

# Cryogenic Liquid Containers

Cryogenic liquid containers, also referred to as liquid cylinders, are designed for the reliable and economic transportation and storage of liquefied gases at cryogenic temperatures, typically colder than -130°F (-90°C). The products found in liquid containers are nitrogen, argon, oxygen, helium, carbon dioxide and nitrous oxide. The containers are double-walled, vacuum vessels with multilayer insulation in the annular space. The two primary advantages of a liquid container are that it contains a large volume of gas at a relatively low pressure and it provides a source of cryogenic liquids which can be easily handled.

Although these containers are well insulated, heat will continuously leak into the product, due to the extremely large temperature difference between the cryogenic liquid and the ambient environment. The heat leak will cause some vaporization to occur. Vaporized product, if not used, will collect in the vapor space above the liquid and build pressure—called the head pressure. Head pressure will build in the container and periodically vent via the pressure relief valve. Vaporization rates will vary and may be as low as 0.4% or as high as 3% of the container's volume per day. This is a normal and safe function of the container.

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.

## General Safety Precautions

The potential hazards for handling cryogenic liquids, in addition to those observed for their respective gases, stem from two properties: extremely cold temperature and the expansion ratio.

The extremely cold temperatures of cryogenic liquids can rapidly freeze human tissue. Leather or insulated gloves and other protective clothing should be worn when operating valves or when the potential exists for contact with product or exposed cold piping. This includes long cuffless pants, long-sleeved shirt, safety glasses, and full face shield.

All cryogenic liquids produce large volumes of gas when they vaporize. The expansion ratio is the amount of gas generated from a given amount of liquid. Table 1 shows the liquid-to-gas expansion ratios for the common cryogenic fluids. If a sufficient amount of liquid is vaporized within a closed container, it will produce enormous pressures that could rupture the vessel. For this reason, cryogenic liquid containers are protected with multiple pressure relief devices. Similarly, any system for the storage and delivery of cryogenic liquids should be carefully designed to avoid trapping cryogenic liquid at any point in the system by installing a relief device.

If liquid nitrogen, argon or helium is accidentally released in a confined space, a dangerous oxygen-deficient atmosphere could be created. Use and store liquid containers in well ventilated areas. The released gas will displace the oxygen concentration in the air. A small spill of liquid will produce a large volume of gas which can, and will, change the conditions of the ambient environment in a confined space very quickly. For example, a spill of one cubic foot of liquid nitrogen will vaporize to 696 equivalent volumes of gas at 70°F. An oxygen-deficient atmosphere can lead to rapid asphyxiation (suffocation). This can cause loss of consciousness and may result in serious injury or death. Never enter an area where oxygen levels are below 19.5% without the use of supplied air.

If liquid oxygen is released, an oxygen-enriched atmosphere could result. An oxygen-enriched atmosphere is dangerous due to the increased potential for a fire to occur. Although oxygen itself is nonflammable, ordinary combustible materials will burn more vigorously. Materials that normally do not burn in air may burn in an oxygen-enriched atmosphere.

## Elevator Transport

Section to Be Modified please come back later.

## Cylinder Tipping or Damage

Always keep liquid containers upright and as near to their correct orientation as possible during storage, transportation, and use. If a liquid container falls over, allow 15 minutes for the container to settle, and assess its structural integrity before approaching it. A minimum of two persons are required to return it to an upright position. They should utilize a mechanical lifting device (e.g., block and tackle, hoist, or crane) secured to an overhead support, such as a portable tripod, capable of supporting the weight. Immediately notify the supplier of this situation.

The team should wear full face shields and gloves and return the container to the upright position. Vent any excess pressure. If there is no buildup of pressure or visible external damage, the container may be returned to service. Notify the supplier of the incident.

**Table 1**

Expansion Ratios at 70°F of Common Cryogenic Fluids (Liquid to Gas\*)

Cryogenic Liquid	Expansion Ratio
Argon	1 to 841
Helium	1 to 754
Hydrogen	1 to 848
Nitrogen	1 to 696
Oxygen	1 to 861

\*For Example, 1 cubic foot of liquid argon will create 841 cubic feet of gaseous argon at 70°F

Container damage may create a hazardous condition and may not be immediately evident. If the container rapidly builds pressure or shows any signs of malfunction, vent it carefully into a well ventilated, safe area. Call your supplier for further instructions.

## Handling and Storage

Liquid containers are supplied in different sizes. A typical 180-liter unit weighs approximately 260 pounds (118 kg) when empty and as much as 774 pounds (351 kg) when filled with liquid argon. Due to their weight and bulkiness, care must be taken when handling and storing liquid containers. Mechanical handling devices should always be used to move them if they are not already equipped with wheels.

### Handling

Liquid 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 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. Liquid containers should only be transported in an upright position and should never be laid on their side. Never roll these containers on their side.

