

5.4 Antidote

Oxygen toxicity is managed by reducing the exposure to increased oxygen levels.

5.5 Health Effects

5.5.1 Signs and Symptoms

The inhalation at 1 atm of 80 percent oxygen for more than 12 h can cause irritation of the respiratory tract, progressive decrease in vital capacity, coughing, nasal stuffiness, sore throat, and chest pain, followed by trachea-bronchitis and later by pulmonary congestion and/or edema.

6 PERSONAL PROTECTIVE EQUIPMENT

6.1 Availability and Use

6.1.1 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 liquid oxygen, it is, in many instances, the only practical means of protecting the worker, particularly in emergency situations. The personal protective equipment protects only the worker wearing it, and other unprotected workers in the area maybe exposed to danger.

6.1.2 The correct usage of personal protective equipment requires the education of the workers in proper employment of the equipment available. 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 hazards.

6.2 Non-Respiratory Equipment

6.2.1 Eye and face Protection

Eyes are most sensitive to the extreme cold of liquid oxygen and its vapours. The recommended personal protective equipment when handling or using liquid oxygen is a full-face shield over safety goggles (*see* IS 8520).

6.2.2 Head Protection

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

6.2.3 Foot and leg Protection

Safety shoes are recommended when handling liquid oxygen containers, cylinders.

6.2.4 Body, Skin and Hand Protection

6.2.4.1 Personnel who have been exposed to high concentrations of oxygen should stay in a well-ventilated or open area for 30 min before going into a confined space or near an ignition source. 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.

6.2.4.2 To use loose fitting thermal insulated cryogenic or leather gloves which must be clean and free of oil and grease. Always wear full sleeve cotton shirt & pant.

6.3 Respiratory Equipment

Not required for properly ventilated areas. In emergency situations, self-contained breathing apparatus (SCBA) must be used [see IS 10245 (Part 2)]. Clothing that is fire resistant in air may be readily ignitable in oxygen-enriched atmospheres. Only trained and certified emergency responders should respond to emergency situations.

7 STORAGE, HANDLING, LABELLING AND TRANSPORT

7.1 General

Storage, handling, and transportation of liquid oxygen require careful consideration due to its cryogenic nature and high reactivity. Liquid oxygen (LOX) is stored and transported at extremely low temperatures ($-183\text{ }^{\circ}\text{C}$ or $-297\text{ }^{\circ}\text{F}$) and is highly volatile, posing significant hazards if mishandled.

7.2 Storage

Liquid oxygen is stored, shipped, and handled in several types of containers, depending upon the quantity required by the user. The types of containers in use include the dewar, cryogenic liquid cylinder, and cryogenic storage tank. Storage quantities vary from a few litres to many thousands of gallons. Store and use liquid containers with adequate ventilation. Do not store containers in a confined area or in area unprotected from the extremes of weather. Oxygen must be separated from flammables and combustibles by at least 6.09 m. Post “No Smoking” and “No Open Flames” signs.

7.2.1 Storage in Containers

Cryogenic containers are equipped with pressure relief devices designed to control the internal pressure. Under normal conditions these containers will periodically vent product. Do not plug, remove or tamper with any pressure relief device.

7.2.2 Storage in Dewars

A loose-fitting dust cap over the outlet of the neck tubes prevents atmospheric moisture from pugging the neck and allows gas produced from vaporized liquid to escape. This type of container is a non-pressurized container. The unit of measure for the capacity of a Dewar is typically the litre. 5 litre

to 20 litre Dewars are available. Product may be removed from small Dewars by pouring, while larger sizes will require a transfer tube. Cryogenic liquid cylinders that are pressurized vessels are sometimes incorrectly referred to as Dewars.

