



Cryogen Safety

**Campus Safety
University of Lethbridge**

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University Of Lethbridge - Cryogen Safety

1. Introduction

Cryogenic liquids (cryogenics) are compressed liquefied gases that are kept in their liquid state at very low temperatures. All cryogenic liquids are gases at normal temperatures and pressures and have boiling points below -150°C(- 238°F) (Carbon dioxide – dry ice – has a higher boiling point and is sometimes included in this category).

Different cryogenics become liquids under different conditions of temperature and pressure, but all have two properties in common:

- they are extremely cold,
- and small amounts of liquid can expand into very large volumes of gas.

The vapours and gases released from cryogenics also remain very cold. They often condense the moisture in air, creating a highly visible fog. Under certain conditions, some cryogenics may condense the surrounding air forming a liquid air mixture.

All personnel who work with cryogenics must be aware of their hazards and know how to work safely with them. Anyone using cryogenics (e.g. liquid nitrogen, liquid helium, dry ice) requires cryogen safety training.

It is the responsibility of PI or Supervisor to ensure that all staff and students have completed cryogen training BEFORE working with cryogenics. All cryogen training needs to be documented and retained by the PI or Supervisor.

1.1 U of L Cryogen Training

Cryogen training is provided in two parts:

Part One - general cryogen safety training (online) Contact safety.services@uleth.ca to register.

Part Two - job specific cryogen training is to be completed in the worksite with PI or Supervisor. This training will include practical hands-on training for using the liquid nitrogen filling station and job-specific training including safe work procedures to be used by the employee (student) while fulfilling his/her work duties.

Cryogen Training is to be documented using the [Cryogen Safety Training and Competency Record.](#)

1.2 Properties of Dry Ice and Safe Handling

Dry ice is solid carbon dioxide (-78 and -110 degrees Celsius) that will sublime to carbon dioxide gas. It has hazards similar to liquid nitrogen and helium. The expansion ratio of solid to gas can displace air in an enclosed area and cause asphyxiation.

Do not place dry ice inside an air tight container. Sublimed vapors will increase the interior pressure and will rupture the container. Store in an insulated cooler (Styrofoam).

Dry ice can freeze exposed skin and must be carefully handled. Wear PPE: full coverage clothing and shoes, lab coat, insulated gloves, and safety glasses. Also wear a face shield if breaking up large pieces of dry ice. Use tongs for handling dry ice.

Dispose of dry ice in a well-ventilated area (e.g. fume hood). Do not dispose in a sink.

1.3 Types of Cryogenics

There are two types of cryogenic liquids used at the U of L:

- Liquid nitrogen
- Liquid helium

Nitrogen and helium are inert gases that do not react chemically to any great extent. They do not burn or support combustion. Liquid nitrogen is used for preservation of tissue samples and lab experiments requiring cold temperatures. Liquid helium and nitrogen are used to cool the superconducting electromagnet in Nuclear Magnetic Resonance (NMR) Spectrometers. Smaller amounts of liquid helium are sometimes used in other instruments.

Dry ice, Carbon Dioxide in a cryogenic solid state, is also frequently used at the U of L. It will undergo sublimation from the solid to gaseous state. It is used with commercial shipments of perishables, for cooling reaction temperatures, etc.

Table 1. Physical properties of various cryogenes.

Properties	Cryogen							
	Ar	He	H ₂	Ne	N ₂	O ₂	CH ₄	CO ₂
Boiling point (1 atm)								
°C	-186	-269	-253	-246	-196	-183	-161	-78
°F	-303	-452	-423	-411	-321	-297	-256	-108
Critical temperature								
°C	-122	-268		-229	-147	-118	-82	31
°F	-188	-450		-379	-232	-181	-116	88
Liquid density, g/l	1402	125	71	1206	808	1410	425	1560
Gas density (27°C), g/l	1.63	0.16	0.082	0.82	2.25	1.4	0.72	2.0
Liquid-to-gas expansion ratio	860	780	865	1470	710	875	650	790
Flammable	No	No	Yes	No	No	No ^a	Yes	No

^a Although oxygen does not burn, it will support combustion. Oxygen-enriched atmospheres may lead to violent reactions, such as rapid combustion or explosions with incompatible materials.