Liquid containers equipped with wheels should always be moved by pushing the container, never pulling it. This reduces the possibility of the container falling on you or a coworker, in the event it becomes unstable.

### Storage

Liquid containers should always be stored in an upright position. Despite the superinsulation used in liquid containers, some heat leak is unavoidable. As a result, when product is not being withdrawn, pressure within the container will gradually increase, due to the small amount of liquid product vaporized by the heat leak. Pressure builds up until the pressure relief device functions and then reseats. This type of venting is usually normal and indicates the container is being protected from over-pressurization. Therefore, it is recommended that liquid containers are stored and used in well ventilated areas or areas with forced ventila-

tion. If this is not possible, monitoring of the area for oxygen concentration is essential. Storage areas, in addition to being well ventilated, should be secure and protected from the weather. Containers should be stored away from air intakes, high traffic areas, floor drains, and other underground openings. The escaping cold gas will be heavier than the surrounding air and will accumulate in low-lying areas.

### Operation

**Caution:** Before use, always confirm that the CGA fittings are appropriate for the product identified on the cylinder label. If a mismatch appears, do not attempt to use the container. Contact your supplier for assistance immediately.

Cryogenic liquid containers are available in a variety of designs, to allow for a variety of product withdrawal modes. Most containers allow either gas or liquid withdrawal, although some allow for only gas or liquid withdrawal. Users must be familiar with the type of container they are using for their application and must ensure that the proper connections for that container are in place.

### Gas Withdrawal:

To withdraw gas from the container, connect the inlet of a suitable pressure regulator or control valve to the gas withdrawal valve, and the outlet of the regulator or valve to the system receiving the gas. Open the withdrawal and the pressure building valves until the container pressure reaches the desired pressure, for example, 125 psig. At this point you may begin withdrawing gas.

**Caution:** When withdrawing gas from the container, the capacity of the internal vaporizer can be exceeded. If gas is withdrawn at a rate greater than the vaporizer capacity, liquid or very cold gas will be discharged. Severe damage to external equipment or injury to personnel could occur from the extremely cold temperature of the product being withdrawn.

If a higher product withdrawal rate is desired, two or more containers can be manifolded together. This will reduce the draw on each container to a safe rate. If two or more containers are manifolded, the vent valves should also be connected together to ensure pressure equilibration between all the containers.

### Liquid Withdrawal:

**Note:** For liquid use requirements, the container should normally be specified with the 22 psig relief valve. Minimizing the pressure reduces the product loss due to flash-off.

Connect a transfer line from the liquid valve to the user's system or vessel being filled. Open the liquid valve to obtain the desired rate of flow. Close the liquid valve when finished. To prevent back-contamination in the container, all valves should be closed when the container has been emptied.

If high withdrawal rates require additional pressure, open the pressure building valve only until the required pressure is obtained, then close the valve. (This feature is not available on 22 psig containers equipped for liquid withdrawal only.)

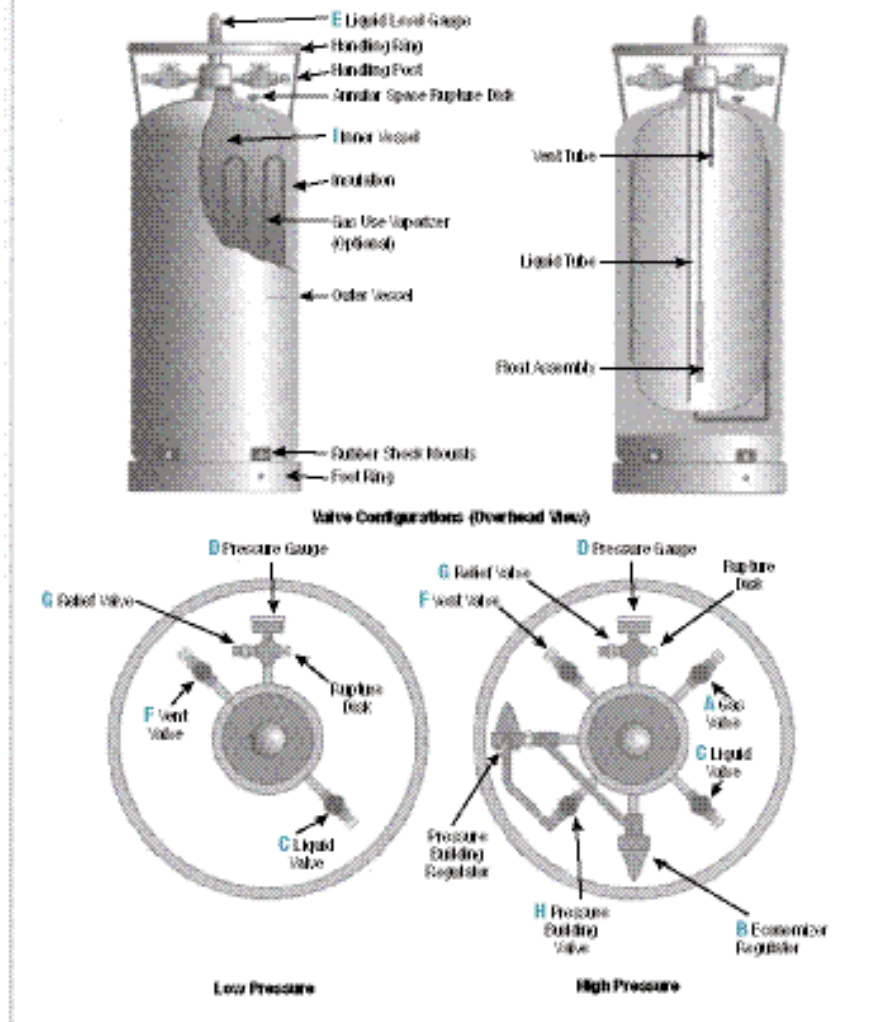
**Caution:** Always wear a full face shield and gloves when transferring liquid product. Transfer of liquid at pressures higher than 22 psig into open vessels such as small dewars can lead to excessive splashing of the product, which may come in contact with the operator or nearby personnel. Care should be exercised to avoid skin or other tissue contact with any cold surface. Always read product labels before using.

