



Cryogenic Liquids

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Cryo-EHS 01

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1.0 Purpose and Applicability

- 1.1 The purpose of this guideline is to ensure the proper management of cryogenic liquids in order to minimize exposure, accidental release, damage to equipment and injury. Hazards include: extremely low temperatures of cryogenic liquids and their vapors when in direct contact with skin or eye tissue can result in severe damage similar to burn injuries, asphyxiation due to displacement of oxygen in the air in confined work spaces, and over-pressurization or explosion due to expansion of the liquid phase to gas phase.
- 1.2 This procedure applies to all personnel who handle cryogenic liquids on the University of Massachusetts Amherst campus and affiliated research stations.

2.0 Definitions

- 2.1 **Cryogenic liquids** are liquefied gases that are kept in their liquid state at very low temperatures. The word "cryogenic" means "producing, or related to, low temperatures," and all cryogenic liquids are extremely cold. Cryogenic liquids have boiling points below -73°C (-100°F) at 14.7 psia (an absolute pressure of 101kPa).

All cryogenic liquids are gases at normal temperatures and pressures. These gases must be cooled below room temperature before an increase in pressure can liquefy them. 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. Example: liquid nitrogen expands in a 700:1 ratio.

Each cryogenic liquid has its own specific properties, but most cryogenic liquids can be placed into one of three groups:

- **Inert Gases:** Inert gases do not react chemically to any great extent. They do not burn or support combustion. Examples of this group are nitrogen, helium, neon, argon and krypton.
- **Flammable Gases:** Some cryogenic liquids produce a gas that can burn in air. The most common examples are hydrogen, methane and liquefied natural gas.
- **Oxygen:** Many materials considered as non-combustible can burn in the presence of liquid oxygen. Organic materials can react explosively with liquid oxygen. The hazards and handling precautions of liquid oxygen must therefore be considered separately from other cryogenic liquids.

- 2.2 **Cryogenic liquid containers**, also referred to as Dewars are double-walled, vacuum vessels with multilayer insulation in the annular space. They are designed for the reliable and economic transportation and storage of liquefied gases at cryogenic temperatures. The inner wall is insulated from the outer wall by a vacuum space. The tank has regulators, vent valves, inner and outer tank rupture disks, pressure gauges, pressure relief valves and vaporizers to assure proper containment of the cryogenic material



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during storage and dispensing. The capacity of these vessels is 160-240 liters and they are equipped with their own standing device that eliminates many of the storage problems associated with gas cylinders.

Other smaller containers are also referred to as Dewars but are not pressurized. These Dewars are open to the atmosphere so the liquid is a boiling liquid at one atmosphere.

Use only manufacturer approved containers (cryovials and racks) specifically designed for liquid phase storage.

3.0 Roles and Responsibilities

- 3.1 The Principal Investigator or the Director of a facility is responsible for training his/her students and staff in the proper handling of liquid cryogenics as directed in this policy and for providing the personal protective equipment used when dispensing or transporting of liquid cryogenics.

4.0 Procedures

- 4.1 **General** - Cryogenic liquids should be stored and handled in well-ventilated areas to prevent excessive buildup of gas. They should never be used in a closed environmental chamber. Liquid nitrogen can displace oxygen in a poorly ventilated space. The cold vapor is heavier than air and will concentrate at lower levels of the room. Oxygen levels should be monitored during dispensing operations. A general ventilation system for a laboratory that gives *6 to 12 room air changes per hour* is normally adequate.

- 4.2 **Protective Clothing** - The extremely cold temperatures of cryogenic liquids can rapidly freeze human tissue and over-pressurization of storage containers can result in an explosion of the vessel. The following must be worn when dispensing or handling cryogenics liquids:

- Full face shield over safety goggles, both compliant to ANSI Z87.1 to protect eyes. Eyes are most sensitive to extreme cold of cryogenic liquids and their vapors.
- Loose fitting cryogenic gloves to protect hands. Gloves should be loose fitting so that quick removal is possible if liquid should splash into them. Even with gloves, contact with cold liquids should be for a very brief time. Do not submerge your gloved hands into the cryogenic liquid.
- Protective clothing should consist of cryogenic aprons, pants, and shoes (not made of canvas) to protect against skin contact in the event of a splash or spill, depending on the hazard.

- 4.3 **Records** - A sign in log is required and should contain name, filling date, and amount.

- 4.4 **Monitoring** - Rooms that are not well-ventilated (at least 6-10 air changes per hour) and contain appreciable quantities of a cryogenic liquid should be outfitted with oxygen meters and alarms. *Call Environmental Health & Safety (EH&S) at: 545-2682* to determine ventilation of storage area before placing a large tank of liquid nitrogen for



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dispensing. Portable or fixed oxygen monitors should be utilized at all liquid cryogenics dispensing sites that are not well ventilated.

Periodic inspection of equipment to store and dispense cryogenic liquids should be routinely performed.

4.5 **Transfer of Cryogenic Liquids from Storage Vessel** - Liquid nitrogen and other cryogenic liquids are delivered and stored in specially designed double walled evacuated containers.

