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BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

Code of Safety for Cryogenic liquid

Part 4 Liquid Helium

(*First Revision of IS 5931*)

भारतीय मानक मसौदा

क्रायोजेनिक तरल के लिए सुरक्षा संहिता

भाग 4 तरल हीलियम

(*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 helium safely is largely a matter of knowing their properties and using suitable procedures based on that knowledge. There arena 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 helium 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 helium. 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 4) prescribes a code of safety concerning hazards relating to liquid helium. It describes the properties and essential information for the safe handling and use of liquid helium, 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 5 Liquid Hydrogen (*first revision*)

Part 6 Liquid Krypton (*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 liquid helium, 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:

IS No.	*Title*

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 (*second revision*)
IS 4155: 2023	Glossary of terms relating to chemical and radiation hazards and hazardous chemicals (*first revision*)
IS 8520: 2023	Guide for selection of industrial safety equipment for eye, face and ear protection
IS 10245 (Part 1): 2023	Respiratory Protective Devices-Specification: Part 2 Self-Contained Open Circuit Breathing Apparatus (*second revision*)
IS 15298 (Part 2) : 2016/ISO 20345: 2011	Personal protective equipment: Part 2 safety footwear (*second revision*)
IS 15803 : 2008	Respiratory protective devices - Self contained closed circuit breathing apparatus chemical oxygen (KO_2) type, self generating, self rescuers - Specification

3 TERMINOLOGY

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

4 PROPERTIES LIQUID HELIUM

4.1 General Information

4.1.1 Liquid helium is inert, colorless, odorless, noncorrosive, extremely cold, and nonflammable. Helium will not react with other elements or compounds under ordinary conditions. Since helium is noncorrosive, special materials of construction are not required. However, materials must be suitable for use at the extremely low temperatures of liquid helium. Vessels and piping must be selected and designed to withstand the pressure and temperatures involved and comply with applicable codes for transport and use.

4.1.2 Most of commercial helium is recovered from natural gas through a cryogenic separation process. Normally, helium is present in less than 1 percent by volume in natural gas. Helium is recovered, refined, and liquefied. Liquid helium is typically shipped from production sources to storage and trans-fill facilities.

4.1.3 Tankers, ranging in size from 5 000 gallons to 11 000 gallons, contain an annular space insulated with vacuum, nitrogen shielding, and multilayer insulation. This design reduces heat leak and vaporization of liquid helium during transportation.

4.1.4 Being odorless, colorless, tasteless, and non-irritating, helium has no warning properties. Humans possess no senses that can detect the presence of helium. Although helium is nontoxic and inert, it can act as a simple asphyxiant by displacing the oxygen in air to levels below that required to support life. Inhalation of helium in excessive amounts can cause dizziness, nausea, vomiting, loss of consciousness and death. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue.

4.1.5 At low oxygen concentrations, unconsciousness and death may occur in seconds and without warning.

4.1.6 *Chemical Name* - He

4.1.7 *Common Name & Synonyms* - Helium (refrigerated), Cryogenic Liquid Helium, Liquid Helium, LHE

4.1.8 *Uses* – General Industrial.

The extremely low temperature of liquid helium is utilized to maintain the superconducting properties of magnets in applications such as MRI, NMR spectroscopy, and particle physics research. The main application for gaseous helium is for inert shielding gas in metal arc and laser welding. Helium provides a protective atmosphere in the production of reactive metals, such as titanium and zirconium. Gaseous helium is used as a coolant during the drawing of optical fibers, as a carrier gas for chromatography, and as a leak detection gas in a variety of industries. Being both lighter than air and non-flammable, helium is used to inflate balloons and airships.

4.2 Identification

4.2.1 *Formula* - He

4.2.2 *CAS Number* - 7440-59-7

4.2.3 *UN Number* - 1963

4.2.4 *UN Class* - 2.2.

4.3 Physical Properties

Liquid helium is inert, colorless, odorless, noncorrosive, extremely cold, and nonflammable. Helium will not react with other elements or compounds under ordinary conditions. Since helium is noncorrosive.

4.3.1

4.3.2 *Molecular Mass* - 4 g/mol

4.3.3 *Physical State* - Liquefied gas

4.3.4 *Colour* - Colorless.

4.3.5 *Odour* - No odor warning properties.

4.3.6 *Boiling Point* - -452 °F (-269 °C)

4.3.7 *Melting Point* - -458 °F (-272 °C)

4.3.8 *Vapour Density (Air=1)* - 0.138 (air = 1) Lighter or similar to air.

4.3.9 *Specific Gravity*

a) Liquid (water = 1) – No data available

4.3.10 *Viscosity at* 30 °C - Not applicable.

4.3.11 *Vapour Pressure at* 76.6 °C - Not applicable.

