Research
Research Laboratory & Safety Services

PO Box 245101
Tucson, AZ 85724-5101
Voice: (520) 626-6850
FAX: (520) 626-2583
rlss.arizona.edu

Use and Storage of Inert Cryogenic Liquids

1. Purpose

Research Laboratory and Safety Services (RLSS) has created this guidance to promulgate and ensure safe and compliant operations int areas/facilities/laboratories where inert cryogenic liquids are used and stored have the proper controls, in accordance with the hierarchy of controls.

2. Scope

This applies to all research facilities, laboratories, and spaces using and storing inert cryogenic liquids (e.g. argon, nitrogen, and helium). Four risk levels of hazard for use and/or storage of inert cryogenic liquids have been determined to describe the relative risk and appropriate corresponding control measures. These levels are outlined in Table 1. All facilities where inert cryogenic liquids are used shall be evaluated and assigned a risk level by RLSS.

3. Hazard Description

Cryogenic liquids, or cryogenics, are liquefied gases that are kept in their liquid state at very low temperatures and have extremely low boiling points (below -150°C or - 238°F). They can cause cryogenic burns (cold burns) and may cause structural damage or harm equipment by making materials more brittle. Cryogenic off-gassing releases gases that are colorless, odorless and tasteless; they are not toxic but can be harmful by displacing oxygen in the room. Their high expansion ratio contributes to their potential to create dangerous oxygen deficient atmospheres by displacing ambient air, which creates serious asphyxiation hazards in areas of use and storage. Liquid nitrogen, for example, expands to nearly 700 times its liquid volume when released.

Oxygen Levels (%)	Symptoms of Exposure
19.5	**Minimum oxygen level without adverse effect.**
15 to 19	**Decreased ability to work strenuously. Impaired coordination. Early symptoms.**
12 to 14	**Breathing rate increases, increase in heart rate. Impaired coordination, perception and judgment.**
10 to 12	**Breathing further increases in rate and depth, lips turn blue. Poor judgment.**
8 to 10	**Mental failure. Fainting. Nausea. Unconsciousness. Vomiting.**
6 to 8	**8 minutes – fatal, 6 minutes – 50% fatal, 4 – 5 minutes – possible recovery.**
4 to 6	**Coma in 40 seconds, Convulsions, Breathing stops, Death.**

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4. Hazard Evaluation

In order to evaluate the hazard of a space containing inert cryogenic liquids several parameters must be considered:

- The volume present at any given time;
- The size of the laboratory;
- Room ventilation (air exchange rates);
- Proposed use(s) of the cryogen(s);
- Failure modes (including worst-case scenarios) necessary to bring about a hazardous situation.

These parameters, and others as required, are utilized in determining the potential for the creation of an Oxygen Deficiency Hazard (ODH). RLSS must assess these values and assign a corresponding hazard level. If an operation has previously been assessed but operations and/or quantities of cryogen have been altered, a reassessment must be performed; contact RLSS before changes are implemented to ensure adequate control measures are enacted proactively.

5. General Control of Hazards

Please see Table 1 for specific controls that will be required based on the level of the facility and relative risk to workers.

a. Engineering Controls

Ventilation

- **Under no circumstances shall inert cryogenic liquids be stored in an unventilated room**. All areas where cryogenics are used and/or stored must be, at minimum, well-ventilated according to regulations (Note: OSHA states 6 air changes per hour as “well-ventilated”).
- Level 4 facilities required emergency ventilation in areas where oxygen depletion may occur rapidly.

Oxygen Monitors

- Room oxygen monitors **must** be in place in Level 3 and 4 facilities.
  - Monitors must be set to alarm when the concentration of oxygen drops below 19.5%.
  - The number of monitors needed and their placement will depend on the room dimensions, size of the cylinders, the quantity of the cylinders, the types of cryogenic gas being used, whether the gas is being piped into a room, and height of the ceiling.
  - Placement of monitors in the space will be determined by the cryogen in use (e.g. liquid nitrogen is heavier than air and monitors may be located close to the ground).

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- Monitors must provide **both** audible and visual alarm when oxygen levels drop below the alarm point.
- Monitor alarms must be noticeable prior entering the cryogen use/storage area(s).
    - Personal badge monitors may be required in addition to external room monitors and alarms.
    - Training and postings must include the necessary response to an alarm.
- Each department/purchaser is responsible for ensuring that the oxygen monitors are operating properly and are calibrated as required.
    - RLSS will keep a record of facilities containing oxygen monitors and will ensure that maintenance is being performed on a regular basis. RLSS and UA Cryogenics may be able to assist in regular certifications and maintenance.
    - Contact RLSS for oxygen monitoring equipment recommendations.

b. Administrative Controls

Administrative controls will be determined on a case by case basis to account for the unique hazards of all spaces using and storing cryogens.

Common administrative controls include but are not limited to:
- Maximum allowable quantity (MAQ) limits for spaces;
- Written standard operating procedures (SOPs);
- A “buddy” or remote check-in system requirement;
- Limited access to hazardous areas;
- Emergency response procedures.

Hazard Communication
- Any facility categorized as level 2 or higher shall have signage and/or warning information posted at the room’s entrance.

