

# Liquid helium

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.

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## Manufacture

Most of commercial helium is recovered from natural gas through a cryogenic separation process. Normally, helium is present in less than 1% by volume in natural gas. Helium is recovered, refined, and liquefied. Liquid helium is typically shipped from production sources to storage and transfill facilities. Tankers, ranging in size from 5,000 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.

## Uses

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 nonflammable, helium is used to inflate balloons and airships.

## Health effects

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

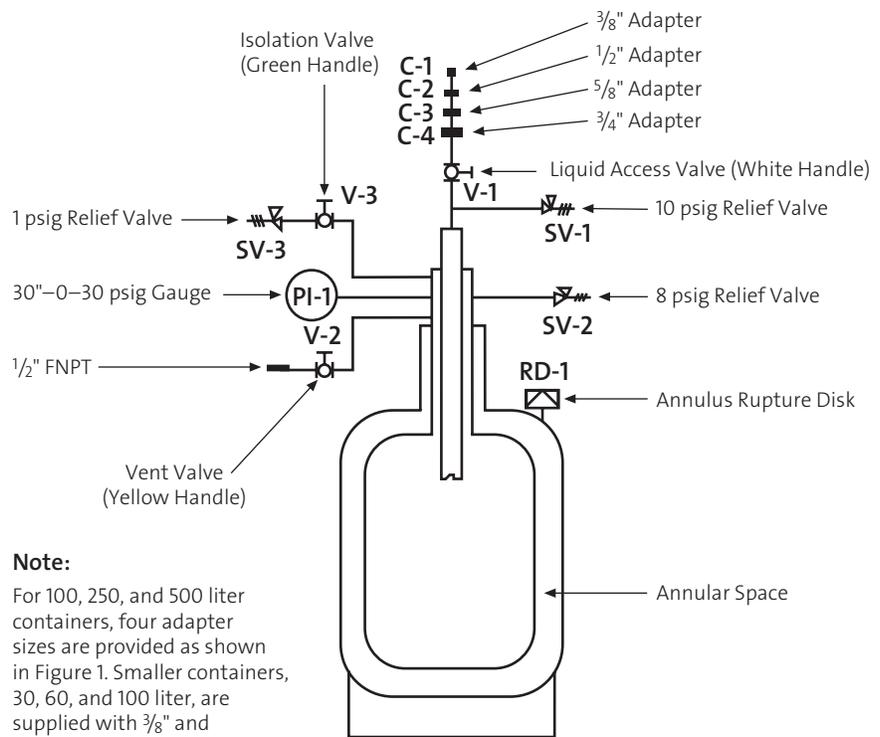
**Personnel, including rescue workers, should not enter areas where the oxygen concentration is below 19.5% unless provided with a self-contained breathing apparatus or air-line respirator.**

For more information on oxygen-deficient atmospheres, consult Air Products' Safetygram #17, "Dangers of Oxygen-Deficient Atmospheres." Extensive tissue damage or burns can result from exposure to liquid helium or cold helium vapors.

**Table 1: Liquid Helium Physical and Chemical Properties**

|  |  |
|--|--|
| Molecular Symbol                                   | He   |
| Molecular Weight                                   | 4.003  |
| Boiling Point @ 1 atm                              | -452.1°F (-268.9°C)                                  |
| Freezing Point @ 367 psia                          | -459.7°F (-272.2°C)                                  |
| Critical Temperature                               | -450.3°F (-268.0°C)                                  |
| Critical Pressure                                  | 33.0 psia (2.26 atm)                                 |
| Density, Liquid @ B.P., 1 atm                      | 7.802 lb/ft <sup>3</sup> (124.98 kg/m <sup>3</sup> ) |
| Density, Gas @ 70°F (21.1°C), 1 atm                | 0.0103 lb/ft <sup>3</sup> (0.165 kg/m <sup>3</sup> ) |
| Specific Gravity, Gas (air=1) @ 32°F (0°C), 1 atm  | 0.138  |
| Specific Gravity, Liquid @ B.P., 1 atm             | 0.125  |
| Specific Volume @ 32°F (0°C), 1 atm                | 89.77 ft <sup>3</sup> /lb (5.604 m <sup>3</sup> /kg) |
| Specific Volume @ 68°F (20°C), 1 atm               | 96.67 ft <sup>3</sup> /lb (6.035 m <sup>3</sup> /kg) |
| Latent Heat of Vaporization                        | 8.72 Btu/lb (20.28 kJ/kg)                            |
| Expansion Ratio, Liquid to Gas, B.P. to 32°F (0°C) | 1 to 754   |

