University Health and Safety

Fact Sheet

Cryogens

Cryogens are gases (e.g. nitrogen, helium or argon) that are liquids at extremely low temperatures less than -250 ˚F or -160 ˚C. Cryogens have an extremely high expansion ratio (average 800:1) as they warm up from liquid to gas. If confined, a large amount of pressure will build up possibly resulting in explosive container failure.

Gas	Boiling Point °C	Boiling Point °F	Expansion Ratio @ 20 °C
Nitrogen	-195.8	-320.4	1:694
Argon	-185.8	-302.5	1:847
Helium	-268.9	-452.1	1:757
Oxygen	-183.0	-297.3	1:860
Methane	-161.5	-258.7	1:638
Dry ice CO2*	-78.5	-109.3	1:554

*Dry ice is not a cryogen, included for comparison

Health & Physical Hazards

a. Asphyxiation (suffocation) from displacement of air by expanding cryogen vapors.
b. Injections and other blast related injuries from large pressure releases
c. Burns from frostbite or fires

Incidents

The most common incidents with cryogens, occurred when sample containers were open (or not fully closed or damaged) at cryogenic temperatures, gases then condensed into the container, then the container was closed and brought back to room temperature, the trapped gases then didn't have enough space and a percussive blast occurs.

The most serious incidents with cryogens involve the large high pressure (> 22 psi) cylinders or tanks typically more than 4 ft tall. Incidents were related to doing transfers too quickly, or faulty pressure relief valves resulting in death from asphyxiation or extensive building damage to concrete walls and steel beams affecting several floors.

Should you use a cryogen?

Only use cryogens if that low a temperature (< -160 °C) is necessary. If not substitute a different cooling agent such as dry ice so oxygen can't inadvertently condense. Cryogens should not be used with organic materials, such as the grease of solvents during vacuum transfers, that will combust or explode if liquid oxygen is present.

Is it safe to use cryogens in the intended room?

Cryogens should only be used in spaces with enough ventilation to prevent an oxygen-deficient atmosphere.

- *NEVER USE- Confined areas such as walk-in refrigerators, environmental chambers, cold rooms or closets.*
    - Note- Elevators are a confined space without ventilation. Use the elevator to transport cryogens, but don't risk asphyxiating yourself, by riding with large amounts. Send the cryogen on the elevator by itself, hit the correct floor and have someone waiting to take it off there. Don't ride with large cylinder tanks.
- If large quantities of cryogens are used or stored, oxygen monitoring and or additional ventilation may be prudent. For example: cryogenic fill stations for large cylinders, MRI machines, NMR machines. Become familiar with the alarms and purge buttons, if present.

Floor surfaces that are likely to be exposed to cryogenic splashes should be of durable material. Tile and laminate are likely to crack and need frequent repairs. Plywood panels can be used to protect the floor but are not appropriate for areas using Liquid Oxygen.

Transporting Containers on Campus

Large cylinders- Move very slowly! These are heavy, top-heavy, awkward and difficult to control at more than a crawl. Do not use feet to brake, ideally use steel toed boots. Avoid fingers and hands getting pinched between cylinder and walls or doorways. Do not ride with on elevator. Do not move outside. Contact vendor or UHS for assistance.

Dewars on wheels- Again Move very slowly! Awkward. Should have pressure relief valve or venting lid

Small dewars with handles- Can be carried if < 4 L, put on cart or add wheels if larger.

Glass Dewars w/out handles or wheels do not transport in unless < 500 ml and only for short distances less than 100 ft. Styrofoam buckets with lids can be a safer form of short-term(< 2 hours) storage and conveyance.

Prepare for Use

Always be aware of pressure and oxygen levels- Where is it? How can it get in/out? How can you get rid of it?

- Keep oxygen in your breathing zone (asphyxiation) and away from cryogenic temperatures (fire if oxygen condenses and organics are present)
- Assume containers are removed from cryogenic temperatures are pressurized until they warm up.

1. Check- Is container appropriate for cryogen temps and in good condition? If applicable, is pressure relief (mercury bubbler or valve on tank) functioning? Slight hissing is a sign a tank is working appropriately. Do NOT adjust relief devices, instead contact the supplier for assistance.

2. Protect- "It's not the splash but the blast"

Face shield	Gloves	Shielding
-when transferring from high pressure(> 22 psi) LN tank, pouring 4 L or more -Handling closed containers that were in LN but haven't thawed.	-Cryogenic gloves when handling cold parts especially metal -Leather when handling potentially pressurized glassware	-Blast shield after removing closed containers from LN while waiting to thaw -Add covers/mesh to glassware

3. Slow, Stay Away- Slowly: change temperatures, transfer cryogens, insert materials into cryogens. Stay away from closed containers that were in cryogens, until back to room temperatures in case of pressure blast.