2.0 Storage and Containment

Sources of cryogenic liquids on the U of L campus:

1. A bulk liquid nitrogen storage tank is located within an enclosure outside of the fourth level of University Hall. The dispensing station is located at B422.
2. Liquid helium is delivered by the supplier in portable pressurized tanks.

Note: dry ice may be purchased from a local supplier or made on-site using specially designed equipment.

2.1 Types Of Storage Containers For Cryogenic Liquids

Cryogenic liquids are shipped and used in thermally insulated containers that are specifically designed to withstand rapid temperature changes and extreme differences

in temperature. These vessels, called Dewars are usually insulated by vacuum jacketing and may have pressure relief valves to protect against over-pressurization.

2.1.1 Liquid Dewar Flasks. Liquid Dewar flasks are non-pressurized, vacuum-jacketed vessels, similar to a "Thermos bottle". They should have a loose fitting cap or plug that prevents air and moisture from entering, yet allows excess pressure to vent. Use only the stopper or plug supplied with the container.



Figure 1. Dewar flasks.

2.1.2 Laboratory Liquid Dewar Flasks. Laboratory liquid Dewars have wide-mouthed openings and do not have lids or covers. These small containers are primarily used in laboratories for temporary storage and convenient transfer.

2.1.3 Pressurized Liquid Cylinders and Dewars. Liquid cylinders are pressurized containers specifically designed for cryogenic liquids. This type of container has valves for filling and dispensing the cryogenic liquid, and a pressure-control valve with a frangible (bursting) disk as backup protection.



Figure 2. Pressurized Dewar flask (left); valve system (right).

2.2 Storing Cryogenics

Keep non-pressurized Dewar flasks covered with a loose fitting cap. This method prevents air or moisture from entering the container yet allows pressure to escape. Use only the stopper or plug supplied with the container.

Ensure that ice does not form in the neck of flasks. Liquids such as helium can freeze the water vapour in the surrounding air, including the air itself, creating an ice block. Pressure may slowly build up and may cause a violent rupture. Moving parts, such as valves or pressure relief devices, can malfunction due to external ice formation.

Inspect all incoming containers before storing to ensure they are not damaged and are properly labeled. Ensure that valves designed for pressure relief are in the open position. Dry ice may be stored in approved insulated containers (e.g. Styrofoam coolers).

Store containers in well-ventilated areas, away from sources of heat and moisture.

3.0 Hazards

If not handled correctly, cryogenics may be hazardous to personnel. There are four major hazards associated with cryogenics: extremely cold temperatures, asphyxiation, oxygen enrichment, and over pressurization of containers and systems.

3.1 Extremely Cold Temperatures

Cryogenics are extremely cold and can cause instant, severe frostbite. A jet of cryogen vapor can freeze the skin or eyes faster than liquid contact. Tissue damage may be extensive, particularly if the eyes are involved; permanent damage may result. Contact with cryogenics can freeze tissue and produce a cryogenic burn or frostbite. Unprotected skin may adhere to metal that is cooled by cryogenics. The skin can tear when pulled away.

Even non-metallic materials are dangerous to touch at low temperatures. At cryogenic temperatures, many materials, such as rubber, plastic and carbon steel can become so brittle that they shatter. Only materials approved for use with cryogenics should be used.

3.2 Asphyxiation

Air consists of 78% nitrogen, 21% oxygen, and trace gases making up the remaining 1%. Cryogenics can create oxygen deficiency because they have large liquid-to-gas expansion ratios (generally >700). For example, one litre of liquid nitrogen vapourizes to 696 litres of nitrogen gas when warmed to room temperature. A small liquid spill produces a large volume of gas that can displace the air in a confined space, thus creating a serious oxygen deficiency (<19.5% oxygen) that can asphyxiate occupants of the area. Although nitrogen is non-toxic, it will displace air and can create a hazardous work environment.

