CRYOGENS

Cryogenic liquids or cryogens are refrigerated, liquefied gases having a boiling point colder than -130°F at a pressure of one atmosphere absolute. Cryogenic liquids are normally stored at low pressures in multi-walled, vacuum-insulated storage containers. Examples of cryogenic liquids include oxygen, nitrogen, argon, neon, krypton, xenon, hydrogen, helium, liquefied natural gas (LNG)/methane, and carbon dioxide.

1. Potential Hazards

1.1 **Extremely cold temperatures:** Cryogenic fluids can freeze human tissue on contact. Protective clothing and eye protection are required to protect against splashes of cryogenic fluids.

1.2 **Potentially high pressure:** If heat enters the storage vessel of a cryogenic liquid, rapid vaporization and expansion of the liquid could result, thus increasing the pressure in the container. Container capacity must allow for that portion of the cryogenic fluid which will be in the gaseous state.

1.3 **Asphyxiation:** Inert gases (e.g. helium, neon, argon, krypton, xenon) in a cryogenic liquid form that escape a storage container will rapidly expand and displace the oxygen necessary to support life in the room. Do not use cryogens in environmental rooms or other areas with limited air flow (i.e. cold rooms).

1.4 **Flammability:** Many cryogens are also flammable gases, such as hydrogen, methane, and carbon monoxide. Liquefied gases such as helium, neon, nitrogen, and hydrogen are capable of condensing oxygen from the air and causing creation of an oxygen-enriched environment that increases the potential of fire.

1.5 **Embrittlement of associated materials used with cryogenic systems:** Due to drastic changes in the properties of materials when exposed to the extremely low temperatures of cryogens, the method of connection and connecting equipment must receive careful consideration. If the properties of a material considered for use with cryogenic liquids are unknown, an experimental evaluation on a pilot or reduced scale should be conducted prior to using the material in a cryogenic system.

2. Safe Handling Procedures for Cryogenic Materials

2.1 All personnel that handle cryogenic liquids must be trained in the hazards of cryogens and in the use of specialized equipment designed for the storage, transfer, and handling of these materials.

2.2 In addition to laboratory attire covering exposed arms and legs, eye and face protection and insulated protective gloves must be worn to prevent skin contact with the extremely cold surfaces associated with the cryogenic system. Lab coat or shirt sleeves should be overtopping glove cuffs. Uncuffed pant legs should also cover shoe tops to prevent cryogenic liquids from becoming trapped between shoe and foot.

3. Transfer from Bulk Container into Dewars

3.1 Any transfer operations of cryogenic liquids into open containers must be conducted slowly to minimize boiling and splashing of the cryogenic liquid.

3.2 Assure that the container being filled is clean, dry and appropriate for cryogen use.

3.3 Transfer operations must be conducted only in well ventilated areas to prevent the possible accumulation of gas which can replace the oxygen in the surrounding atmosphere and cause asphyxiation or produce a buildup of flammable vapors.

4. Cryogen Storage

4.1 Store cryogenic fluids only in double wall, evacuated containers (Dewar flasks) of either metal or glass.

4.2 Avoid all contact of moisture with cryogenic materials. A small amount of moisture freezing across the opening of a Dewar flask, or its safety relief valve, could cause a pressure buildup and potential explosion. The cloudy vapor that appears when a liquefied cryogenic gas is exposed to the air is condensed moisture, not the gas itself.

4.3 Wrap the exposed glass of Dewar flasks with cloth woven tape to prevent flying glass in the event of rupture.

4.4 Caution must be observed when lowering objects or experiments into a Dewar flask of cryogenic liquid to prevent an object from freezing tight in the neck of the flask. The obstruction of the Dewar flask opening will cause excessive and dangerous buildup of internal pressure in the flask and could potentially rupture the vessel.

4.5 Never handle or carry Dewar flasks by the neck, as the neck is the main support for the inner liner of the container. Always use the handles provided on the container.

4.6 All cryogenic liquid vessels must be stored in a secure location to prevent access by untrained personnel.

4.7 No smoking, open flame, or spark-producing equipment is permitted in an area where flammable cryogenic liquids or oxygen are loaded/unloaded, stored, handled, or used.

5. Transport of Cryogens Within and Between Buildings

Special precautions must be taken to prevent a spill while transporting cryogens in addition to minimizing exposures from liquids and vapors. The high liquid to vapor expansion ratio could rapidly displace all oxygen in a room and result in asphyxiation. Implement the following procedures to minimize exposures:

5.1 Transport within the laboratory or lab building:

5.1.1 Wear all required PPE including a lab coat, eye protection, insulated protective gloves and face protection when pouring.