7.2.3 Storage in Cryogenic Liquid Cylinders

Cryogenic liquid cylinders are insulated, vacuum jacketed pressure vessels. They come equipped with safety relief valves and rupture discs to protect the cylinders from pressure build up. These containers operate at pressures up to 350 psig and have capacities between 80 litre and 450 litre of liquid. Liquid oxygen may be withdrawn as a gas by passing liquid through an internal vaporizer or as a liquid under its own vapour pressure.

7.2.4 Storage in Cryogenic Storage Tanks and Connected Transfer Lines

Tanks may be spherical or cylindrical in shape. They are mounted in fixed locations as stationary vessels or on railroad car or truck chassis for easy transportation. Sizes range from 500 gallons to 420 000 gallons, and all tanks are powder and vacuum-insulated in the annular space. Tanks are equipped with various circuits to control product fill, pressure build up, pressure relief, product withdrawal, and tank vacuum.

7.2.4.1 Transfer lines connected to storage

A liquid transfer line is used to safely remove liquid product from dewars or cryogenic liquid cylinders. A typical transfer line for dewars is connected to a bayonet that provides a means of using product vapor pressure build up or an external pressure source to remove the liquid. For cryogenic liquid cylinders, the transfer line is connected to the cylinder's liquid withdraw a valve. Liquid product is typically removed through insulated withdrawal lines to minimize the loss of liquid product to gas. Insulated flexible or rigid lines are used to withdraw product from storage tanks. Connections on the lines and tanks vary by manufacturer.

7.2.5 The location should comply with *Static and Mobile Pressure Vessel Rules (SMPV) 2016*, and annual external inspection should be carried out in accordance with *SMPV Rules, 2016*.

7.2.6 Avoid installing liquid storage vessel in indoor environment and near drain or pits.

7.2.7 Oxygen storage should be separated from vacuum and medial air compressor plant to avoid possible oil contamination.

7.2.8 It is important to provide adequate ventilation in areas where liquid oxygen in use, due large expansion ratio of liquid to gas. A minimum of six

changes per hour is suggested. The oxygen enriched atmosphere is one containing more than 23.5 percent of oxygen.

NOTE — Oxygen has no warning properties.

7.2.9 Do not store containers in a confined area or in areas unprotected from the extreme weather.

7.2.10 Cryogenic containers are equipped with pressure relief devices designed to control the internal pressure. Under normal conditions these containers will periodically vent product. Do not plug, remove or tamper with any pressure relief device.

7.2.11 Liquid containers should not be left open to the atmosphere for extended periods. Keep all valves closed and outlet caps in place when not in use. If restriction results from freezing moisture or foreign material present in openings and vents, contact the vendor for instructions. Restrictions and blockages may result in dangerous over pressurization. Do not attempt to remove the restriction without proper instructions. If possible, move the cylinder to remote location.

7.3 Handling

7.3.1 Cryogenic containers must be stored, handled and transported in the upright position. When moving, never tip, slide or roll containers on their side. Use a suitable hand truck for moving smaller containers. Move larger containers by pushing, not pulling. Avoid mechanical and thermal shock. Never allow any unprotected part of the body to come in contact with uninsulated pipes or equipment containing cryogenic product. The extreme cold will cause flesh to stick fast and potentially tear on withdrawal. Use only oxygen-compatible materials and lubricants.

7.3.2 If there is any difficulty in operating the container valve or container connections, discontinue use and contact the vendor. Do not remove or interchange connections. Use only the properly assigned connections. Do not use adapter. Use only transfer lines and equipment designed for use with cryogenic liquids. Some elastomers and metals, such as carbon steel, may become brittle at extremely low temperatures and may easily fracture. These materials must be avoided in cryogenic service. It is recommended that all vents be piped to the exterior of the building. On gas withdrawal systems, use check valves or other protective apparatus to prevent reverse flow into the container. On liquid systems, pressure relief devices must be used in lines where there is the potential to trap liquid between valves.

7.3.3 If these liquids are vaporized in a sealed container, they can produce enormous pressures that

could rupture the container. For this reason, pressurized cryogenic containers are normally protected with multiple devices for prevention of over-pressurization. Common pressure relief devices are a pressure relief valve for primary protection and a rupture disc for secondary protection.