### Container Design

In order to safely withdraw gas or cryogenic liquid from a liquid container, it is important to be familiar with the container design and proper functioning of the components. Low-pressure liquid containers are designed for cryogenic liquid withdrawal only, whereas high-pressure liquid containers provide economic, efficient gaseous withdrawal in addition to liquid withdrawal. These containers are designed to operate under pressure and contain automatic pressure building to maintain delivery pressure. These containers could be used for all cryogenic liquids except hydrogen and helium.

Low-pressure liquid containers operate at pressures up to 22 psig while high-pressure liquid containers operate at pressures up to 230 psig. Super-high-pressure containers that operate at pressures up to 350 psig are also available. Always ensure regulator and container pressure compatibility prior to making connections.

**Figure 1. Cryogenic Liquid Vessels**



The most common liquid container sizes are 160-liter, 180-liter and 230-liter. Storage volumes and gas delivery rates vary.

There are a number of operating components outside and inside the container. These features are illustrated in Figure 1.

**Gas Withdrawal Valve (A):** This valve allows gaseous product withdrawal through the internal vaporizer and/or the economizer. It has the recommended Compressed Gas Association (CGA) connection that matches the gas service for which the container is configured. *Never remove or exchange this connection, or use adapting fittings.* If the fittings mismatch, contact your supplier immediately for assistance.

**Economizer (B):** When the head pressure is near the relief setting, an economizer circuit preferentially directs gas from the vapor space to the gas use valve when it is open. This minimizes the loss of gas to over-pressurization venting. Excess pressure in the vapor space of the container is relieved to the gas use valve outlet while preserving normal operating pressure. The economizer requires no operator attention and will function automatically.

**Liquid Withdrawal Valve (C):** Liquid product is added or withdrawn from the container through the connection controlled by this valve. It has a CGA connection specified for the appropriate cryogenic liquid. *Never remove or exchange this connection.*

**Pressure Gauge (D):** The pressure gauge displays the internal container pressure. It does not indicate the volume of product in the container.

**Contents Gauge (E):** This is a float-type liquid level gauge. This is used to indicate the approximate amount of container contents.

**Vent Valve (F):** This controls a line into the vapor space of the container. It is primarily used in the fill process to vent the vapor space while filling and can be used to vent unwanted pressure during storage and use.

**Relief Devices (G):** To protect the container from over-pressurization, it is equipped with two relief devices. The first is a reseating spring-loaded relief valve that, depending on the setting, will relieve pressure at 22 psig, 230 psig, or 350 psig. The second is a burst disk rated to protect the inner vessel. *Never plug, restrict, or remove any relief device. Never attempt to cap or seal a venting relief device in any way.* Notify your supplier about any container that continuously vents through any of the relief devices.

*Caution: Some liquid containers may be equipped with a threaded connection on the outlet of the relief device. This is only for users to connect vent piping to the relief device to safely exhaust venting gas. It is recommended that vent lines be exhausted outdoors or to a safe, well ventilated location. Never place a cap or plug on this device as this will defeat the container's pressure relief capability.*

**Pressure Building Valve (H):** The pressure building circuit is used to create sufficient operating pressure. It is controlled by a regulator that opens to allow liquid to flow from the bottom of the container, through a vaporizer, where it becomes a gas. The gas then collects in the vapor space at the top of the container. The vaporization of the liquid into gas increases the pressure in the container.

**Internal Vaporizer (I):** This is an internal heat exchanger that functions as a gas vaporizing coil to convert liquid product to gas.