**Figure 1: Liquid Helium Container Design Features**



**Figure 2: Proper Valve Positions**

## Containers

Liquid helium is stored, shipped, and handled primarily in vacuum-insulated liquid containers, which are sometimes mistakenly referred to as dewars. Liquid container capacities have been standardized to range from 30 liters to 500 liters. Larger quantities of liquid helium are transported in tanks with capacities ranging from 5,000 to 11,000 gallons.

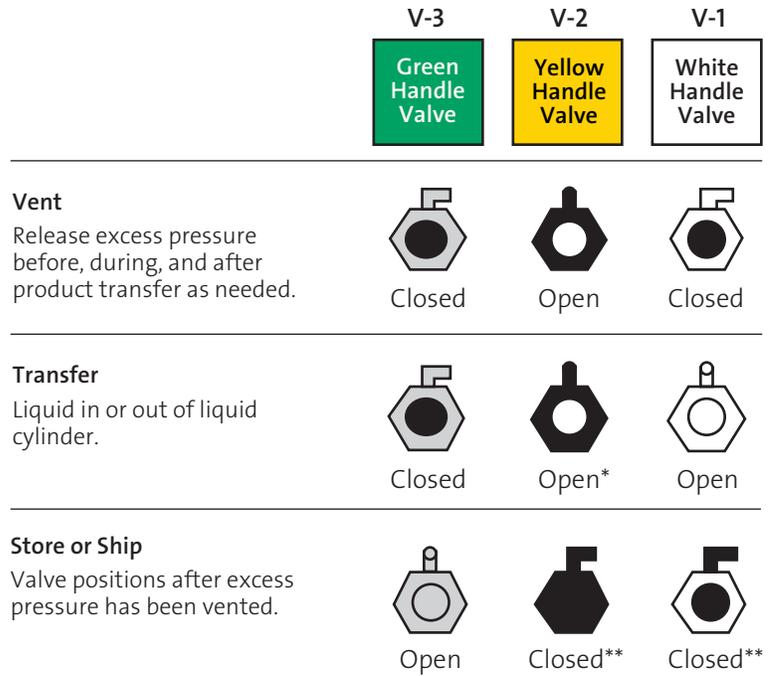
Since heat leak is always present, vaporization takes place continuously in smaller containers. Rates of vaporization vary, depending upon the design of the container and the volume of the stored product. Containers are designed and manufactured according to applicable codes and specifications for the pressures and temperatures encountered with liquid helium.

## Liquid cylinders

Liquid helium is most frequently provided to customers in a liquid cylinder. Figure 1 depicts a typical liquid container design. The liquid cylinder consists of two cylindrical vessels, one within the other. The annular space is evacuated and contains multilayer insulation. Helium is typically withdrawn as a liquid but may be withdrawn as a gas at low flow rates and pressure. Multiple pressure relief devices are installed on these liquid containers to protect against overpressure.

A 1 psig relief valve SV-3 protects the vessel from overpressure during shipment and storage. When the container is placed in service, an isolation valve V-3 is closed to isolate this pressure relief valve. The vessel pressure is now limited by an 8 psig relief valve SV-2. This permits the vessel to be pressurized to just under 8 psig to enhance the removal of liquid helium. The transfer tube has a 10 psig relief valve SV-1 to protect the container from any back-pressure from the filling operation. The outer vessel is protected by a rupture disk RD-1.