Best practices- Avoid direct contact with cryogenic liquids and un-insulated cryogenic piping systems and reservoirs. Use loose-fitting cryogenic gloves and personal attire, so that they do not collect cryogenic liquids and can be readily removed, if a cryogen does splash into them. Do not tuck pants into shoes/socks. When using a face shield, always also use safety glasses or goggles. Leave a large head space to account for expansion, do not overfill containers. Ensure all secondary containers are secured when filling. Dewar flasks are under high vacuum and can collapse as a result of thermal shock or a very slight mechanical shock. Use metal Dewar flasks whenever feasible. Glass dewars, should be shielded either by a layer of fiber-reinforced friction tape or by enclosure in a wooden or metal container.
For more information about specific cryogens, read the Safety Data Sheet for the substance in question or contact University Health and Safety.

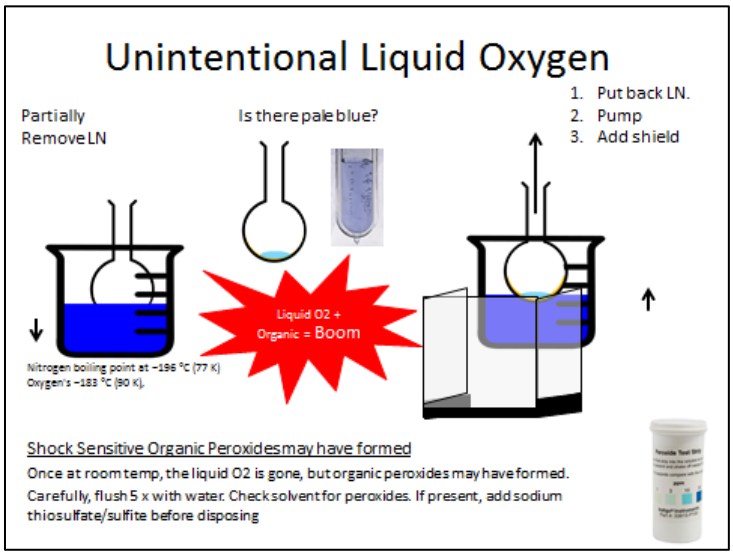
Early signs of potential problems

- Vacuum not achieved
- Pale blue liquid visible (liquid oxygen)
- More liquid than expected
- Excessive frost on large cylinder

Emergencies

Liquid Oxygen, what to do if

If an unexpected pale blue liquid appears at cryogenic temperatures, it is likely liquid oxygen that has condensed from the surrounding air. It can cause the spontaneous explosion of any organics it comes into contact with. Even trace amounts will react with significant force. The best way to deal with liquid O_2 is to <u>put up a blast shield, and get everyone out of the room.</u> If you take down a dewar and see liquid O_2, quickly put the dewar back up, leave the vacuum *on*, and let the gases evaporate slowly over time behind a shield. Then carefully check for organic peroxides.



Spill response

A spilled cryogenic liquid will evaporate and does not need to be cleaned up. As a general rule, if more than 4 L of a cryogenic liquid are spilled, everyone should temporarily leave the area for a few minutes. There is a

significant risk of oxygen deficiency if percent oxygen drops below 19.5% O_2. This could happen if more than 4 L of liquid nitrogen spills in a small room 3 m x 3 m x 3 m (10 ft by 10 ft by 10 ft). Most lab rooms are larger than this but the area immediately above the spill could still be oxygen deficient. If more than 16 L is released or the rupture disk on a pressurized dewar goes, Leave the area, evacuate those nearby and call 911.

First Aid

Do NOT rub frozen body parts because tissue damage may result. Remove any clothing that is not frozen to the skin. Place the affected part of the body in a warm water bath (not above 40°C). Never use dry heat. Consult a medical professional, as soon as possible. If the victim is experiencing symptoms of hypothermia, burn area is extensive or pain significant Call 911.

Knowledge Checks

- When are O_2 monitors needed in LN storage areas?
- How long is too long to be breathing cryogenic vapors?
- When are safety glasses and gloves vs face shield necessary?
- When are thermos containers appropriate? Why?
- Other than the gauge how can you tell the difference between a low 22 psig and high pressure 230 psig liquid cylinder? are they constructed differently?
- Why will storing liquid N2 in a cold room not slow down the evaporation? What other hazards will be introduced by this?
- How can you tell if a noise is the normal safety valve releasing built up pressure vs. rupture of the back-up disk which would require evacuation to prevent asphyxiation?
- What is the difference between the liquid valve and the vent valve?
- Can you re-set the spring-loaded relief valve or the rupture disk?
- Do you need to do anything about the ice/frost that builds up around the pressure relief valve?
- What does a phase separator look like? What does it do? Where should it be?
- If gas is continuously venting, what should you do? If the safety valve has ice around it what should you do? If there is frost on all the walls of the cylinder?
- What should the pressure building regulators be set to? What is the safety relief valve setting?
- Why would frost form on just the top of the cylinder during periods of high product use?
- If you open valves too quickly what might happen?
- How far should you fill a container?
- If LN does contact your skin and cause a burn what should you do? Rub it? Add hot water?
- Which materials will shatter if in contact with LN latex, tygon, rubber etc.?