7.3.4 Vaporization of liquid oxygen in an enclosed area can create an oxygen enriched atmosphere.

7.3.5 Always handle cryogenic liquids carefully. Their extremely low temperatures can produce cryogenic burns of the skin and freeze underlying tissue. 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. They can cool large areas. The vapours coming from these liquids are also extremely cold and can produce burns.

7.3.6 Exposure to these cold gases, which is too brief to affect the skin of the face or hands, may affect delicate tissues, such as the eyes.

7.3.7 Stand clear of boiling and splashing liquid and the cold vapours that are released. Boiling and splashing always occur when charging a warm container or when inserting objects into the liquid. Always perform these operations slowly to minimize the splashing and boiling.

7.3.8 The extremely cold material may stick fast to skin and tear the flesh when you attempt to withdraw it. Even non-metallic materials are dangerous to touch at these low temperatures. Use tongs to immerse and remove objects from cryogenic liquids.

7.3.9 In addition to the hazards of frostbite or flesh sticking to cold materials, objects that are soft and pliable at room temperature, such as rubber or plastics, are easily broken because they turn brittle at low temperatures and may break when stressed.

7.3.10 Use only oxygen-compatible materials and lubricants.

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 should 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.

7.4.3 Each tanker and each railroad car carrying one or more containers shall be labelled as:

In case of leakage/fire:
 Keep away flames and oil/grease.
 Use water fog or water spray for cooling or dilution.
 Evacuate upwind from cold liquid and white water vapor.

7.5 Transport

7.5.1 Transportation of Container

7.5.1.1 Liquid oxygen containers must only be unloaded from or loaded onto a delivery vehicle by

means of a crane, fork truck, or a power-assisted tailgate. Liquid oxygen containers may be moved using a forklift if they are secured on a pallet, in a cradle, or some other device designed for this purpose. When the container is removed from a pallet, it should only be moved using a specially designed four-wheel handcart.

7.5.1.2 Liquid oxygen containers should only be transported in an upright position and should never be laid on their side. For proper ways to handle a liquid container is as given in [Fig. 1](#). Never roll these containers on their side. Liquid oxygen containers equipped with wheels should always be moved by pushing the container, never pulling it. This reduces the possibility of the container falling on co-worker in the event it becomes unstable. Pushing the liquid oxygen container up any type of grade will increase the force necessary to move it. A grade as low as 5 percent (5 inch rise in 10 feet of travel) will increase the force necessary to start to push the container by as much as 50 percent.

