Cryogenic Liquid Safety

1. SCOPE

LN2 is one of the cryogenic liquids commonly used in research labs. As "cryogenic" means related to very low temperature, it is an extremely cold material. It is liquefied under high pressure condition and can expand to a very large volume of gas. Other commonly used cryogenic liquids are liquid helium (LHe) and liquid argon (LAr). This chemical safety guidance describes basic prudent safety practice for handling cyogenic liquids with an emphasis on LN2.

The principal investigator (PI) or the lab manager is responsible for developing and implementing standard operating procedures (SOPs) for the purchase, storage, and safe handling of this chemical that are specific to the PI's research.

At departmental and/or building level procedures for dispensing (if done at a central location) and transport of LN2 must be developed by the Local Safety Team. Safety & Risk Services can also assist with the development of these documents.

2. HAZARDS

Thermal burns due to extreme cold temperatures

- Contact with cryogenic liquid, its boil-off gases, or components cooled to these low temperatures can readily cause **frostbite** or **cryogenic burns**.
- Release of these cryogens into the work area can damage equipment and property (e.g., frozen water pipes, damaged flooring, damaged electrical cables and their insulation).

High Pressure caused by warming of cryogenic liquids

- Cryogenic fluids confined and allowed to warm can generate very **high pressures**. LN2 confined and allowed to warm to room temperature will generate a nominal pressure of 10,200 psig. The pressure similarly generated by LHe is 11,000 psig. Other cryogens behave in similar fashion. Dry ice (CO2) can generate hundreds of psig pressure if confined.
- The function of vent lines can be defeated by the **formation of ice** (from condensed moisture) in the vent line. With Liquid Helium, air or other gases can solidify to form this blockage.
- If a cryogenic fluid is subjected to a large amount of heat input, a **flash vaporization** can occur. This will result in a rapid pressure rise that can be described as a BLEVE (boiling liquid expanding vapor explosion).

Oxygen Deficiency (suffocation/asphyxiation)

- Cryogenic fluids have large liquid-to-gas expansion ratios:
  - LN2 is approximately 680 to 1, (based on volume)
  - LHe is approximately 740 to 1
  - LAr is approximately 820 to 1

These ratios mean that any accidental release or overflow of these cryogenic liquids will quickly boil into gas and may create an **asphyxiation hazard** by displacing the oxygen content of the surrounding area.

- In the case of LN2, the nitrogen gas generated from malfunctioning equipment or spills will be cold and denser than ambient air. Even well-ventilated lab spaces that have pits or other low-lying (or recessed) areas could have the oxygen displaced by this cold, dense N2 gas.
- Argon or carbon dioxide also have heavier-than-air hazards.
- Large-volume sources used in small laboratory spaces or in poorly ventilated areas increase the asphyxiation hazard. Oxygen monitors may be advisable in some applications (see part 3, Risk Assessment).

Oxygen enrichment causing explosion risk

- LN2 is cold enough to condense the surrounding air into a liquid form. The concentration of O2 in this condensed air is enhanced. This condensed "liquid air" can be observed dripping from the outer surfaces of uninsulated/nonvacuum-jacketed lines carrying LN2. This "liquid air" will be composed of approximately 50% O2 and will **amplify any combustion/flammable hazards** in the surrounding areas.
- Open dewars of LN2 can condense O2 from the air and cause an O2 enrichment that can reach levels as high as 80% O2.
- Air should be prevented from condensing into LN2 with loose-fitting stoppers or covers that allow for the venting of LN2 boil-off gas.
- Large quantities of LN2 spilled onto oily surfaces (such as asphalt) could condense enough O2 to present a combustion hazard.

3. RISK ASSESSMENT

An oxygen-deficiency risk assessment must be conducted if work with cryogenics is required. This type of risk assessment takes into account to size of the room, the total volume of liquid, and the worst-case scenario possible. An ODH Calculator can be used to determine the level of hazard. Contact research.safety@ubc.ca to assist with the calculations and risk assessment required for your lab.

4. TRAINING REQUIRED

Only trained and qualified personnel should handle LN2. This training includes, but is not limited to:

- Chemical Safety Course
- Understanding the departmental/lab standard operating procedures and/or protocols (site specific training)

5. PERSONAL PROTECTIVE EQUIPMENT

Many operations are considered low risk. For example: handling small amounts (<5 L) of LN2 in non-pressurized open containers at atmospheric pressure (e.g., pouring LN2 from a non-pressurized dewar into another open container or cryotrap). In these limited situations, a combination of PPE,

engineering controls, and/or administrative controls (e.g., training) can prevent splashed LN2 from becoming trapped against the skin.

