Cryogenic Liquid Safety

# Hazards and Safe Handling of Cryogenic Liquids

Cryogenic liquids have boiling points less than -73ºC (-100ºF). Liquid nitrogen, liquid oxygen and carbon dioxide are the most common cryogenic materials used in the laboratory. Hazards may include fire, explosion, embrittlement, pressure buildup, frostbite and asphyxiation.

Many of the safety precautions observed for compressed gases also apply to cryogenic liquids. There are also additional hazards due to the unique properties of cryogenic liquids:

* Extremely Low Temperatures: The cold boil-off vapor of cryogenic liquids rapidly freezes human tissue. Most metals become stronger upon exposure to cold temperatures, but materials, such as; carbon steel, plastics and rubber become brittle or fracture under stress at these temperatures. Proper material selection is important. Cold burns and frostbite caused by cryogenic liquids can result in extensive tissue damage.
* Vaporization: All cryogenic liquids produce large volumes of gas when they vaporize. Liquid nitrogen will expand 696 times as it vaporizes. The expansion ratio of argon is 847:1, hydrogen is 851:1 and oxygen is 862:1. If these liquids vaporize in a sealed container, they can produce enormous pressures that could rupture the vessel. For this reason, pressurized cryogenic containers are usually protected with multiple pressure relief devices.
* **Vaporization of cryogenic liquids (except oxygen) in an enclosed area can cause asphyxiation!**
* Vaporization of liquid O2 can produce an oxygen-rich atmosphere, supporting and accelerating combustion of other materials. Vaporization of liquid hydrogen can form an extremely flammable mixture with air.

Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, cold boil-off gases condense the moisture in the air, creating a highly visible fog.

* Always handle carefully to avoid skin burns and frostbite. Exposure that may be too brief to affect the skin of the face or hands may damage delicate tissues, such as the eyes.
* Use and store cryogens in well-ventilated areas. Closets, small rooms, and walk-in cold rooms (or similar small/unvented spaces) should be avoided to prevent buildup of gases and displacement of oxygen.
* Boiling and splashing always occur when charging or filling a warm container with cryogenic liquid or when inserting objects into these liquids. Perform these tasks slowly to minimize boiling and splashing. Use tongs to withdraw objects immersed in a cryogenic liquid.
* Never touch uninsulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. Even nonmetallic materials are dangerous to touch at low temperatures.
* Cylinders and dewars should not be filled to more than 80% of capacity, since expansion of gases during warming may cause excessive pressure buildup.
* Check cold baths frequently to ensure they are not plugged with frozen material.

# Personal Protective Equipment

Eye, hand, and body protection must be worn to prevent contact of liquid cryogens with the eyes or exposed skin. The following are the minimum PPE requirements for cryogenic operations:

| **Body Part** | **Recommended Personal Protective Equipment (PPE)** |
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| **Eyes** | When pouring liquid nitrogen from a dewar, use non-vented chemical goggles or safety glasses with side shields. When working with liquid nitrogen in an open container or when transferring liquid nitrogen from a pressurized device, use safety glasses and a full-face shield. |
| **Hands** | When working on piping systems with exposed components at cryogenic temperatures, wear loose-fitting gloves made for cryogenic work to assure that skin will not freeze to cold pipes or metal parts. These gloves can be thrown off readily if cryogen is spilled into them. Small spills of liquid nitrogen, if not trapped against the skin, will usually evaporate without causing damage. |
| **Feet** | Wear closed-toe shoes that cover the top of the foot or boots with trouser legs extended over the top of the boot. |
| **Body** | Wear long-sleeved clothing made of non-absorbent material, cuff-less long trousers worn outside boots or over shoes, and an apron made of leather (or other appropriate material) when handling large quantities of cryogens. |
| **Ears** | Ear plugs or earmuffs may be required where excessive noise levels occur near filling and venting operations. |

# Cooling Baths and Dry Ice

* Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air, because oxygen can condense from the air, leading to an explosion hazard.
* Wear insulated, dry gloves and a face shield when handling dry ice.
* Add dry ice slowly to the liquid portion of the cooling bath to avoid foaming over. Do not lower your head into a dry ice chest, since suffocation can result from carbon dioxide buildup.

# Liquid Nitrogen Cooled Traps

* Traps that open to the atmosphere condense liquid air rapidly. If you close the system, pressure builds up with enough force to shatter glass equipment. Therefore, only sealed or evacuated equipment should use liquid nitrogen cooled traps.

# Transporting Cryogenic Materials

* Store and transport cryogenic materials only in dewars or cryogenic liquid cylinders designed for that particular material. Inspect dewars daily to insure that no air or ice plugs exist in the neck openings.
* Wear appropriate PPE. Keep containers vertical at all times and always push containers on wheels. Pulling can cause injury if they tip and fall on you. Use appropriate carts when moving heavy containers with no wheels, and always secure the container during transport.
* Do not transport containers holding cryogens inside elevators at the same time as people. Put the container into the elevator and place a sign on it with the cylinder facing the door “Do not enter elevator, asphyxiation hazard”. Send the elevator to the desired floor and have somebody there to pick it up. It is best to use service elevators with good ventilation (e.g., with screen walls or doors)

# Emergency Procedures for Frostbite Injuries

The most likely cause of frostbite to the hands and body is contact with cold metal surfaces. Frostbite can be instantaneous if the skin is moist. Immediate treatment is vital. Report promptly to the **Detroit Receiving Emergency Room or call the WSU Police at 313-577-2222** and follow these suggestions:

* Warm the affected area rapidly by immersion in water (not to exceed 105° F), contact with body heat, or exposure to warm air.
* Calm the victim and avoid aggravating the injury.
* People with frostbitten feet should not walk on them. Do not rub or massage the affected parts of the body.
* If the eyes are affected, flush them with water for least 15 minutes.