ENVIRONMENTAL HEALTH & SAFETY

The University of Alabama at Birmingham

Guidelines for Using Cryogenic Liquids on UAB Campus

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Cryogenic Liquids

Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures. Cryogenic liquids have boiling points below -150°C (- 238°F). Even though carbon dioxide and nitrous oxide have slightly higher boiling points, they are sometimes included in this category. All cryogenic liquids are gases at normal temperatures and pressures. Different cryogens 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.

Everyone who works with cryogenic liquids must be aware of their hazards and know how to work safely with them.

Health Hazards associated with cryogenics

There are three groups of health hazards associated with cryogenic liquids:

Extreme Cold

Cryogenic burns by contact with liquid nitrogen or associated cold surfaces: Extremely low temperatures can freeze flesh rapidly. The gas issuing from the liquid is also extremely cold. Delicate tissue, such as eyes, can be damaged by exposure to cold gas alone. Unprotected body parts contacting objects cooled by liquid nitrogen may stick fast. This may result in injuries by flesh being torn whilst attempting to withdraw from the object

Asphyxiation

Asphyxiation is the greatest hazard associated with cryogens like liquid nitrogen. For example liquid nitrogen rapidly vaporizes to gas with about 700 times the liquid volume. By displacing air the gas may kill by asphyxiation. Addition of any gas, except oxygen, to air reduces the oxygen concentration through displacement and dilution. Breathing as little as one or two breaths of air containing too little oxygen can have serious and immediate effects, including unconsciousness. Because there are no warning signs of reduced oxygen concentrations, these environments are extremely dangerous.

Effects of Reduced Levels of Oxygen	
Volume % of Oxygen	Effect
17	Reduced night vision, accelerated heart beat
16	Dizziness, Reaction time for tasks doubled
15	Impaired attention, coordination and judgment, intermittent breathing, loss of muscle control
12	Very poor muscular coordination, loss of consciousness, permanent brain damage
10	Inability to move, nausea, vomiting
6	Convulsive movement, spasmatic breathing, death in 5-8 minutes

Toxicity

Each gas can cause specific health effects. For example, liquid carbon monoxide can release large quantities of carbon monoxide gas, which can cause death almost immediately. Refer to the material safety data sheet for information about the toxic hazards of a particular cryogen.

Explosions

Explosions due to expanding gas

Trapped cryogenic liquids inside a sealed container may cause an explosion. This can happen if cryovials are immersed in liquid nitrogen.

Condensation of liquid oxygen

Cryogenic fluids with a boiling point below that of liquid oxygen are able to condense oxygen from the atmosphere. Violent reactions, e.g. rapid combustion or explosion, may occur if the materials, which make contact with the oxygen, are combustible. Extreme care must be exercised when using liquid

nitrogen as a cold trap coolant to avoid condensing liquid oxygen. Systems including liquid nitrogen traps must never be opened to the atmosphere until the trap is removed from the coolant. Since oxygen has a higher boiling point than nitrogen, it will condense and collect in a liquid-nitrogen cooled vessel. Liquid oxygen forms highly explosive mixtures with many organic materials.

Control Measures

Facilities that use or store inert cryogenic liquids must have appropriate levels of engineering controls, administrative controls, postings and training. All facilities where inert cryogenic liquids are used must be evaluated by EH&S to assign the required levels of controls. Hazard Analysis must be done before identifying the appropriate controls. Hazard analysis must take into consideration the following: size of the room, amount of cryogen present and room ventilation.

Facilities must contact EH&S prior to start using cryogenics to identify and implement controls and practices to reduce exposure risk. It is the responsibility of the facility to provide facility specific training to all employees and maintain any documentation pertaining to the up keeping of the required monitors, detectors and alarms.

EH&S will conduct hazard analysis and provide recommendations to establish control measures. EH&S is also responsible for providing training on general hazards associated with use of inert cryogenic liquids.

Individuals working with cryogenics are responsible for participating in all required training programs, following the policies and guidelines established by OH&S and the laboratory and reporting any safety issues, incidents/leaks to the supervisor.