5.1.2 No fewer than two individuals should transport cryogenic liquids using Dewar flasks secured on carts, or handcarts equipped with brakes for large Dewar flasks and cylinders

5.1.3 **NEVER** transport an open container of cryogenic liquid regardless of size or volume.

5.1.4 Plan the route of transport. The BEST PRACTICE IS TO AVOID USING AN ELEVATOR. If elevator use is necessary, use a freight elevator when possible. If using an elevator is necessary, send a second person to the receiving floor, load the Dewar flask and remain on the loading floor while you send the Dewar flask to the receiving floor unmanned. If the transport by elevator takes place over multiple floors, clearly label the Dewar flask with a sign reading; "Cryogen Transfer - DO NOT ENTER Elevator" warning anyone wanting to use the elevator to wait until the transport process is complete. In the event of an elevator failure or cryogen release/spill, the elevator car may quickly undergo oxygen displacement. Call 412-624-2121.

5.1.5 Always use extra care when handling equipment, as Dewar flasks are fragile. Damage to Dewar flasks could result in the loss of vacuum and increased evaporation.

5.1.6 When at all possible, do not hand-carry cryogenic liquids. For larger Dewar flasks use a stable wheeled base designed for Dewar flask transport. Check to ensure stability before commencing transport.

5.1.7 When carrying a small Dewar flask, make sure it is the only item you are carrying. Hold the Dewar flask as far away from the face as possible. Be on the lookout for other people who may run into you or bump you.

5.1.8 Large mobile Dewar flasks used for transport should be equipped with a braking mechanism. Do not use feet to brake. Steel toed shoes are recommended.

5.1.9 Take care to avoid crushing hands or fingers between the vessel or cart and walls or door frames.

5.1.10 If there is any risk of tipping, a cart should be used. Wheeled trolleys may not be used if the vessel must pass over elevator thresholds or other slots/crevasses wider than 25% of the wheel width.

5.2 Transport between buildings:

5.2.1 In addition to guidelines above, avoid grates, large cracks in sidewalks/pavements, or other hazards that could cause tripping or tipping of Dewar flask.

5.2.2 For transport of large nitrogen Dewar flask outside – over pavement, sidewalks, wheelchair curb-cuts – a 4-wheeled tipcart should be used. The casters welded to the tank, and/or the casters on the trollies in common use, are not meant for transport over pavement and concrete.

5.2.3 While in route, exercise great care – stay completely clear of sewer grates, large cracks, and/or uneven portions of the pavement, and any other hazards which could catch a cartwheel and cause tipping.

5.3 Vehicular transport:

5.3.1 **NEVER** take liquid nitrogen or other cryogenic fluids in a car or van where the driver's compartment is not segregated and sealed from the load. The load/cargo compartment of the van must be ventilated. Where a specimen needs to be transported frozen, consider whether dry ice would be suitable since it reduces risks.

5.3.2 Before transporting cryogens in a vehicle, ensure the following have been addressed:

- A risk assessment has been conducted.
- The container of the cryogenic material is labeled with the name of its contents and a danger hazard warning sign.
- The driver has been fully informed as to what is being carried and its associated hazards.
- The appropriate personal protective equipment (PPE) has been provided.
- An information sheet/bill of lading is carried within the vehicle to provide emergency response services with specific data about the material in the event of an accident.
- The quantity to be transported is consistent with DOT regulations.

5.3.3 Transportation of cryogenic substances is covered by the US Department of Transportation (DOT), 49 CFR 173.

- These regulations cover specific volumes/mass of dangerous goods that may be transported, duties of responsibility, correct packaging and labeling of goods, vehicle usage and driver training.
- Exceptions for cryogenic liquids transport can be found in 49 CFR 173.320 as follows:
  - Liquid Helium and Nitrogen Material of Trade (MOT):

- Container limits of 220 pounds (includes container / cylinder weight).
- Packaging constructed and vented so that pressure will not exceed 25.3 psig.
- Closures secured (held in place) against shifting in vehicle.
- Cylinders must contain all required DOT markings including: Common name or proper shipping name.
- Vehicle limits (total MOT on board) < 440 pounds.

o Liquid Nitrogen containers with < 1 liter are DOT Exempt:

- Packaging requirements permit non-pressurizing receptacle.
- Containers with double glass wall, insulated construction.
- Strong outer packaging (placed in box with cushioning).
- Marked with common name (Liquid Nitrogen).
- Still cannot be transported in closed vehicles.