Level 2 Signage:
- All rooms assigned as risk level 2 must be posted with a sign indicating the presence of an inert cryogenic liquid. The posting will be chosen at the discretion of RLSS.
- The signage will be either:
    - Warning Sign: indicates the potential for low oxygen environments.
    - Danger Sign: indicates the potential for an ODH of <19.5%

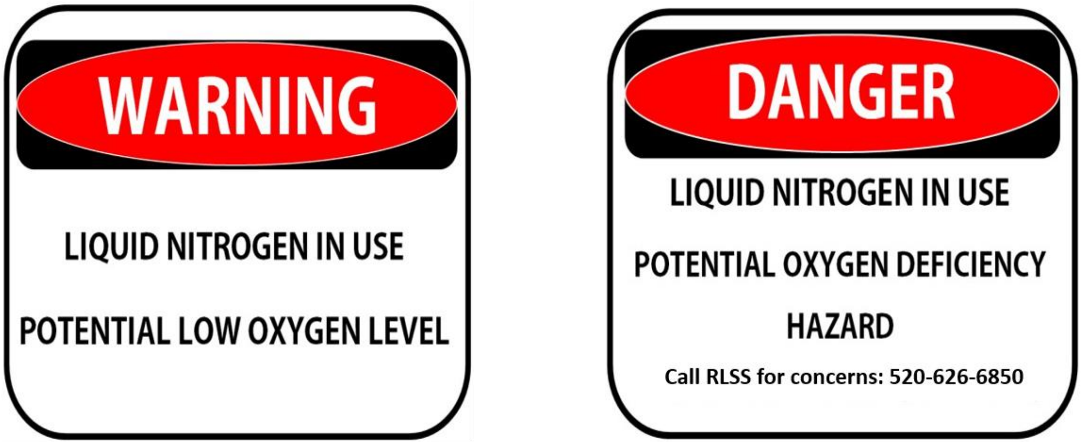

Figure 1: Example sign posting for a Level 2 facility

Level 3 and 4 Signage:
All rooms assigned as risk level 3 and 4 must be posted with a sign indicating the following:

- Presence of liquid nitrogen
- Do not enter if facility oxygen monitor alarm is sounding (not to include potential alarms from low liquid levels or other equipment alarms)
- Instructions for what to do in case of emergency

Level 4 facilities must also post entry requirements and may require additional signage or restrictions.

Figure 2. Example sign posting for Level 3 and 4 facilities

Training

- Any person working with or around cryogenic liquids must be trained on the procedures for its use and be made aware of the hazards involved.
- Training must be documented and include trainee signatures and training dates whenever possible.

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- General Laboratory Chemical Safety Training is available on the RLSS website.
- Lab specific training must also be provided by the PI/Facility Manager or designee.

- The training received shall provide information on the following topics:
  - Properties and hazards of the cryogen being used;
  - Personal Protective Equipment (PPE) requirements;
  - Facility-specific procedures, including appropriate handling and filling methods;
  - Proper use and function of engineering controls, including oxygen monitors, instrument interlocks, fume hoods, and other room ventilation;
  - Review of all administrative controls;
  - Incident/Exposure response and emergency contact;
  - Transporting cryogenic liquids.

c. Personal Protective Equipment (PPE)

Appropriate PPE is imperative to protecting users from cryogenics burns and must be worn when handling or dispensing cryogenic liquids.

Standard requisite PPE includes:
- Safety goggles,
- Closed-toed shoes, long sleeved shirts and long pants;
- Laboratory coat;
- Gloves (fresh nitrile with thermal gloves over top);
- Face shields (when pouring, filling dewars, or otherwise manipulating cryogens).

6. Storage & Transport of Cryogenic Liquids

Storage
- Cryogens should only be stored in containers specifically designed to house them such as dewars; containers must be insulated and double walled. Store all cryogenic liquid containers upright in well-ventilated areas. Cryogen tanks and containers should not be stored near elevators, walkways and unprotected platform edges or in locations where heavy moving objects may strike or fall on them.

Transport
- Cryogenic liquid containers should be moved 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 inert cryogenic liquids must be transported by elevator, routes and procedures must be evaluated to ensure that the cryogens can be moved safely.

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    - Evaluation of the routes must consider the amount of material being transported, the vessel used, typical evaluation rates, and ventilation in all locations, including elevators.
  - 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.

7. Spill and Incident Procedures

In the event of a spill that poses a threat to health and/or the environment, immediately evacuate the area and call 911. Follow the University Chemical Hygiene Plan's Compressed Gas Standard Operating Procedure and University Chemical Hygiene Plan Section 8 for response, in addition to any site specific plans or SOPs that are developed in conjunction with RLSS.

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Table 1. Risk Levels for Laboratories and Facilities using Inert Cryogenic Liquids

**Oxygen Deficiency Hazard (ODH)*

Level	Risk	General Requirements	Definition/ Typical Application
1	• Cryogenic burns • Negligible ODH	• Lab Specific Training	Minimal use where a worst-case scenario (e.g. dewar spill) will not bring O_2 level below 19.5%
2	• Cryogenic burns • Minor ODH • Impaired coordination	• Lab Specific Training • Cryogen Signage and Postings: Warning/Danger • Appropriate ventilation	Typical in locations where liquid nitrogen is stored or its use does not require extensive transfer. Worst-case scenario calculations may show that O_2 level may drop between 15-19.5%. Lower levels are possible if 2 independent modes of low probability are required to reach the level.
3	• Moderate to Major ODH • Impaired coordination, perception and judgment	• RLSS hazard assessment • Lab Specific Training • Cryogen Signage and Postings • Ventilation • Oxygen Monitors (personal and/or facility)	Typical in locations where large amounts of inert cryogenics are transferred or where a single failure mode can lead to oxygen levels <15%. **RLSS must be notified to perform a hazard assessment**

4	• Major to catastrophic ODH
	• Mental failure, unconsciousness or death
		• RLSS hazard assessment
		• Lab Specific Training
		• Cryogen Signage and Postings
		• Ventilation
		• Oxygen Monitors (person and/or facility)
		• Additional requirements may be needed, such as:
		    ○ Secured Facility
		    ○ Rescue Oxygen
		    ○ Emergency Ventilation
			Highest hazard level. O_2 level may drop below 12% quickly in the event of a release or failure.
			
			RLSS must be notified to perform a hazard assessment