Safety Precautions and Regulations for Dispensing Liquid Nitrogen

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The purpose of this document is to highlight general cryogenic safety practices and detail the process of dispensing liquid nitrogen from the common system outside of Phillips Hall. Lab and system-specific cryogenic safety training should be completed by the lab PI or other qualified personnel.

Portions of this document were adapted from the Argonne National Laboratory Physics Division Cryogenic Safety Manual.

1. Overview of Cryogenic Safety Hazards

The safety hazards associated with the use of cryogenic liquids can be categorized as follows:

1) Cold contact burns

Liquid or low-temperature gas from any of the specified cryogenic substances will produce effects on the skin similar to a burn.

2) Asphyxiation

Degrees of asphyxia will occur when the oxygen content of the working environment is less than 20.9% by volume. Effects from oxygen deficiency become noticeable at levels below ~18% and sudden death may occur at ~6% oxygen content by volume. This decrease in oxygen content can be caused by a failure/leak of the cryogenic vessel or transfer line and subsequent vaporization of the cryogen.

3) Explosion - Pressure

Heat flux into the cryogen from the environment will vaporize the liquid and potentially cause pressure buildup in cryogenic containment vessels and transfer lines. Adequate pressure relief must be provided to all parts of a system to permit this routine outgas sing and prevent explosion.

4) Explosion - Chemical

Cryogenic fluids with a boiling point below that of liquid oxygen are able to condense oxygen from the atmosphere. Repeated replenishment of the system can thereby cause oxygen to accumulate as an unwanted contaminant. Similar oxygen enrichment may occur where condensed air accumulates on the exterior of cryogenic piping. Violent reactions, e.g. rapid combustion or explosion, may occur if the materials which make contact with the oxygen are combustible.

2. Training of Cryogenic Personnel

All personnel working with cryogenic fluids must be thoroughly familiar with the hazards involved. They must also be familiar with all emergency measures that might be required in the event of an accident. Employees who have not worked with cryogenic fluids and systems must be trained on the job by experienced employees until thoroughly familiar with safe methods of operation.

The training will address:

- The physical, chemical and physiological hazards associated with cryogenic fluids
- The proper handling procedures for cryogens and cryogenic containers
- The emergency procedures required in case of an accident
- The reporting procedures in case of an accident

Additionally, each employee will receive training by the responsible scientist on the specific cryogenic equipment or system he is expected to use. This will cover:

- Description of the equipment
- Operating procedures
- Maintenance schedule and procedures
- Specific hazards
- Reporting of incidents

The training shall be documented. The documentation shall include: 1) content of training, 2) date, 3) name of trainer, 4) a dated training attendance list showing names of the trainees (typed or printed) and their signatures.

2.1 Cryogen Handling

The hazards associated with the handling of cryogenic fluids include:

2.1.1 **Cold contact burns and freezing** (contact with cold liquid, gas or surface)

The potential for freezing by contact with the extreme cold of cryogens necessitates varying degrees of eye, hand and body protection. When a cryogenic fluid is spilled on a person, a thin gaseous layer apparently forms next to the skin. This layer protects tissue from freezing, provided the contact with the cryogen involves small quantities of liquid and brief exposures to dry skin. However, having moist skin, exposure to moving cryogens, or extended periods of time, can freeze tissue.

The most likely cause of frostbite to the hands and body is contact with cold metal surfaces. Since there is no protective layer of gas formed, frostbite will occur almost instantaneously, especially when the skin is moist. The damage from this freezing (frostbite)occurs as the tissue thaws. Intense hypothermia (abnormal accumulation of blood) usually takes place.

Additionally, a blood clot may form along with the accumulation of body fluids, which decreases the local circulation of blood.

Adequate protection and clothing is required at all times when handling, transferring or operating near cryogenic fluids. Should a burn occur, immerse the injured tissue in tepid water but do not rub or scratch the area.

2.1.2 Asphyxiation (displacement of oxygen by inert gas)

When liquid cryogens are expelled into the atmosphere at room temperature, they evaporate and expand on the order of 700 to 800 times their liquid volume. Even small amounts of liquid can displace large amounts of oxygen gas and decrease the oxygen content of the atmosphere below a safe level with a possibility of asphyxiation.

Whenever possible, handling of cryogenic fluids where release into the atmosphere is possible should be done in open, well-ventilated areas.

When there is the possibility of an oxygen deficiency hazard, oxygen monitors should be installed. If such a monitor triggers an ODH alarm, personnel are to leave the area immediately.