Engineering Controls

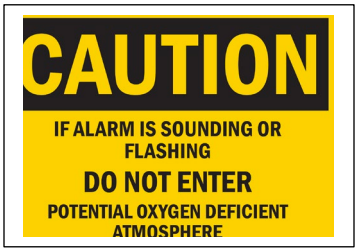
Areas where cryogenics liquids stored and used must have ventilation controls as per the NFPA guidelines. The type of ventilation depends on the risk level (Table 1) of the area. Areas with higher risk levels may require additional ventilation. Please consult EH&S at 4-2487 for recommendations. Never store or work with cryogenic liquids in an unventilated area.

Table 1: Risk Levels

Level	Risk	Control Measures	Activities/definition
Low	Froze bite	Basic cryogenic training, minimum PPE as specified in this document	Minimal use, storage of one 25 L dewar
Medium	Cold burn, impaired coordination and judgment, labored breathing	Basic cryogenic training, lab specific training, ventilation, door signs, job specific PPE, Oxygen Monitors	Storage areas where extensive transferring occurs
High	Mental Failure, unconsciousness or death	Basic Cryogenic Training, door signs, Ventilation, Oxygen Monitors, may also require: Personal Monitors, Emergency Ventilation, buddy system	Oxygen level can quickly drop below 12% in an event of release

Oxygen Monitors

Depending on the size of the room, quantity of the material used and type of the material, some areas may require oxygen monitors. Consult EH&S to conduct a hazard analysis to identify the need and type of monitors required for each area. The monitors must have both audible and visual alarms. The purchaser is responsible for installing and maintaining the monitors according to the NFPA guidelines. The entry to the area should be posted for "oxygen deficiency potential." Areas with monitoring devices must have posted signage (image).



Administrative Controls

E.g. of administrative controls include:

1. Developing lab specific standard operating procedures (SOP)
2. Developing and providing lab specific safety trainings
3. Restricting access to areas where cryogenics are used
4. Posting warning signs
5. Developing emergency response plan
6. Limiting the amount of cryogenics stored in the lab

EH&S can provide assistance to identify appropriate administrative controls required for each facility/room/area based on the risk level.

PPE

PPE appropriate for the risk level must be worn while working or handling cryogenics liquids. Minimum PPE requirement include:

- Eye protection: full face shield with safety goggles is the best
- Hand protection: heavy loose fitting leather or cryogenic gloves
- Lab Coat
- Closed toe shoes

Face shield and thermal gloves are required while filling/transferring dewars or working with large quantities of liquids.

Ordering Cryogenic Liquids

All cryogenic liquids for Airgas can be purchased through the **BuyUAB website** with a P-Card. Researchers should work with their department leadership to determine what process they have put into place regarding P-Cards, as some issue individual P-Cards and others centralize their P-Card purchases. For details, refer to the link https://www.uab.edu/ehs/chemical-safety/purchasing-airgas-products

Safe Handling and Use of Cryogenics

All employees are expected to take reasonable care to ensure the safety of themselves, their colleagues, patients and members of the public.
All personnel involved in the filling, handling, use or transportation of liquid nitrogen dewars shall:

- Be aware of, and trained in, the hazards of liquid nitrogen

- Wear of appropriate hand, eye, feet and body protection when handling full or empty dewars
- Ensure that dewars are correctly and clearly labeled for nitrogen service before filling
- Only use dewars which are correctly and clearly labeled
- Only transport dewars which are correctly labeled for transport
- Be adequately trained in the handling of liquid nitrogen dewars
- Know what actions to take in the event of a liquid spillage
- Know what actions to take if in incident results in a cold burn or asphyxia casualty

Storage

Cryogens must be stored in well -ventilated areas. Store all containers in upright position and never stores near elevators, walkways or exit/egress areas.
Storage of Dewars in Rooms: Storing single dewars of up to 25L in rooms is considered acceptable with adequate ventilation. However, the storage of large numbers of small dewars or dewars over 25 liter capacity may require additional precautions. In these circumstances consideration should be given to: the size of the room, the storage conditions, ventilation levels, and the possible use of low oxygen level alarms. Contact EH&S for a hazard analysis to recommend appropriate storage requirements.
Dewars must not be stored in sealed rooms (e.g. walk in refrigerated rooms)

Containers:

- Use only containers designed for low-temperature liquids.
- Containers should be filled slowly
- Never plug, restrict, cap, seal or remove any venting device
- Do not use any stopper or other device that would interfere with venting gas.
- Check the unit periodically to be sure that the venting is not restricted by accumulated ice or frost.

