



Cryogenic Liquids

This Laboratory Guidance Document was created by Syracuse University Environmental Health & Safety Services (EHSS) to assist researchers in developing laboratory specific standard operating procedures (SOPs) for the storage, handling, and disposal of cryogenic liquids.

Potential Hazards:

- Extreme Cold
 - Direct contact with cryogenic materials, or contact with uninsulated cryogenic equipment, can instantly freeze body tissue (causing frostbite). Unprotected skin can adhere to cryogen cooled metal surfaces and tear when pulled away. Direct eye contact with these materials can freeze the liquids within the eye, causing permanent eye damage.
- High Pressure
 - As cryogenic liquids rapidly vaporize, volumes increase substantially. Without adequate pressure relief or venting devices on containers, the pressure build up can cause an explosion.
- Embrittlement
 - Cryogenic temperatures can cause thermal stress fracturing of materials which are normally structurally sound (e.g. carbon steel, zinc, plastic, and rubber). Fast, unexpected structural failure can pose a physical hazard.
- Asphyxiation
 - During cryogen vaporization, oxygen can be displaced during rapid volumetric expansion. Symptoms of oxygen deficiency can become apparent as the air oxygen percentage drops below 19.5%.
An oxygen deficient atmosphere is defined by OSHA as an atmosphere that has an oxygen concentration below 19.5%.

Properties:

A cryogenic liquid is defined as a liquid with a boiling point below -150°C (-238°F). Carbon dioxide and nitrous oxide have slightly higher boiling points, but are often classified as cryogenics. All cryogenic liquids are gases at room temperature/pressure. Cryogenics must be cooled down before an increase in pressure can liquefy them.

Properties of Common Cryogenic Liquids

Cryogen	Boiling point (1 atm), $^{\circ}\text{C}$ ($^{\circ}\text{F}$)	Critical pressure, psig	Liquid density, g/L	Gas density (27°C), g/L	Liquid-to-gas expansion ratio	Type of gas
Argon (Ar)	-186(-303)	710	1402	1.63	860	Inert
Helium (He)	-269(-452)	34	125	0.16	780	Inert

Hydrogen (H ₂)	-253(-423)	188	71	0.082	865	Flammable
Nitrogen (N ₂)	-196(-321)	492	808	2.25	710	Inert
Oxygen (O ₂)	-183(-297)	736	1410	1.4	875	Oxidizer
Methane (CH ₄)	-161(-256)	673	425	0.72	650	Flammable

General Precautions:

1. **Training.**

The Principal Investigator is responsible for ensuring all personnel under their supervision are aware of the hazards of cryogenic liquids, have received appropriate hands-on training, adhere to the laboratory SOPs, and are provided with the appropriate personal protective equipment.

2. **Awareness**

Cryogenic liquids often present other associated hazards, such as flammability. Be aware of all hazards present, and adjust SOPs accordingly.

3. **Visual Inspection**

Cryogenic liquid containers that exhibit unusual performance characteristics (e.g. excess frost/ice, non-stop valve venting) should be assumed damaged and dangerous.

Personal Protective Equipment (PPE):

- In addition to the standard laboratory attire (i.e., long pants and closed toe shoes), the following PPE is recommended:
 - Insulated cryogenic gloves
 - ANSI certified (Z87.1) chemical splash goggles
 - Knee-length lab coat
- Additional PPE may be necessary based on other hazards present.

Best Practices for the Safe Handling of Acutely Toxic Chemicals:

Although SOPs will vary according to the material used, the following practices are generally applicable for projects involving cryogenic liquids:

1. Demarcate cryogen use areas by posting a hazard warning sign (*Appendix I*) in the use area.
2. Review the SDS, laboratory SOP, and emergency procedures before starting any work requiring cryogenic liquids.
3. Know the location of the nearest eyewash, safety shower, and fire extinguisher before beginning work.
4. Avoid contact with any uninsulated cryogenic liquid containment/transfer devices.
5. When transferring cryogenic liquids between containers, pour slowly to minimize splashing. Do not use a standard funnel, which has a propensity to freeze shut and generate splash back. Instead, use a phase separator.
6. When filling a dewar, allow the phase separator (which is attached to the end of the transfer line) to rest at the bottom of the dewar to reduce splashing within dewar.
7. Avoid overfilling dewars.

8. Ensure cryogen use areas/rooms are well ventilated.
9. Avoid wearing metal jewelry/watches when handling cryogenic liquids. These objects can freeze to the skin if exposed to the cryogen.
10. Avoid cryogen contact with rubber, plastic, and carbon steel.
11. Use tongs to slowly add or remove objects from cryogenic liquids.

Storage:

1. Demarcate cryogen storage areas by posting a hazard warning sign (*Appendix I*) in the storage area.
2. Keep cryogenic liquids segregated from incompatible chemicals, and away from heat/flame.
3. Only store cryogenic liquids in containers designed for cryogenic liquid use. Such containers are insulated and fitted with pressure relief devices.
4. Periodically inspect containers and remove any ice or frost blockages from valves/openings. If a cryogen container pressure release valve is not functioning properly, safety move the container to a well ventilated area, post a warning sign, and contact the distributor/manufacturer.

Disposal & Waste Management:

1. Contact the distributor/manufacturer for return/disposal.
2. Do not evaporate cryogenic liquids in laboratory spaces as a means of disposal.
3. Do not pour cryogenic liquids down the drain. PVC plumbing in laboratory sinks can be permanently damaged via thermal stress fractioning.

Spill Response:

Large spills, or smaller spills in poorly ventilated areas, can create to an oxygen deficient work environment. In such instances, immediately evacuate the area and contact the Department of Public Safety (DPS). EHSS will oversee and direct the mitigation of spills. Depending on the location and/or severity of the spill, EHSS may seek assistance from an outside emergency response services provider.

First Aid:

The manufacturer's SDS should be used as a reference for determining appropriate first aid measures.

1. **Skin Contact:**
 - Quickly remove all PPE and clothing that may contain the cryogenic liquid.
 - Any PPE, clothing, or other material that may be frozen to the skin should be left in place.
 - Rinse (or submerge) the affected area in lukewarm water for at least 15 minutes, or until the affected area has gradually thawed.
 - Do not rub the affected area, this can cause further tissue damage.
 - Seek medical attention.
2. **Eye Contact:** Flush eyes with lukewarm water for at least 15 minutes and seek medical attention immediately.
3. **Ingestion:** Seek medical attention immediately.
4. **Inhalation:** Move to fresh air and seek medical attention immediately.

Incident Response:

All laboratory emergencies must be reported to DPS at 315-443-2224.

Appendix I. Hazard Signage.

Post this warning sign at all storage and use areas.