Simple asphyxiants, such as nitrogen do not have good warning properties and one may simply pass out without any warning and may die without regaining consciousness. Oxygen sensors should be used in confined areas to indicate oxygen deficiency. The NMR labs at CCBN and in University Hall have oxygen sensor systems.

3.3. Oxygen Enrichment.

Liquid helium is so cold that it can liquefy air upon contact. When transferring nitrogen through uninsulated metal pipes, the air surrounding the containment system may condense. Nitrogen, which has a lower boiling point than oxygen, will evaporate first. This can leave an oxygen-enriched condensate on the surface that may increase the flammability (combustibility) of materials near the system, presenting all of the same hazards as liquid oxygen. Many materials considered non-combustible could burn in the presence of liquid oxygen.

3.4 Over-pressurization of Containers and Systems

Without adequate venting or pressure-relief devices on the containers, enormous pressures can build up. Cryogenics boil as they sit in their storage vessels by absorbing heat energy from their much warmer surroundings. The gas boiling out of the liquid must escape or the pressure will increase. The pressure can cause an explosion called a "boiling liquid expanding vapour explosion" (BLEVE). Users must ensure that cryogenics are never contained in a closed system. Use a pressure relief vessel or a venting lid to protect against pressure build up. Unusual or accidental conditions such as an external fire, or a break in the vacuum which provides thermal insulation, may cause a very rapid pressure rise. Since the pressure relief valve may not be able to handle this increased pressure, the containers must also have another backup device such as a frangible (bursting) disc.

The expansion ratio for liquid nitrogen to gas is approximately 1:700. This means as it vaporizes the volume it occupies will expand close to 700 times. If liquid nitrogen gets into a vial, this expansion rate is what causes vials to explode when removed from liquid nitrogen storage. Liquid nitrogen can get into a vial if: the vial is defective or past its expiration date; if the vials are over or under tightened; if there is water on the vial threads; or if the wrong type of vials are used. There are various suppliers of cryogenic vials. Most manufacturers do not recommend storage in liquid nitrogen but in vapour phase only.

Safety precautions for removing vials from liquid nitrogen:

- 1. Always wear a face shield and other PPE when removing vials from liquid nitrogen.**
- 2. Immediately loosen the lid and put vials in a container or behind a shield when thawing.**
- 3. Do not remove PPE until the vials have reached room temperature.**
- 4. Do not hold tubes in your hand to warm them up.**
- 5. Never mix liquid nitrogen with ice or water. Ice can solidify around it, trapping gas at high pressure and the ice can become a projectile.**
- 6. Select vials which are specially designed for liquid nitrogen storage.**

3.5 Exposure to Excessive Noise

Noise levels produced when filling open Dewars at B422 may exceed Occupational Exposure Limits for noise. Always wear the ear plugs and ear muffs provided to protect yourself from hearing loss.

4.0 Personal Protective Equipment

4.1 Avoid Skin Contact

Cover all exposed skin by wearing long sleeve shirts, long pants, a long sleeved lab coat, and shoes that fully cover the feet. It is recommended that canvas shoes not be worn, canvas absorbs LN and can increase the potential for burns. Gloves should be loose-fitting, lightweight, flexible, and insulated so that they can be quickly removed if cryogenic fluids are spilled on them.

Remove watches and metal jewelry from your hands before working with cryogenics. If exposed to cryogenic liquids or boil-off gases, the jewelry can freeze to the skin.

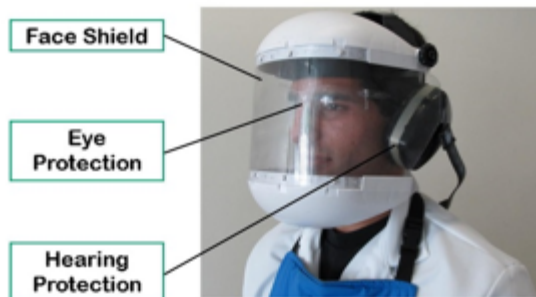
4.2 Protect Your Eyes and Face

Wear safety glasses whenever you are near a cryogenic liquid. Face shields shall be used in the following situations: when a cryogen is poured; for open transfer; if fluid in an open container is likely to bubble.