2.1.3 Explosion (excessive buildup of pressure in container of cryogenic fluid)

Heat flux into the cryogen is unavoidable regardless of the quality of the insulation provided. Since cryogenic fluids have small latent heats and expand 700 to 800 times to room temperature, even a small heat input can create large pressure increases.

Dewars must be moved carefully. Sloshing liquid into warmer regions of the container can cause sharp pressure rises.

Pressure relief devices must be provided on each and every part of a cryogenic system. Satisfactory operation of these devices must be checked periodically and may not be defeated or modified at any time.

Vents must be protected against icing and plugging. When all vents are closed, enough gas can boil off in a short time to cause an explosion. Vents must be maintained open at all times.

Liquid helium is cold enough to solidify atmospheric air. Only helium should be introduced or allowed to enter the helium volume of a liquid helium dewar. Precautions should be taken to prevent air from back-diffusing into the helium volume.

Some materials may become brittle at low temperature and fail in the case of overpressure or mechanical shock. Only suitable materials may be used to store or transfer liquid cryogens.

2.1.4 Fire/explosion (condensation of liquid oxygen)

Liquid oxygen liquifies at a higher temperature than liquid helium or nitrogen. Consequently, liquid oxygen can condense on the exterior of cryogenic containers or transfer lines. An explosive situation may result if this oxygen-rich liquid is allowed to soak insulating or other

materials which are not compatible with oxygen.

Some oils can form an explosive mixture when combined with liquid oxygen. Surfaces where there exists a possibility of liquid oxygen condensation must be thoroughly cleaned and degreased.

2.2 Protective Clothing

Whenever handling or transfer of cryogenic fluids might result in exposure to the cold liquid, boil-off gas, or surface, protective clothing shall be worn. This will include:

- face shield or safety goggles
- safety gloves
- long-sleeved shirts, lab coats, aprons
- closed-toe shoes
- ear muffs or ear plugs

Eye protection is required at all times when working with cryogenic fluids. When pouring a cryogen, working with a wide mouth dewar or around the exhaust of cold boil-off gas, use of a full face shield is recommended.

Hand protection is required to guard against the hazard of touching cold surfaces. Loose insulating gloves can be used. Inspect the gloves for damage before use.

3. Dispensing of LN2

1. Under *no circumstances* should you leave the area while filling a dewar.
2. Put on protective clothing as described in 2.2.
3. Open the combination lock on the gate. See Beverly for the combination.
4. Look for any warning signs or indications that the tank should not be used.
5. Ensure that the tank is more than 20% full. If not, do not fill your dewar and let Beverly know.
6. Attach the hose fitting to your dewar or attach the fill-tube (you will need at least one wrench) and place the tube in the dewar.
7. Open the venting valve on your dewar, if applicable.
8. Open the valve on the fill line. (Turn the valve handle counterclockwise.)
9. If filling a wide mouth dewar, keep one hand on the tube and adjust the flow to reduce resonance (whistling).
10. As the dewar is filling, watch and listen for indications that it is nearly full.
11. Close the valve and check the level to avoid overspill.
12. When finished, close the valve (turn the valve handle clockwise) and remove the hose or the fill tube from the dewar.
13. Move your dewar from the filling area and lock the gate.

4. Emergency Procedures

If problems occur with the filling valve, the main valve of the tank can be used to shut off the flow. It is located on the back left side of the tank.

In case of emergency, e.g. explosion of a dewar, leave the area immediately and dial 911.

If liquid nitrogen comes in contact with eyes or immerses skin, seek immediate medical attention.

Report all emergencies and accidents to your PI and the P&A Safety Committee.

Restrictions

1. Liquid nitrogen is to be used only for legitimate teaching and research needs. Use for off-campus demo shows or departmental activities should be approved in advance by departmental administrators. Any other use is considered theft and is prohibited.

2. Liquid nitrogen is to be obtained only by those who have been appropriately trained to do so.

3. Do not put liquid nitrogen into any vessel with a tight-fitting lid.

4. Failure to wear appropriate protective clothing will result in suspension of privileges.

Tips

There is no need to open or close the valve with tools. It should be closed firmly, but does not require blue-faced torque. This can damage the valve.

When filling a wide-mouth dewar, a meter stick can be used as a dipstick. Dunk it for a few seconds and when removed, the frost line will indicate the height of the liquid.

A cold dewar fills much more efficiently than a warm dewar. As with your car, do not wait until yours is completely empty to fill it back up.