Transferring cryogenics from primary container

- Always wear personal protective equipment (PPE) including cryogenic gloves, eye and face protection
- Ensure the tank has the right regulators
- Never use an unapproved container as a secondary container
- Open valves slowly to minimize thermal effects and control gas escape
- Do not fill dewar and secondary containers more than 80% percentage of the capacity
- Use caution when inserting pipes or tubes

Labeling

- Cryogenic dewars shall be clearly and adequately labeled
- Areas where more than two 25L dewars are stored must have “cryogenic liquid” warning signs

Working with cryogenics

- Only trained personnel can work with liquid nitrogen
- Wear appropriate PPE
- Use well ventilated and less trafficked areas
- Avoid breathing the vapors
- Do not leave open containers unattended

Transporting Cryogenic Liquids

Cryogenic liquid containers must be transported on a hand truck, cart, or other appropriate transportation method. Containers need to be secured while being transported and kept upright at all times. If passenger elevator is used in transporting inert cryogenic liquids, routes and procedures should be evaluated to ensure that the cryogens could be moved safely. Mitigating procedures such as sending containers alone on elevators or keeping others informed as to when cryogenic liquids are being transported may be required based on a hazard assessment.

Training

Employees and students working with or around cryogenic liquids must be trained on the procedures of its safe use and the dangers associated with it. Training must be documented and the supervisors must maintain the records. General training (OHS200: Managing Compressed Gas Cylinders) can be received through OH&S by accessing Learning Management System (LMS). The PI/Facility Manager or designee must provide facility specific training. The training received shall provide information on the following topics:

- Properties and hazards of the cryogen being used;
- Personal Protective Equipment (PPE) requirements;
- Lab-specific procedures, like appropriate handling and filling methods;
- Proper use of engineering controls, including oxygen monitors, fume hoods, and other room ventilation;
- Review of all administrative controls;
- Emergency Response
- Transporting cryogenic liquids.

Embrittlement of Materials

Extreme cold temperatures can have adverse effect on the structural integrity of materials. All systems designed to use cryogenic liquids must be made of compatible materials. It is known that latex hoses for example, can withstand the extreme cold of liquid nitrogen compared to tygon hose.

Emergencies

- If there is a large spill or rupture of a container, call 911 from campus phone or 205-934-3535 form cell phone. EH&S contact information is at 205-934-2487
- Evacuate the area of the spill

- Do not walk or step into pools of liquefied gas.
- Do not put water spray or fog on pool of liquefied gas (this can result in it freezing delaying evaporation or it can significantly increase the rate of vaporization).
- A wet towel can be used to temporarily stop leaks.
- Due to the large expansion ratios, oxygen deficient environment can quickly develop
- Warn others in the area
- Contact EH&S

First Aid

Skin / Eye Contact

- Immediately flush thoroughly with copious quantities of tepid water ☐
- DO NOT apply any form of direct heat, place in a warm water bath
- DO NOT rub affected parts either before or after warming.
- Move patient to a warm place
- Notify the supervisor
- For minor injuries make the injured person comfortable and loosen any clothing that may restrict blood circulation.
- Do not pull clothes away from burned or frozen area.
- If a person seems to become dizzy or loses consciousness while working with liquid nitrogen, move to a well ventilated area immediately
- Seek medical attention if necessary

Warning signs and postings

Areas where large quantities of cryogenic liquids are used must have warning signs posted outside indicating the use/storage of cryogenic liquids. Facilities where cryogenic liquids stored/used must consult EH&S ay 205-934-2487 to identify the requirement of posting warning signs.

References

1. Compressed Gas Association: (http://cganet.com)
   CGA P-1, 2000. *Safe Handling of Compressed Gases in Containers*
2. NFPA 45 *Standard on Fire Protection for Laboratories Using Chemicals*, 2015 Edition
3. NFPA 55 *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2015 Edition
4. OSHA 29 CFR 1910.101 *Compressed Gases – General Requirements* (http://www.osha.gov)
5. DOT 49 CFR 173 *Hazardous Materials Transportation* (http://hazmat.dot.gov/)