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Risks and Safe Handling Guidelines for Liquid Nitrogen / Cryogenic Liquids

1. Hazard Overview

Hazard	Description
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**. LN_2 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 (CO_2) 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: • LN_2 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 LN_2, 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.
Oxygen enrichment causing explosion risk	LN_2 is cold enough to condense the surrounding air into a liquid form. The concentration of O_2 in this condensed air is enhanced. This condensed "liquid air" can be observed dripping from the outer surfaces of uninsulated/nonvacuum-jacketed lines carrying LN_2. This "liquid air" will be composed of approximately 50% O_2 and will **amplify any combustion/flammable hazards** in the surrounding areas. • Open dewars of LN_2 can condense O_2 from the air and cause an O_2 enrichment that can reach levels as high as 80% O_2. • Air should be prevented from condensing into LN_2 with loose-fitting stoppers or covers that allow for the venting of LN_2 boil-off gas. • Large quantities of LN_2 spilled onto oily surfaces (such as asphalt) could condense enough O_2 to present a combustion hazard.

2. Potential Accidents with Cryogenic Liquids

Potential Accident	Description
Accidental Release (or overflow)	Accidental releases (or overflows) of LN_2 can present hazards and cause property damage, as noted in the hazards discussed above. • The most frequent cause of accidental releases is inadequate training on specific hazards and procedures. • The level of concern over these releases increases with the volume of the cryogen source. • Releases of LN_2 into a building or lab space are the most hazardous, presenting the primary hazards of asphyxiation, personnel exposure, and property damage.
Tipping of dewars	Storage dewars of LN_2 or LHe may be accidentally tipped over when

	crossing obstructions, such as door thresholds. • Handle dewars with appropriate care. • Ensure floor surfaces are free of obstructions and appropriate for moving dewars. • Ensure all parts of the dewar (wheels, handles, etc.) are in proper functioning condition.
Accidents caused by equipment not designed for cryogenic service	Cryogenic liquids should only be handled in apparatuses specifically designed for that purpose. • Accidents frequently occur when equipment not designed for cryogenic service is used, such as when a consumer-rated Thermos® bottle is used for LN_2 or dry ice. Overpressure that ruptures the container is frequently the result. • Accidents can also occur when cryogenic-rated equipment is inappropriately modified and the original safe-venting design is compromised.

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. Typically an ODH Calculator can be used to determine the level of hazard. Contact health.safety@uregina.ca to assist with the calculations and risk assessment required for your lab.

4. Personal Protective Equipment (PPE)

Many operations are considered low risk. For example: handling small amounts (<5 L) of liquid nitrogen (LN_2) in nonpressurized open containers at atmospheric pressure (e.g., pouring LN_2 from a nonpressurized 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 LN_2 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.

Please consult the table below to determine the most appropriate PPE for your activities.

Operation	Face Shield	Safety glasses w/ side shields	Cryogen gloves	Closed-toe shoes	Long pants (no cuffs)	Lab Coat or long sleeved shirt	Comments
Pouring small non-pressurized (<5L) volume of LN_2 between open containers		✓	✓*	✓	✓	✓*	Avoid pouring from above chest level
Work with samples immersed in LN_2 in small (~1L) dewar		✓	✓*	✓	✓	✓*	Thermally insulated hand tools may be an alternative to gloves
Dispensing LN_2 from a pressurized line to an open dewar**	✓	✓	✓	✓	✓	✓	

✓* = Recommended. For a few limited operations these may not be needed

** = When using a phase separator between the pressurized LN_2 line and the open non-pressurized dewar, the risk of a cryogen splash is substantially reduced.

5. Other guidelines for use of cryogenic liquids

- 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 LN_2 dewars have insulating covers or loose-fitting stoppers to reduce the condensation of air into the LN_2, while still allowing for venting of the LN_2 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 liquid nitrogen 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

6. Transporting Cryogen Dewars

Guidelines for Elevator Use
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.
People must **not** ride in an elevator in which large cryogen dewars are being transported.
When large dewars are transported in an elevator, a clearly visible sign must be used to warn staff and students not to enter the elevator while the dewar is present. After the dewar reaches its destination, the person transporting the dewar will remove the dewar from the elevator and return it to normal service.

Guidelines for Transport between and within Buildings
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.
Wear appropriate PPE when transporting cryogens around buildings.

7. Procedures in the Event of an Emergency

In the event of an emergency, all present must:

- Evacuate and not enter the area until oxygen levels in the area can be confirmed to be safe (contact health.safety@uregina.ca in order to have levels tested).
- Notify personnel in surrounding areas who may be affected.
- Seek medical attention for any injuries or cryogenic burns. Call 911 and Campus Security (306-585-4999) for assistance.
- Report the event to their supervisor, as well as health.safety@uregina.ca

References: The majority of the information contained in this document was adapted from the "Safe Handling of Cryogenic Liquids" Policy from Lawrence Berkeley National Laboratory which can be found here: http://www.lbl.gov/ehs/pub3000/CH29/CH29.html