To transfer cryogenic liquids from the storage vessel to a transfer vessel, the following procedures should be observed:

4.5.1 Attach a 1-3 foot length of suitable hose that has a phase separator in place to the control valve located on the top of the storage vessel. The supplier provides the hose and valve for dispensing from a large storage vessel that is under pressure to portable Dewars.

4.5.2 Dispensing cryogenic liquids from a bulk storage tank to a large storage Dewar (160-240 liter) under pressure requires constant attendance while filling. *Do not leave containers unattended.* Dispensing from a large storage Dewar to portable cryogenic containers and vessels also requires constant attendance and should not be filled unattended.

4.5.3. Use only approved containers with vented lids to store and transport cryogenic liquids. All transfers from a large storage Dewar (160-240 liters) must go to a small transfer Dewar with a handle so it can be easily poured and controlled. *Do not use other insulated containers such as a picnic cooler, Styrofoam container or a thermos bottle to transport cryogenic liquids.*

4.5.4 Withdraw liquid slowly at first because the interior of the flask may still be at room temperature and rapid boil off will occur.

4.5.5 Do not fill to more than 80% of capacity to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure.

4.6 **Disposal of Cryogenic Liquids**

4.6.1 Evaporation in a well-ventilated area, from a well-anchored Dewar flask is the best method of disposal of cryogenic liquids. Some cryogenic liquids can fractionally distill air causing liquid oxygen to collect in the cryogenic vessel. Since it may be oxygen rich, care must be exercised in disposing of the final residue of an open container of liquid nitrogen.

4.6.2 Do not dispose of cryogenic liquids down the sink. The material that a sink or plumbing fixture is composed of may not withstand the cryogenic temperatures and will become brittle and crack.

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- 4.7 **Flammable Cryogenics** - Combustible cryogenics, such as liquid hydrogen, oxygen and liquid natural gas, must be handled with the same precautions as flammable gases. Precautions include: proper grounding, local exhaust ventilation, avoiding open flame and ignition sources, and the correct discharge of venting gases to a safe location.
- 4.7.1 Closed or flame-arrested hydrogen systems should be used to prevent a backflow of air and prevent an explosion hazard.
- 4.7.2 Although oxygen is not itself combustible, it can promote the very rapid combustion of flammable materials and other materials which, in other circumstances, might not be thought of as flammable. Enriched oxygen levels can also cause extinguished fires to spontaneously reignite. Liquid oxygen in conjunction with fuel substances (e.g., grease, wood, bitumen, solvents) can be a sensitive and violent explosive.
- 4.7.3 Liquid hydrogen should be regarded as being particularly dangerous because of its highly flammable nature. Hydrogen fires burn with an almost invisible flame. Because of its low temperature, liquid hydrogen can condense air which must be suspected of being oxygen rich. Such a mixture can form a sensitive and violent explosive.
- 4.7.4 Vaporization of cryogenic liquids in an enclosed area can cause asphyxiation. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere which will support and accelerate the combustion of other materials. Liquid oxygen should not be vented to hood systems that might contain any flammables or potentially flammable substances. Vaporization of liquid hydrogen can form an extremely flammable mixture with air.
- 4.7.5 Environmental Health and Safety's Laboratory Safety Program (545-2682) requires prior notification by anyone using flammable cryogenics: the cryogenics in use, the time period they will be used, the procedures to be employed, and the storage location. NFPA recommends that flammable cryogenics are stored away from other combustible materials and used indoors with consideration for volume and ventilation.
- 4.8 **Emergency/First Aid Procedures for Cryogenic Liquids**
- 4.8.1 **Immediate Treatment:** Rapidly re-warm contact area by immersion in warm water (100-110°F), with body heat, or warm air. **DO NOT USE AN OPEN FLAME FOR THIS PURPOSE.** (NOTE: This is the opposite procedure for a burn injury, which is to rapidly cool the contact area.) Do not rub or massage the affected area. Prevent infection by cleansing with mild soap and water. Seek medical attention.

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4.8.2 **General Treatment:** Contact University Health Services Urgent Care immediately at: 577-5000.

4.9 Elevator transport of cryogenics liquid containers – Care must be taken when transporting cryogenic liquid containers in elevators. When possible, use a freight elevator to transport cryogenics. Once the container is placed inside the elevator, all other users should be locked out. *Do not transport a liquid cryogenics container in the elevator with other passengers in the car.*

5.0 References

5.1 Prudent Practices in the Laboratory: Handling, Storage, and Disposal of Chemicals National Research Council. National Academies Press, Washington, D.C., 1995.

5.2 Airgas www.airgas.com
27 Northwestern Dr., Salem, NH 03079 (800)562-3815

5.3 Air Products and Chemicals, Inc. www.airproducts.com
7201 Hamilton Boulevard, Allentown, PA 18195-1501 (610)481-4911

5.4 SPI Structure Probe Inc. www.2spi.com
569 East Gay Street, West Chester, PA 19380 (800)242-4774

5.4 Vendors for storage vessels, supplies and PPE -
 Air Gas Products www.airgas.com (800)562-3815
 Fisher Scientific www.fishersci.com (800)766-7000
 Lab Safety Supply www.lss.com (800)356-0783
 SPI Supplies www.2spi.com (800)242-4774

Vendor for gas detecting and monitoring devices -
 Industrial Scientific Corporation www.indsci.com (412)788-4353