The user of any cryogenic liquid container should be thoroughly familiar with the product and the mechanical workings of the container before using the product. The appropriate liquid helium valve positions are presented in Figure 2. Valve handles on the container are color-coded green, yellow, and white. During transportation and storage, the liquid transfer valve V-1 (white) and the vent valve V-2 (yellow) are closed, while the isolation valve V-3 (green) is open to the auxiliary relief device.



**Failure to close these two valves may result in a potential hazard.**

\* The yellow valve is used to pressurize the liquid container with clean, dry helium gas.

\*\* Failure to close this valve may cause an ice plug in the neck of the liquid container, creating a potential hazard.

To transfer liquid helium, a vacuum-jacketed withdrawal stinger (dip tube) is first inserted through V-1 (white); V-3 (green) is closed and V-2 (yellow) is opened and used to pressurize the liquid container with clean, dry helium gas. When the container is pressurized to the desired level, the transfer of liquid helium can begin. Excess pressure in the container can be relieved before, during, and after the liquid helium is transferred. To vent gas, V-2 (yellow) can be opened.

Prior to placing the liquid container in storage or shipment, V1 (white) and V-2 (yellow) should be placed in the closed position, and V-3 (green) should be placed in the open position. Failure to close V-1 (white) and V-2 (yellow) may cause an ice plug in the neck of the liquid container, creating a potential hazard. Air Products does not recommend the removal or attempt to repair of any component of the liquid container package. If in doubt about the functionality of any part of the container, please contact Air Products for assistance.

Customers must be aware of the importance of correct valve positioning on liquid helium containers. Loss of product or potentially hazardous conditions may result from improper valve configuration.

**Figure 3: Nonflammable Gas Shipping Label**



### Transfer lines (vacuum-jacketed line)

A vacuum-jacketed (VJ) transfer line should be used to remove liquid product from the liquid containers. A typical transfer line provides a means to remove the liquid helium using either product vapor pressure buildup or an external pressure source to transfer product through this line. If an external source is used to pressurize the liquid container, pressure regulators and relief devices should be installed as necessary to adequately protect the lines from the external high-pressure source. Regulators and relief devices are intended to prevent overpressurization of the liquid container. Dry helium is the only acceptable gas for external pressurization of the liquid container. Using any other gas source for pressurization will cause potential ice plugs in the liquid container.

### Shipment of liquid helium

Containers used for transporting liquid helium at less than 25 psig (40 psia) pressure are UN/DOT authorized containers. Containers used for transporting liquid helium at pressures greater than 25 psig (40 psia) are required to be designed, manufactured, and tested to national or international specifications.

For air shipments, all packages must be in compliance with International Air Transport Association/International Civil Air Organization (IATA/ICAO) Dangerous Goods Regulations, as well as national ground transport regulations.

**Hazard Class:** 2.2

**Shipping Label:** Nonflammable Gas (Figure 3) except none for cargo tanks under 23 psig

**Identification Number:** UN1963

**Proper Shipping Name:** Helium, Refrigerated Liquid, 2.2, UN1963

## Safety considerations

The hazards associated with liquid helium are exposure to cold temperatures, which can cause severe burns; overpressurization due to expansion of small amounts of liquid into large volumes of gas in inadequately vented equipment; and asphyxiation due to displacement of oxygen in the air in confined work areas.

If oxygen-deficient atmospheres are suspected or can occur, use oxygen monitoring equipment to test for oxygen-deficient atmospheres. Review the liquid helium Material Safety Data Sheet (MSDS).

Attempting to transfer liquid helium in non-vacuum-jacketed piping can cause air surrounding the outside of the transfer pipe to condense and liquefy. The nitrogen in this liquid will evaporate first, leaving an enriched oxygen liquid behind. The area where this liquid collects should be insulated and oxygen-compatible.

Operating procedures recommended by Air Products for the use of liquid helium containers should be followed to avoid personnel injury and equipment damage. Should there be any question or problem when using the liquid helium container, contact Air Products immediately.