4.3 Hearing Protection

When using the liquid nitrogen filling station (B422) to fill an open Dewar, the noise level may exceed safe exposure limits. Wearing ear plugs **AND** ear muffs is mandatory when filling an open Dewar.

Mandatory Personal Protective Equipment (PPE) When Filling Liquid Nitrogen Tanks



Always minimize your skin exposure when handling liquid nitrogen



The operator filling the tank is responsible for maintaining **SAFE** distances for those passing through the area.



Figure 3. Personal Protective Equipment

5.0 Handling and Use of Cryogenics

Only handle cryogenics if you are trained and fully aware of the properties of the materials and the equipment to be used.

5.1 Ventilation Requirements

To reduce the risk asphyxiation, ensure proper ventilation where cryogenics are stored or used. When dispensing liquid nitrogen from bulk storage into an open dewar, ensure adequate ventilation by opening the overhead door 15-30 cm. When filling pressurized dewars opening the overhead door is not required unless the O₂ sensor alarms and emergency procedures are followed. An oxygen sensor must be installed whenever cryogenics are used in confined areas, such as NMR labs. In the event of a quench, large volumes of liquid nitrogen or liquid helium would be released, displacing the air from the room. There is an O₂ sensor near B422.

5.2 Transporting Cryogenics

Move cryogenic liquid containers carefully. Always use a hand truck, flat deck trolley, or other proper handling device and use a strap to secure the container. Keep cryogenic liquid containers upright at all times except for the minor tilting on the cart during transport.

If cryogenics must be transported by elevator, use the elevator key lock to send the filled Dewar to the desired floor. The greatest risk of spillage occurs when moving the Dewar in or out of the elevator (e.g. the elevator does not stop level with the floor or if the transport cart wheel becomes lodged in the space between the elevator and the floor). Use extra caution when loading and unloading the elevator to prevent accidental spillage. Always enter the elevator last when loading a Dewar into the elevator; always exit the elevator first when unloading a Dewar from the elevator.

Do not place a filled container in your vehicle. Contact Shipping/Receiving at (403) 329-2615 to arrange for transport of liquid nitrogen from University Hall to other locations on campus.

5.3 Selecting Materials for Use with Cryogenics

Only use materials approved for use with cryogenics. Many common materials such as carbon steel, plastics and rubber become brittle and can crack if exposed to the extremely low temperatures of cryogenic liquids. Many materials also shrink at cryogenic temperatures, potentially causing leaks at hose connections.

5.4 Cooling Operations

When using cryogenic liquids to cool an object, insert the object SLOWLY using tongs. This procedure minimizes any boiling and splashing which occurs when warm objects are added rapidly.

5.5 Transferring Cryogenic Liquids

When transferring cryogenic liquids from one container to another, cool the receiving Dewar flask before filling it. Always start filling slowly to allow the vaporization to chill the receiving container. After the vaporization and liquid boiling has decreased, fill the container at the normal rate. A diffuser should be attached to the transfer hose to reduce turbulence and the release of gas while filling. Never fill containers higher than the indicated level. Fill containers only with liquids they are designed to hold.

Transfer or pour cryogenics slowly to minimize boiling and splashing. Use a phase separator or special filling funnel (the top of the funnel should be partly covered to reduce splashing).

When it is not safe or convenient to tilt the container, use a transfer tube to remove the liquid. Insert the transfer tube through the neck of the container and well down into the liquid. The packing material or stopper on the transfer tube should form a seal in the neck of the container. Normal evaporation usually produces enough pressure to push liquid out. If necessary, the container may be pressurized with the same gas as the liquid or with an oil-free inert gas. Use just enough pressure to force liquid out.