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* – 0.0 015 g/l

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* - No data available.

4.4.2 *Polymerization* – No data available

4.4.3 *Allotrope formation* – No data available

4.4.4 *Corrosion properties* –. No data available

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 - No data available.

4.5.4 *Upper Explosive Limit* - Not applicable.

4.5.5 *Lower Explosive Limit* - Not applicable.

4.5.6 *Fire Risk*

Since helium is non flammable, special firefighting equipment and instructions are not needed. As a note of caution, however, water streams must not be directed toward venting helium, as the water will freeze and plug the pressure relief vent and may result in a container failure.

5 HEALTH HAZARD & TOXICITY INFORMATION

5.1 General Information

5.1.1 Being odorless, colorless, tasteless, and nonirritating, helium has no warning properties. Humans possess no senses that can detect the presence of helium. Although helium is nontoxic and inert, it can act as a simple asphyxiant by displacing the oxygen in air to levels below that

required to support life. Inhalation of helium in excessive amounts can cause dizziness, nausea, vomiting, loss of consciousness and death. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self rescue.

5.1.2 At low oxygen concentrations, unconsciousness and death may occur in seconds and without warning.

5.1.3 Personnel, including rescue workers, should not enter areas where the oxygen concentration is below 19.5 percent unless provided with a self-contained breathing apparatus or air-line respirator. For more information on oxygen deficient atmospheres. Extensive tissue damage or burns can result from exposure to liquid helium or cold helium vapors.

5.2 Routes of entry

5.2.1 *Skin*

Contact with liquid may cause cold burns/frostbite. May cause severe frostbite.

5.2.2 *Eyes*

Contact with liquid may cause cold burns/frostbite.

5.2.3 *Ingestion*

Ingestion is not considered a potential route of exposure.

5.2.4 *Inhalation*

In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Asphyxiation may bring about unconsciousness without warning and so rapidly that victim may be unable to protect themselves.

5.3 Toxicity information

a) Time Weighted Average (TWA) — No Data Available

b) Short Term Exposure Limit (STEL) — No Data Available

c) Immediately Dangerous to Life and Health (IDLH) – No Data Available

d) Lethal Dose (LD_{50}) — No Data Available

e) Inhalation (Rat) Lethal Concentration (LC) — No Data Available

5.4 Antidote

There is no antidote.

5.5 Health Effects

5.5.1. *Signs and Symptoms*

The sign and symptoms related to oxygen-deficient atmosphere is as prescribed in **Table 1**.

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 liquidhelium, it is in many instances the only practical means of protecting the worker, particularly in emergency situations. One should keep firmly in mind that personal protective equipment protects only the worker wearing it, and other unprotected workers in the area maybe exposed to danger.

6.1.2 Eyes are most sensitive to the extreme cold of liquid helium and its vapors. The recommended personal protective equipment when handling or using liquid helium is a full face shield over safety goggles; loose-fitting thermal insulated or leather gloves; and long sleeved shirts and pants without cuffs, especially whenever the possibility of exposure or a spill exists. In addition, safety shoes are recommended for those involved with the handling of liquid helium containers.

6.2 Non-Respiratory Equipment

6.2.1 *Eye and face Protection*

Eyes are most sensitive to the extreme cold of liquid helium and its vapors. The recommended personal protective equipment when handling or using liquid helium 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 helium 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 phenol 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 as described below:

6.3.1 *Self-Contained Breathing Apparatus*

This apparatus permit the wearer to carry a supply of oxygen or air compressed in the cylinder (*see* IS 10245 (Part 1)) and the self-generating type which produces oxygen chemically (*see* IS 15803). These allow considerable mobility. The length of time, a self-contained breathing apparatus provides protection varies according to the amount of air, oxygen, or regenerating’

material carried. Compressed oxygen should not be used where there is danger of contact with flammable liquids, vapours, or sources of ignition, especially in confined spaces, such as tanks or pits.

7 STORAGE, HANDLING, LABELLING AND TRANSPORT

7.1 General

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 50 °C (122 °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 Liquid helium shall be stored and used only in a well-ventilated place. If enough helium 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 Helium 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 helium shall not be disposed of in a confined area or a place where someone else may enter.

7.3.3 Liquid helium is colder than liquid oxygen. Therefore, if it is exposed to the air, oxygen from the air may condense into the liquid helium. If this is allowed to continue for any length of time, the oxygen content of the liquid helium may become appreciable and the liquid will require the same precautions as for handling liquid helium. However, most liquid nitrogen containers are entirely closed except for a small neck area and the nitrogen 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 helium`1 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 Liquid helium 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 Liquid helium 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. Cryogenic liquids in containers and piping at temperatures at or below the boiling point of liquefied helium [–302.6 °F (–185 °C)] can cause cold burn if touched.