## Buildings

Because of the large expansion ratio of liquid to gas, it is very important to provide adequate ventilation in areas using liquid helium. A minimum of six air changes per hour is suggested in these areas.

Provide monitoring for areas where oxygen displacement may occur.

OSHA has established 19.5% oxygen concentration as the minimum for working without supplied air.

**Remember, helium has no warning properties!**

## Handling and storage

Helium equipment includes liquid containers, vacuum-jacketed transfer lines, process equipment, and accessories needed to safely handle and use the product.

1. Store liquid containers, when not in use or connected to a closed system, in a well-ventilated storage area.
2. When moving, never tip, slide or roll liquid containers on their side. Liquid or gaseous containers must be secured during transport. Keep the liquid containers vertical at all times. Avoid mechanical or thermal shock. Always move liquid helium containers by pushing, not pulling.
3. Liquid helium container valves should never be left open to atmosphere for extended periods. Keep the fill/withdrawal vent outlets closed to prevent contamination. Check the system regularly for frost accumulation. If restrictions resulting from freezing moisture or air or foreign material are present in openings or vents, immediately contact Air Products for instructions; blockage or restriction of openings or vents may lead to excessive vessel pressure and subsequent rupture. Do not attempt to remove restrictions without proper instructions from the liquid helium supplier. If possible, move the liquid helium container to a remote location.
4. Provide a safety relief valve on any part of the system where liquid can be trapped between closed valves in lines or vessels.

5. Transfer liquid helium from containers by using the product vapor pressure or external gaseous product pressure. Use pressure reducing valves and pressure relief devices, as necessary, if the pressure source is high. Dry gaseous helium should also be used to purge the transfer lines and receiving vessels prior to liquid helium transfer. Transfer lines should be well insulated and vacuum jacketed. Never pour liquid helium out of the container. Refer to Figure 1 and Figure 2 for proper valve orientation.
6. Provide protection for liquid helium containers against extremes of weather where outside storage areas are used.
7. Some elastomers and metals, such as carbon steel, may become brittle at low temperatures and will easily fracture. These materials must be avoided in cryogenic service. It is recommended that all vents be piped to the exterior of the building.

## Personal protective equipment (PPE)

Personnel must be thoroughly familiar with properties and safety considerations before being allowed to handle liquid helium and/or its associated equipment.

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 glasses, loose-fitting thermal insulated or leather gloves, and long-sleeved shirts and pants without cuffs worn on the outside of boots, 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.

In emergency situations, self-contained breathing apparatus (SCBA) must be used.

## First aid

People suffering from lack of oxygen should be moved to fresh air. If the victim is not breathing, administer artificial respiration. If breathing is difficult, administer oxygen. Obtain immediate medical attention.

### **Self-contained breathing apparatus (SCBA) may be required to prevent asphyxiation of rescue personnel.**

For skin contact with cryogenic liquid helium, 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 that has a temperature not in excess of 105°F (40°C). Never use dry heat.

Call a physician as soon as possible. Frozen tissue is painless and appears waxy with a possible yellow color. It will become swollen, painful, and prone to infection when thawed. If the frozen part of the body has been thawed, cover the area with a dry, sterile dressing and a large, bulky protective covering, pending medical care.

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

If the eyes are exposed to the extreme cold of the liquid helium or its vapors, immediately warm the frostbite area with warm water not exceeding 105°F (40°C) and seek immediate medical attention.

## Fire fighting

Since helium is nonflammable, special fire fighting 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.

### Emergency Response System

T 800-523-9374 (Continental U.S. and Puerto Rico)

T +1-610-481-7711 (other locations)

For regional ER telephone numbers, please refer to the local SDS 24 hours a day, 7 days a week for assistance involving Air Products and Chemicals, Inc. products

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### Technical Information Center

T 800-752-1597 (U.S.)

T +1-610-481-8565 (other locations)

Monday–Friday, 8:00 a.m.–5:00 p.m. EST

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