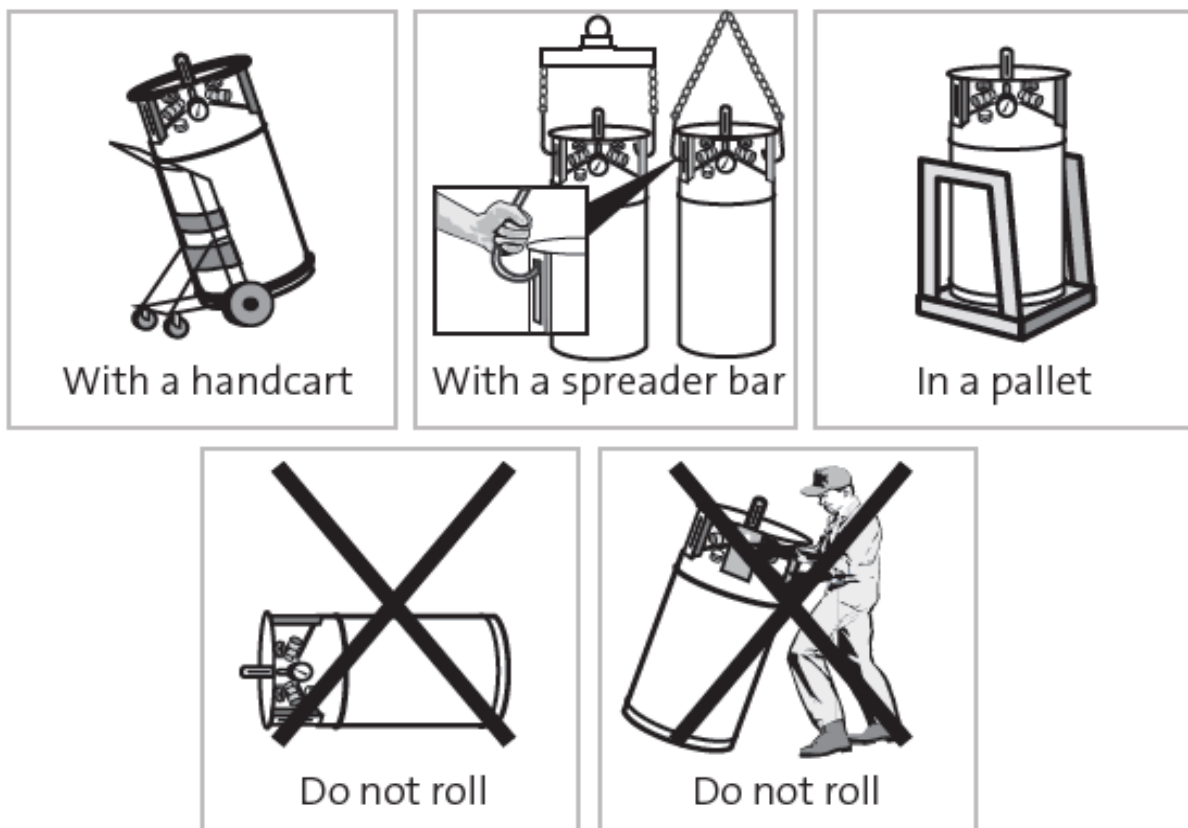


FIG. 1 HOW TO HANDLE LIQUID CONTAINERS

7.5.2 Elevator Transport

7.5.2.1 Care must be exercised when transporting liquid oxygen containers in elevators. If possible, transport the container only on a freight elevator that is not generally used for personnel transport.

7.5.2.2 After the container is placed in the elevator, the elevator should be locked out to all other users. The sender should remain outside the elevator and activate it. Another person should be available on the receiving floor to take the liquid oxygen container off the elevator at its destination. If a freight elevator is not available, a passenger elevator can be used provided it is locked out to all other users. If it is absolutely necessary to have an attendant in the elevator with the container, an escape pack supplemental breathing apparatus must be carried in the elevator. Do not transport a liquid oxygen container at any time in an elevator with any other personnel in the car.

7.5.3 Tankers should be periodically inspected, and they must be maintained with proper care and caution and the insulation of the container of the tanker must be checked regularly.

7.5.4 The safety relief valve (SRV) in the truck should be periodically tested. All other tanker accessories including temperature and pressure gauges should be in good condition and must be calibrated at regular intervals.

7.5.6 Containers should be clearly identified so that only the correct contents may be filled or withdrawn. Mixing liquid oxygen with another liquefied atmospheric gas may be hazardous; in certain instances, the oxygen concentration may increase as time progresses due to the evaporation of lower boiling point liquids such as nitrogen and argon. Unknown concentrations of oxygen always represent a hazardous condition. If liquid oxygen is introduced into a liquid nitrogen refrigerator, the oxygen may cause any organic material in the refrigerator to burst into flame.

7.5.7 Obtain clearance certificate where it is necessary for work to be carried out involving a flame or arc in which case there is likely to be oxygen enrichment of the surrounding atmosphere.

7.5.8 Make certain that there is adequate ventilation and circulation of air where oxygen cutting, gas welding, brazing or arc welding is required to be carried out in a confined space.