7.3.16 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.

7.3.17 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 over-pressure prevention. Common pressure relief devices are a pressure relief valve for primary protection and a rupture disc for secondary protection.

7.3.18 Vaporization of a cryogenic liquid in an enclosed area can cause asphyxiation by displacing the air.

7.3.19 The cold "boil-off" gases condense the moisture in the surrounding air, creating a highly visible fog. This fog can also be formed around cold equipment when no release of the cold liquid or vapors has occurred. Fog clouds do not define the vapor cloud. They define the area where the vapors are still cold enough to condense the moisture in the air.

7.3.20 The vapors can extend well beyond the fog cloud, depending on the product and atmospheric conditions.

7.3.21 Although fog clouds may be indicative of a release, they must never be used to define the leak area and should not be entered by anyone. The dense fog clouds associated with the handling or transfer of cryogenic liquids can obstruct visibility. Care should be exercised so that any clouds do not interfere with vehicle traffic or safety escape routes.

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

7.3.23 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.

7.3.24 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.

Manufacturers name with label warnings required by regulations or ordinances form part of the label or placard.

7.4.2 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 General

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 liquid helium 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 liquid helium suppliers shall be contacted immediately.

7.5.2 *Driver*

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

7.2.3 *Air Transportation*

7.2.3.1 Air transportation of liquid helium requires special safety measures

in addition to those required for general shipment.

7.2.3.2 Liquid helium may only be transported by air when the container is specially equipped for air transportation and satisfies the appropriate legal requirements with regard to safety as well as packaging, labelling and documentation.

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

9.2 Spill will rapidly vaporize forming an oxygen deficient vapor cloud. Vapor cloud may obscure visibility. Do not direct water spray at container vent. Move away from container and

cool with water from a protected position. Keep containers and surroundings cool with water spray.

9.3 Wear self-contained breathing apparatus for firefighting if necessary.

10 TRAINING

10.1 All personnel directly involved in the commissioning, operation and maintenance of liquid helium 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 helium;

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 helium 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 helium 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 helium 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 *General Principles*

Remove victim to uncontaminated area wearing self-contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

11.1.2 *Contact with Skin*

In case of frostbite, obtain medical treatment immediately. As soon as practical, place the affected area in a warm water bath- which has a temperature not to exceed 40 °C (105 °F). Do not rub frozen parts as tissue damage may result. Cover wound with sterile dressing.

11.1.3 *Contact with Eye*

In the case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Keep eye wide open while rinsing.

11.1.4 *Ingestion*

Ingestion is not considered a potential route of exposure.

11.1.5 *Inhalation*

Move to fresh air. If breathing has stopped or is labored, give assisted respirations. Supplemental oxygen may be indicated. If the heart has stopped, trained personnel should begin cardiopulmonary resuscitation immediately. In case of shortness of breath, give oxygen.

12 ADDITIONAL INFORMATION

12.1 Transfer of Liquid Helium

12.1.1 Purging of cryogenic liquid vessels prior to use is essential to remove any matter considered undesirable to product purity, injurious to equipment functioning or hazardous to personnel. When purging a vessel, knowledge of the freezing and boiling points of all likely contaminants is important. When liquid helium vessels are involved, it shall be recognized that all other liquids and gases will solidify at liquid helium temperatures. Entrance, therefore, of any gas except pure, dry helium into a helium-cooled vessel will cause formation of solid deposits on internal cold surfaces, thus creating a very hazardous condition.

12.1.2 To purge such contaminants from a vessel at liquid helium temperature, it is necessary to remove any liquid helium present, and warm the vessel to the temperature corresponding to the highest boiling point of any of the contaminants suspected. Therefore, if air has been drawn into the vessel, the vessel shall be warmed to at least - 183°C (the boi1in.g point of oxygen) in order to purge the vessel of the air constituent having the highest boiling point. If moist air were drawn into the vessel, it would be necessary to warm the vessel to above the freezing point of water so that the water could be evaporated and the vessel purged with warm dry air or dry nitrogen.

12.1.3 It should be borne in mind that it is not possible to purge a vessel at liquid helium temperature (- 269°C) directly with nitrogen, since the purging fluid will immediately freeze upon contact with the helium cold vessel surfaces. However, once a vessel is warmed to above liquid nitrogen temperature, pure nitrogen gas at ambient temperature or above may be used for purging to speed the warming of the vessel. Likewise, if it is possible to utilize pure helium gas economically (such as in a recoverable system), it may be circulated directly through the liquid helium-cold vessel, warming it in one operation to the warmest boiling point temperature of any contaminant.

12.1.4 During purging, the temperature of the vessel may be best approximated at any given time by monitoring the temperature of the existing purge gas, which will normally be close to that of the inner vessel.