Many skin injuries have occurred when cryogen becomes trapped against the body by PPE. This is why cryogen gloves are designed to be loose fitting. They provide users with a way to quickly remove them in cases where a user is splashed with cryogen. For the same reason, webbed shoes (e.g., athletic shoes) or cuffed trousers must not be worn when there is a potential to be splashed with cryogen.

The eyes are especially sensitive and require protection from splashes or sprays of cryogenic liquids. Severe eye and facial injuries have been sustained when sample vials removed from liquid phases have warmed and exploded in hand. A face shield and thick gloves are necessary to protect against the shrapnel generated by this type of explosion.

Table 1. Choosing the appropriate PPE for your activities involving LN2

Operation	Face shield	Safety glasses w/side shields	Cryogen gloves	Closed -toe shoes	Long pants (no cuffs)	Lab coat (long sleeves)	Comments
Pouring small non-pressurized (<5L) volume of LN2 between open containers		X	X*	X	X	X	Avoid pouring from above chest level
Work with samples immersed in LN2 in small (~1L) dewar		X	X*	X	X	X	Thermally insulated hand tools may be an alternative to gloves
Dispensing LN2 from a pressurized line to an open dewar*	X	X	X	X	X	X	
Removing samples from LN2 storage	X		X	X	X	X	

* When using a phase separator between the pressurized LN2 line and the open non-pressurized dewar, the risk of a cryogen splash is substantially reduced.

6. GENERAL HANDLING PRECAUTIONS

- Transfer cryogenic liquids slowly and at low pressure to minimize the splashing and boil-off of liquid, insert transfer lines slowly to minimize boil-off of cryogen liquids and the resultant pressure increase, and check the pressure on storage dewars before starting transfer procedures.
- Keep containers for cryogenic liquids clean and free of contamination from fuels, oils, and greases as this increases the risk of fires (caused by the oxygen enrichment combined with a fuel source).

- Verify that open LN2 dewars have insulating covers or loose-fitting stoppers to reduce the condensation of air into the LN2, while still allowing for venting of the LN2 gas.
- Use cryogenic liquids only in well-ventilated areas or with local exhaust ventilation.
- Cold rooms are poorly ventilated small rooms and must not be used for the storage of LN2 vessels.
- Never pour cryogenic liquids into any drain
- Even relatively small quantities of cryogenic liquids can damage equipment and can crack floor tiles, damage water pipes, and damage electrical insulation on wiring
- When removing samples stored in liquid Nitrogen, guard against potential explosion by wearing a face shield, lab coat and thick gloves

7. TRANSPORTING CRYOGEN DEWARS

7.1. Guideline for elevator transport

- People must **not** ride in an elevator in which large cryogen dewars are being transported. The transportation of cryogenic liquids in elevators represents a potential asphyxiation and fire/explosion risk if workers become trapped in an elevator with a dewar of cryogen.
- **Each building where cryogen dewars are transported by elevator must develop a site-specific Safe Work Procedure for transport.** The Safe Work Procedure must be approved by Safety & Risk Services and must contain clear instructions on:
    a) What elevator can be used (e.g. freight elevator)
    b) How will personnel know not to board the elevator when dewars are transported (e.g. signage, locking mechanism)
    c) How many people need to be involved in transport

7.2. Guidelines for transport between and within buildings

- Put on appropriate PPE (see PPE section above).
- Consumer products such as Thermos® bottles are not approved for cryogenic applications. Although the container itself may hold cryogenic liquid in an adequate manner, the lid, even when loosely applied, does not allow for proper venting of boil-off gases.
- In most situations, large dewars (i.e., greater than 5 liters) with wheels can safely be moved from the cryogen filling station to the lab. If the large dewar does not have its own wheels, the dewar must be secured to an appropriate dolly and transported to the use area.

8. PROCEDURES IN CASE OF AN EMERGENCY

8.1. First aid

- If any of the cryogenic liquids come into contact with eyes or skin, immediately flood the affected area with large quantities of cold or tepid water and then apply cold compresses.
    - Never use hot water or dry heat.
    - Do not rub frozen parts, as tissue damage may result.
    - Medical advice should be sought immediately!

- People suffering from lack of oxygen should be moved to fresh air. If the victim is not breathing, administer artificial respiration. If breathing is difficult, administer oxygen. Call 991 to obtain immediate medical attention.

8.2. Spills

- Minor spill (< 1 liter) - allow liquid to evaporate, ensuring adequate ventilation.
- Major release (> 1 liter) - shut off all sources of ignition, evacuate area of all personnel and call the Campus Security at 604.822.2222. DO NOT return to the area until it has been declared safe.

9. DOCUMENT INFORMATION

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