7.5.9 Make certain that all assemblies and components, including piping, which will be in contact with gaseous or liquid oxygen, are

thoroughly degreased and entirely free from oil or grease of any description.

7.5.10 Only pressure gauges marked 'OXYGEN - USE NO OIL' are to be used for any oxygen service and on no account are these gauges to be used on other services where there is a possibility of the gauge becoming contaminated with oil or any other foreign matter.

7.5.11 Never use oxygen as a substitute for compressed, air or nitrogen.

7.5.12 Oxygen is not to be used for clearing fumes in a confined space. Such use has caused fatal accidents through the worker's clothing getting ignited.

7.5.13 No painting is to be carried out around an oxygen plant when the latter is in operation.

7.5.14 Make certain that all pressure is relieved from the system before attempting to remove any fittings or commencing a repair.

7.5.15 The liquid oxygen should be disposed of by pouring it gently, avoiding splashing on to the ground, which is free from any holes or pockets or preferably in the open, well away from other personnel, naked lights, lighted cigarettes.

7.5.3 Driver

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

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

Do not touch or walk through spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapours or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. If possible, turn leaking containers so that gas escapes rather than liquid. Prevent entry into waterways, sewers, basements or confined areas. Allow substance to evaporate. Ventilate the area.

CAUTION — When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning.

8.2 Spillage

8.2.1 General Information

Spillage of liquid oxygen can be extremely hazardous due to its highly reactive nature. It is essential to approach any spillage of liquid oxygen with extreme caution and prioritize safety to minimize the potential risks and consequences associated with such incidents.

8.2.2 Emergency procedures shall be prepared by the site operator to include action to be taken in the event of spillage of liquid oxygen. Local emergency services shall be party to the preparation of the emergency procedures. Works employees likely to be affected shall know the actions required to minimize the adverse effects of a spillage. Consideration shall be given to the carrying out of practical exercises.

8.2.3 The following are guidelines, which should be used for formulating emergency procedures:

- a) Raise the alarm;
- b) Summon help and emergency services;
- c) Isolate the source of oxygen, if appropriate and where safely possible;
- d) Evacuate all persons from the danger area and seal it off; and
- e) Alert the public to possible dangers from vapor clouds in the immediate vicinity and evacuate when necessary.

8.2.4 After the liquid oxygen spillage has been isolated, oxygen enrichment checks should be carried out in any enclosed areas where the vapor cloud may have entered. This includes basements, pits and confined spaces.

8.2.5 Oxygen itself does not pose a hazard to the environment. However, because of extreme cold of the liquid, damage to ecology can occur in the immediate environs of the spill. Beware of oxygen-enriched atmospheres encountering readily combustible materials.

8.2.6 Small Spills

Shut off the source of escaping oxygen. Ventilate the area.

8.2.7 Large Spills

Evacuate the area. Shut off the source of the spill if this can be done without risk. Restrict access to the area until completion of the clean-up procedure. Ventilate the area using forced draught if necessary.

8.2.8 If liquid oxygen spills on asphalt or other surfaces contaminated with combustibles, do not

walk on or roll equipment over the area of the spill. Keep sources of ignition away for 30 min after all frost or fog has disappeared.

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.

8.3.3 Disposal of Packaging

The disposal of containers must only be handled by the gas supplier.

9 FIRE PREVENTION AND FIRE FIGHTING

The liquid oxygen itself does not burn. Use extinguishing media appropriate for surrounding fire.

9.1 General

9.1.1 Smoking or open flames or naked light shall not be permitted in any area where liquid oxygen is stored, handled, or where it is loaded or unloaded. Post 'NO SMOKING' signs conspicuously in all such areas and on storage tanks.

9.1.2 Organic material or flammable substance of any kind shall not be permitted to come in contact with liquid oxygen. Some of the materials that can react violently with oxygen under certain conditions of pressure and temperature are oil, grease, asphalt, kerosene, cloth, wood, paint, tar and dirt which may contain oil or grease. Under certain conditions, mixtures of powdered organic materials with liquid oxygen may detonate.