12.1.5 If a small vessel contains only pure helium gas, it may be filled directly with liquid helium without concern of contamination. However, if the vessel was first precooled with liquid nitrogen to conserve helium losses during filling, if would require complete removal of all nitrogen by purging the nitrogen-cold container with pure, dry helium gas before being filled with liquid helium.

12.2 Precooling

12.2.1 Depending upon economy, a 'warm' vessel (above liquid nitrogen temperature) may be cooled directly with cold helium gas produced from flash-off of liquid helium, or may be precooled with another cryogenic liquid, 'preferably liquid nitrogen for safety reasons.

12.2.2 If nitrogen precooling is used, the quantity of liquid nitrogen for cool-down should be no' greater in weight than the full liquid helium capacity of the vessel to prevent over-load-vessels suspension system. Equipment shall be provided for transferring the liquid nitrogen both into and out of the vessels, since the normal filling and withdrawal procedures for liquid helium containers may not work satisfactorily with the heavier, warmer liquid nitrogen.

12.2.3 Cool-down of transfer lines should always be accomplished wherever possible by trickling liquid helium into the line immediately prior to transfer,' thereby making maximum use of the sensible heat of the cold vapour to cool the line. Any attempt to cool the line with large quantities of liquid helium will result in abnormally high evaporation loss from cool-down.

12.2.4 Liquid nitrogen should never be used to precool a flexible helium transfer line; nitrogen is difficult to remove from the convolutions of the flexible line, and will later freeze and cause plugging.

12.3 Withdrawing Liquid Helium

12.3.1 Because of its very low latent heat of vaporization, liquid helium shall always be transferred through well-insulated., vacuum-jacketed lines. Non-vacuum insulation will result in total loss of liquid. The general procedures given in **12.3.1.1** to **12.3.1.7** should be used while withdrawing liquid from any helium container.

12.3.1.1 The transfer line and receiving vessel shall be adequately purged with pure, dry helium gas. Care shall be exercised to purge all joints before assembly of transfer components, and to purge any dead-ended or auxiliary parts of lines which will be helium cooled.

12.3.1.2 When withdrawal dip tubes are used, the dip tube should be inserted into a vessel through a section of rubber hose that may be clamped to the dip tube and container neck (unless other sealing provision is made) to prevent helium leakage about the tube. This is important to prevent loss of transfer ~pressure and also to avoid condensed air on the exposed portion of the dip tube from running into the vessel during removal of the tube.

12.3.1.3 Pressure for transfer may be provided by normal evaporation pressure build-up or by addition of pure helium gas from a regulated cylinder. The unusual properties of helium make low pressure transfer preferable. Transfers are generally made at a differential pressure of about 0.07 kg/cm^2 to 0.14 kg/cm^2 on gauge.

12.3.1.4 To prevent air, carbon dioxide or atmospheric moisture from freezing and causing restrictions in inlet and exhaust lines, a positive pressure shall be maintained at all times in the supplying and receiving vessels. When the ratio of venting falls off, a relief valve or other restriction should be added to retain positive pressure in the helium system.

12.3.1.5 In terminating transfer, the flow of external pressurizing gas (if used) should be immediately stopped so as not to add more warm gas to the supply vessel. The liquid withdrawal line should be immediately removed from open neck-tube type containers, or the liquid withdrawal valve of containers .so equipped, immediately closed. Any backflow of vapour through a withdrawal line will bubble up through the liquid and cause unnecessary evaporation of the remaining liquid helium.

12.3.1.6 Where protective caps are provided on transfer connections, they should be replaced immediately after transfer to prevent condensation of moisture on the cold connections.

12.3.1.7 When fill or withdrawal dip-tubes are removed from open neck-tube type helium containers, a closure containing a relief valve should be immediately secured over the opening.

12.4 Filling Small Vessels with Liquid Helium

12.4.1 The vacuum jacketed transfer tube should extend down into the vessel to or below the level at which liquid temperature is finally desired.

12.4.2 Liquid helium should not be impinged on the mass to be cooled. It should be directed toward the bottom of the vessel to prevent excessive boiling and splashing.

12.4.3 Openings into these vessels should be restricted or relief devices added after filling in order to maintain positive pressure in the vessel.

12.4.4 After a small helium vessel has-been precooled to liquid nitrogen temperature, it is more efficient to insert the transfer line into the small Dewar after cold helium vapour starts issuing from the transfer line. Otherwise, the expanding warm gas during cool-down of the transfer line may build up too much back pressure in a small Dewar.

12.4.5 After a small helium vessel has been filled, it is essential to remove the transfer line while liquid is still issuing from the line. If the transfer is stopped by reducing the pressure on the supply Dewar, the superheated liquid and gas in the transfer line may flash all the liquid in the small helium vessel before the transfer line is removed.