

Liquid Nitrogen Use Guidelines

Liquid nitrogen is inert, colorless, odorless, non corrosive, nonflammable, and extremely cold. Nitrogen makes up the major portion of the atmosphere (78% by volume). Nitrogen is inert and will not support combustion; however, it is not life supporting. When nitrogen is converted to liquid form it becomes a cryogenic liquid.

Cryogenic liquids are liquefied gases that have a normal boiling point below -150°C (-238°F). Liquid nitrogen has a boiling point of -195.8°C (-320.5°F). All cryogenic liquids produce large amounts of gas when they vaporize.

Health Effects

Extensive tissue damage or burns can result from exposure to liquid nitrogen or cold nitrogen vapors.

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

Containers

Liquid nitrogen is stored, shipped, and handled in several types of containers, depending upon the quantity required by the user. The types of containers in use are the dewar, cryogenic liquid cylinder, and cryogenic storage tank.

Dewars

This type of container is a non-pressurized container. The unit of measure for the capacity of a dewar is typically the liter. Five to 200 liter 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.

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 buildup. These containers operate at pressures up to 350 psig and have capacities between 80 and 450 liters of liquid.

Cryogenic Storage Tanks

Tanks may be spherical or cylindrical in shape. They are mounted in fixed locations as stationary vessels. Tanks are designed to ASME specifications for the pressures and temperatures involved.

Use only suitable vessels for the handling and/or transport of cryogenic liquids. Do not store liquid nitrogen in any container with a tight fitting lid; a loose fitting lid helps preventing air and moisture from entering the container and at the same time allows pressure to escape.

Safety Considerations

Cold contact burns

Liquid or low-temperature gas from any of the specified cryogenic substances will produce effects on the skin similar to a burn. The extremely low temperature of the liquid can cause severe frostbite or eye damage upon contact. Symptoms of frostbite include change in skin color to white or grayish yellow and the pain after contact with liquid nitrogen may quickly subside. Items in contact with liquid nitrogen become extremely cold. Touching these items may result in torn flesh.

Asphyxiation

Liquid nitrogen gas released in a confined space can displace sufficient oxygen to make the atmosphere incapable of sustaining life and cause asphyxiation without warning. Degrees of asphyxia will occur when the oxygen content of the working environment is less than 20.9% by volume. Effects from oxygen deficiency become noticeable at levels below ~ 18% and sudden death may occur at ~ 6% oxygen content by volume. This decrease in oxygen content can be caused by a failure/leak of the cryogenic vessel or transfer line and subsequent vaporization of the cryogen.

Explosion – Pressure

Heat flux into the cryogen from the environment will vaporize the liquid and potentially cause pressure buildup in cryogenic containment vessels and transfer lines. On vaporization liquid nitrogen expands by a factor of 696; one liter of liquid nitrogen becomes 24.6 cubic feet of nitrogen gas. Adequate pressure relief must be provided to all parts of a system to permit this routine out gassing and prevent explosion.

Explosions – Chemical

Cryogenic fluids with a boiling point below that of liquid oxygen are able to condense oxygen from the atmosphere. Repeated replenishment of the system can thereby cause oxygen to accumulate as an unwanted contaminant. Similar oxygen enrichment may occur where condensed air accumulates on the exterior of cryogenic piping. Violent reactions, e.g. rapid

combustions or explosion, may occur if the materials which make contact with the oxygen are combustible.

Buildings

Because of the large expansion ratio of liquid to gas (1:696), it is important to provide adequate ventilation in areas using liquid nitrogen. A minimum of six air changes per hour is required in these areas.

Oxygen level monitoring should be provided for areas where oxygen displacement may occur.

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

Remember, nitrogen has no warning properties!

Storage and Handling

Store and use liquid nitrogen containers with adequate ventilation. Do not store containers in confined areas or in areas unprotected from the extremes of weather. Cryogenic containers are equipped with pressure relief devices designed to control the internal pressure. Under normal condition these containers will periodically vent product. Do not plug, remove or tamper with any pressure relief device.

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 container by pushing, not pulling.

Use freight elevators whenever possible to transport liquid nitrogen. Do not ride in the elevator with the liquid nitrogen. Make arrangements for someone to send the elevator to a receiving person waiting on the desired floor.

Avoid mechanical and thermal shock.

Never leave the vessel unattended while transferring liquid nitrogen. Ensure that the delivery of the liquid nitrogen is directly below the mouth of the receiving vessel. Always fill warm dewars slowly to reduce temperature shock effects and to minimize splashing. Do not fill cylinders and dewars to more than 80% of capacity.

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.

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 adapters.

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.

On gas withdrawal systems use check valves or other protective apparatus to prevent reverse flow in the containers. On liquid systems pressure relief devices must be used in lines where there is the potential to trap liquid between valves. It is recommended that all vents be piped to the exterior of the building.

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 a remote location.

Storage of Cryovials

Use only manufacturer approved containers (e.g. cryovials) for storage in liquid nitrogen.

Laboratory personnel must use extreme caution when preserving samples in liquid nitrogen. Liquid nitrogen storage consists of a liquid phase and a gaseous phase. If cryovials are immersed in the liquid phase, liquid nitrogen can enter the closed cryovials during storage. The cryovial may then explode when it is removed from storage due to the vaporization and expansion (1:696 expansion ratio) of the liquid nitrogen inside the cryovial.

Do not store cryovials in the liquid phase of liquid nitrogen unless specifically approved by the manufacturer for liquid phase storage. If storage in the liquid nitrogen liquid phase is required use only manufacturer approved cryovials specifically designed for liquid phase storage. Use gaseous phase approved cryovials that are then sealed in an outer protective envelope designed for use in liquid nitrogen. The risk of explosion of cryovials stored in the liquid phase can be reduced by moving cryovials to the gaseous phase in the liquid nitrogen container for at least 24 hours prior to removal.

Personal Protective Equipment (PPE)

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

Eyes are most sensitive to the extreme cold of liquid nitrogen and its vapors. The recommended personal protective equipment when handling or using liquid nitrogen is a full face shield over safety glasses/goggles; loose-fitting thermal insulated gloves; and long-sleeved shirts and pants

without cuffs. In addition, safety shoes are recommended for those involved with the handling of liquid nitrogen containers.

First Aid

In the event a person is injured by liquid nitrogen, the following first aid treatment should be given pending the care of a physician ONLY if there is no risk to you.

For skin contact with cryogenic liquid nitrogen, remove any clothing that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. People with frostbitten feet should not walk on them. 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.

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 with a large bulky protective covering, pending medical care. In case of massive exposure, remove clothing while showering the victim with warm water. Do not use hot water. Call a physician immediately.

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

Take a copy of the MSDS to the physician.

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. Do not attempt to rescue an individual that has been overcome due to lack of oxygen. The rescuer then becomes the second victim.

References

Air Products Safetygram-7: Liquid Nitrogen
Air Products Safetygram-27: Cryogenic Liquid Containers
Nunc™ Cryopreservation Manual