9.1.3 Combustibles in contact with liquid oxygen may explode on ignition or impact. Some materials which are non-combustible in air may burn in the presence of an oxidizer. Contact with organic and most inorganic materials may cause fire. Vapor cloud may obscure visibility. Move away from container and cool with water from a protected position. Do not direct water spray at container vent. If possible, stop flow of product.

9.2 Prevention

9.2.1 When organic materials are exposed to liquid oxygen, they will burn violently if ignited, even several minutes after they have been in contact with the liquid. Any clothing that has been splashed or soaked with liquid oxygen should be removed immediately and aired away from sources of ignition for at least an hour until it is completely free of oxygen.

9.2.2 Any person working with liquid oxygen should ensure that his clothing's are aired before approaching any source of ignition.

9.3 Fighting Fires Involving Liquid Oxygen

Since oxygen itself does not burn, fire not caused unless combustible materials also present. In any fire involving liquid oxygen, the oxygen plays the same part as oxygen from the air in an ordinary fire. However, the presence of additional oxygen will make any fire burn much faster and more violently. The following fire fighting procedures should be observed:

- a) Remove every one not actively engaged in fighting the fire;
- b) If possible, shut off the flow of oxygen; and
- c) Use large quantities of fire extinguishing agent, such as water, preferably in the form of a spray, below the ignition point. To cool the burning material, if electrical equipment is involved in the fire, do not use water, use carbon dioxide or dry chemical.

10 TRAINING

10.1 All personnel directly involved in the commissioning, operation and maintenance of liquid oxygen storage systems shall be fully informed regarding the hazards associated with oxygen and oxygen enrichment 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 oxygen;
- 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 liquid oxygen 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 liquid oxygen 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 liquid oxygen 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 Health Monitoring

Periodic medical examination aims to detect susceptible workers for whom corrective actions are required before they develop overt occupational diseases. Meanwhile safety and health measures at work should be reviewed for necessary remedial actions.

11.2 First Aid

11.2.1 General Principles

If any of the liquefied oxygen contact the eyes or skin, immediately flood the affected area with large quantities of unheated water and then apply cold compress. If the skin is blistered or if there is any chance that the eyes have been affected, take the patient immediately to a doctor treatment.

11.2.2 Contact with Skin

11.2.2.1 For skin contact with liquid oxygen, remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. As soon as practical, place the affected area in a warm water bath with a temperature not exceeding 105 °F (40 °C) for at least for 15 min. Never use dry heat. Call a physician as soon as possible. Cover wound with sterile dressing.

11.2.2.2 Frozen tissue is painless and appears waxy with a possible yellow colour. It will become swollen, painful, and prone to infection when

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thawed. If the frozen part of the body has been thawed, cover the area with a dry sterile dressing with a large bulky protective covering, pending medical care.

11.2.3 *Contact with Eyes*

In the case of contact with eyes, rinse immediately with plenty of luke warm water temperature less than 40 °C (105 °F) for at least for 15 min and seek medical advice.

11.2.4 *Ingestion*

Ingestion is not considered a potential route of exposure.

11.2.5 *Inhalation*

Consult a physician after significant exposure. Move to fresh air.

11.2.6 In case of massive exposure, remove clothing while showering the victim with warm water. Call a physician immediately.