Figure 4. Dewar and Transfer tube.



Figure 5. Transfer tube.

6.0 Equipment Maintenance

The liquid nitrogen supplier will inspect the bulk storage tank and dispensing system on a bi-annual basis and provide an inspection report for follow-up. Problems with the dispensing station, PPE, Dewars, or any other approved storage containers must be reported immediately to **Arts and Science Dean's Office (403 380 1813)** and the lab supervisor.

Avoid forcing connections, using homemade adaptors, or tampering with containers in any way. When doing maintenance work on oxygen handling systems, cleanliness is extremely important. Grease or oil must not be allowed to contaminate any parts.

7.0 Disposal

Never dispose of liquid cryogenics down the drain. Piping in laboratory sinks may not be able to withstand cryogenic temperatures. Allow cryogenics to boil off in a fume hood.

8.0 First Aid Measures

Avoid contact with cryogenic liquids, their vapours and any cooled surfaces. Obtain medical assistance as soon as possible if cryogenics contact the skin or eyes. Immediately upon exposure, the frozen skin appears waxy and yellow and the burn is usually not painful; however, the affected area will painfully swell and blister while the skin defrosts.

If contact does occur, immediately flush the area with large quantities of warm (not hot) water. If the skin is blistered or the eyes have been exposed, obtain medical attention immediately.

Locate emergency eyewash stations and safety showers wherever there may be accidental exposures to cryogenics. Report all injuries to Safety Services (Campus Safety). Submit an online Campus Accident/Incident Report (CAIR).

9.0 Emergency Procedures For The Liquid Nitrogen Dispensing Station

1. In the event of an emergency, **press the red emergency stop button** located to the right of the dispensing station. This will stop the flow of liquid nitrogen from the storage tank.
2. **Call 2345.**
3. **If the situation is immediately dangerous to life or health, call 911.** Your location is 4th level entrance to University Hall and can be accessed by traveling east on Valley Road and turning right on Coulee Trail.
4. Ensure the area is well ventilated by opening the overhead door.
5. Restrict access to the area.

If the O2 sensor alarms:

1. Open the overhead door to increase ventilation.
2. Push the red button to stop the flow of liquid nitrogen from the storage tank.
3. If in 10 minutes the alarm does not stop call Security 329 2345.
4. When alarm stops you should do one of the following things: (a) in the case of a pressurized dewar fill you should completely close the overhead door; (b) in the case of a non-pressurized dewar fill you should close the door to the point where it is only open 15-30 cm. Make sure to determine what caused the O2 sensor to alarm before continuing with the fill (i.e. improper ventilation, equipment malfunction, incorrect procedure).

If you are unable to stop the release by pressing the emergency stop button:

1. Retrieve the key to the outdoor storage tank enclosure (key is located in the Utilities office; Security also has a key.)
2. Put on the insulated gloves and face shield.
3. Open the door and turn off the main supply valve HCV-19 (see photo; valve is painted red).
4. Remove any casualties from immediate danger. Avoid all contact with liquid nitrogen. Ensure space is well ventilated before entering.

If you are unable to turn off the main supply valve, call the Praxair Emergency Number 1-800-363-0042.

In the event of a large spill or accidental release, the following procedures should be followed:

1. Evacuate the area. Deploy warning signs if necessary.
2. Ventilate the area. Open doors and windows or activate forced ventilation to allow any spilt liquid to evaporate and the resultant gas to disperse.
3. Try to stop the release if at all possible e.g. turn off valves, but only if it is safe to do so - always wear protective clothing and PPE.
4. Contact the Security Services 24/7 emergency number (403) 329-2345 and report the incident.
5. Do not re-enter area unless it is safe to do so. Oxygen monitors (if available) will indicate the oxygen levels in the vicinity.
6. Prevent liquid nitrogen from entering drains, basements, pits or any confined space where accumulation may be dangerous.
7. Submit an online CAIR.

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