12 ADDITIONAL INFORMATION

Workers involved in emergency activities must not allow emotions to override safe work procedures and training. Only trained, qualified personnel equipped with necessary safety equipment should attempt a rescue and or firefighting, arresting of leakages in accordance with safe procedures.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Chemical Hazards Sectional Committee, CHD 07

<i>Organization</i>	<i>Representative(s)</i>
National Safety Council, Navi Mumbai	DR LALIT R. GABHANE (Chairperson)
Alkali Manufacturers Association of India, New Delhi	SHRI K. SRINIVASAN SHRI HARI SARAN DAS (<i>Alternate</i>)
Atomic Energy Regulatory Board, Mumbai	DR DIPTENDU DAS SHRI VISHWAJIT V. BHAKHANDE (<i>Alternate</i>)
Centre for Fire and Explosive Environment Safety, Defence Institute of Fire Research, New Delhi	DR AARTI BHATT SHRIMATI DIPTI BARUI BOSE (<i>Alternate</i>)
Crop Care Federation of India, New Delhi	DR J. C. MAJUMDAR
CSIR - Central Food Technological Research Institute, Mysuru	DR PRASANNA VASU DR USHARANI DANDAMUDI (<i>Alternate</i>)
CSIR - Indian Institute of Chemical Technology, Hyderabad	DR BANKUPALLI SATYAVATHI DR SRIPADI PRABHAKAR (<i>Alternate</i>)
CSIR - Indian Institute of Petroleum, Dehradun	DR NEERAJ ATRAY DR PANKAJ KUMAR KANAUIA (<i>Alternate</i>)
CSIR - Indian Institute of Toxicology Research, Lucknow	DR D. K. PATEL DR SHEELENDRA PRATAP SINGH (<i>Alternate</i>)
Defence Research Development Organization, Ministry of Defence, New Delhi	DR PRABHAT GARG DR VIRENDRA VIKRAM SINGH (<i>Alternate</i>)
Department of Chemicals and Petrochemicals, Government of India, New Delhi	DR ROHIT MISRA
Department of Space, Bengaluru	SHRI MURALEEKRISHNAN R. SHRIMATI LAKSHMI V. W. (<i>Alternate</i>)
Directorate General Factory Advice Service and Labour Institutes, Mumbai	SHRI KUNAL SHARMA DR SAMIR PAINE (<i>Alternate</i>)
Gas Industries Association, Mumbai	SHRI SUNIL KHER SHRI ANOOP TANDON (<i>Alternate</i>)
Hindustan Unilever Limited, Mumbai	SHRI SANJAY HARLAKA SHRI RAKESH WADALKAR (<i>Alternate</i>)
ICMR - National Institute of Occupational Health, Ahmedabad	DR B. RAVICHANDRAN DR H. R. RAJMOHAN (<i>Alternate</i>)
Indian Chemical Council, Mumbai	DR C. NANDI SHRI DHRUMIL SONI (<i>Alternate</i>)
Institute of Chemical Technology, Mumbai	PROF G. D. YADAV DR B. M. BHANAGE (<i>Alternate</i>)
Ministry of Environment Forest and Climate Change, New Delhi	SHRI VED PRAKASH MISHRA SHRI DINESH RUNI WAL (<i>Alternate</i>)

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National Institute of Technology, Thrichi	PROF S. P. SIVAPIRAKASAM DR SREEJITH MOHAN (<i>Alternate</i>)
National Safety Council, Navi Mumbai	SHRI A. Y. SUNDKAR SHRI K. D. PATIL (<i>Alternate</i>)
Oil Industry Safety Directorate (Min. of Pet. & Natural Gas), Noida	SHRI SHATHISH KUMAR S. SHRI AMIT SHARMA (<i>Alternate</i>)
Pesticides Manufacturer and Formulators Association of India, Mumbai	DR SAMIR P. DAVE DR ARCHANA KUMARI (<i>Alternate</i>)
Petroleum & Explosives Safety Organisation, Nagpur	SHRI ANUJ KUMAR SHRI S. D. MISHRA (<i>Alternate</i>)
Safety Appliances Manufacturers Association, Mumbai	SHRI MOHAMMAD SHRI DEVANG MEHTA (<i>Alternate</i>)
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Member Secretary
Ms SHUBHANJALI UMRAO
SCIENTIST 'C'/DEPUTY DIRECTOR
(CHEMICAL), BIS

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