University at Buffalo
The State University of New York

Environment, Health & Safety Services

EH&S Campus Safety How-To

CRYOGENICS

I. Definition – Cryogenics deals with the uses and behavior of materials at ultra-low temperatures. These temperatures are primarily achieved by the liquefaction of gases.

There are more than twenty-five that gases that are liquefied for use. The most commonly used cryogenic liquids include nitrogen, helium, oxygen, fluorine, hydrogen and argon. Solid carbon dioxide (dry ice) is also commonly used.

Cryogenic materials are used in a wide variety of research applications, including food processing and refrigeration, physics, chemistry, microbiology, medicine, surgery, electronics, data processing, and metalworking.

II. Properties of Cryogenic Materials
   a. Cryogenic fluids exist at temperatures of approximately -100°F (-60°C) to -460°F (-269° C).
   b. Cryogenic liquids vaporize with a volume increase of 700-800 times.
   c. Their primary cooling mechanism is vaporization (latent heat).
   d. Expanding cryogenic liquids can cause rapid and violent pressure changes if confined.

Gas	Boiling Point (°C)	Volume Expansion to Gas	Flammable	Toxic*	Odor
Nitrogen	-196	682	No	No	No
Helium	-269	738	No	No	No
Carbon Dioxide	-78.5 (sublimes)	845	No	Yes – Asphyxiant**	Pungent
Oxygen	-183	860	No***	No	No
Hydrogen	-186	822	Yes	No	No
Argon	-186	822	No	No	No

*All gases are capable of displacing air and may be considered asphyxiants.
**Increased CO_2 levels can cause physiological responses that can lead to nausea, vomiting, dizziness, headache, rapid breathing, flushing. Severe cases progress to confusion, convulsions and loss of consciousness.
***Supports combustion.

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III. Hazards
   a. Physical Hazards
      i. Explosion – the large ratio of volume expansion can cause violent changes in pressure, especially if this occurs in a confined space. Pressure must be vented from confined spaces. Pressurization can occur due to:

         1. Ice formation on a venting tube, plugging it and preventing gas release
         2. Loss of vacuum inside a cryostat or dewar
         3. Direct contact of a cryogenic liquid with water in a tube, resulting in rapid vaporization of the cryogenic liquid and causing the tube to explode

      ii. Damage to Equipment – due to extreme cold, cryogenic liquids can damage equipment and materials, which can result in cracking or breaking equipment and release of materials. Spills can damage furniture, equipment, and flooring materials.
      iii. Flammability – some gases are flammable and their cryogenic properties are the same. However, other, normally non-flammable gases used as cryogenic materials may increase flammability of other materials under certain conditions. For example, oxygen will increase the flammability of ordinary combustibles, and may even cause some non-combustible materials to readily burn.

   b. Health Hazards
      i. Frostbite/burns – burns from cryogenic materials are similar to thermal burns. Pooled liquid under an eyelid, in a cupped palm, or in a sleeve or cuff may cause severe injuries. Boil-off gases can freeze skin or eyes faster than liquid or metal contact.
      ii. Asphyxiation – evaporation of cryogens in small or enclosed areas can result in displacement of breathing air. The gases themselves may be harmful to breathe.
      iii. Injuries –
         1. From glass and liquids during an explosion of a vessel or dewar
         2. From trips and falls from a spilled cryogen causing water vapor to condense from air and causing a fog
         3. From unprotected skin contacting low-temperature surfaces and sticking, tearing flesh upon removal

IV. Handling and Use of Cryogenic Materials
   a. Handling
      i. Always use a dewar flask (a double-walled, evacuated container). Use a double-walled metal container for large quantities; make sure vessel properties are consistent with properties of cryogenic material
      ii. Wherever possible, try to avoid using a glass-walled dewar or storage vessel, but when necessary tape exposed glass to minimize hazards of flying glass if container breaks or implodes

iii. Transfer liquids from dewars with special transfer tubes or pumps designed specifically for use with cryogenic materials
iv. Do not overfill containers
v. Stay out of the path of boil-off gases and ensure proper ventilation of the boil off gas, which can increase significantly during cryogen transfer
vi. Transfer and pour cryogens slowly to minimize boiling, splashing and thermal shock
vii. Keep receiving vessel dry
viii. Position dewars so that pressure relief valves and rupture disk vent paths are directed away from personnel, critical equipment or designated work areas
ix. Keep equipment and systems clean. Avoid contamination that may create a hazardous condition upon contact with cryogenic fluids or gases in the system
x. Use a cart when possible, rather than carrying containers
xi. Do not hold the neck of the container
xii. Do not transport containers in enclosed spaces, such as elevators, if possible. Elevators can be confined spaces. If transportation of a Dewar in an elevator is necessary, take the following precautions:
    1. Use a freight elevator, not a passenger elevator, if possible
    2. Restrict use of elevator while Dewar is inside; label or place sign on door
    3. Have one person place the Dewar in the elevator and another wait for it at its destination
xiii. Store containers in a well-ventilated area, not in refrigerators, cold rooms, sealed rooms or basements. If asphyxiation is a hazard, the area should have an oxygen alarm

b. Use
    i. All personnel should be trained in the hazards of cryogenic materials and safety precautions to be taken, including equipment, safety equipment, and emergency procedures BEFORE working with materials
    ii. Areas in which cryogenic materials are stored and used should be posted.
    iii. Examine vessels and equipment often and do not use if damaged
    iv. Hydrogen – restrict use to areas that are clearly marked and well ventilated. No open flames, electrical ignition sources, sources of static electricity, or potentially combustible materials should be allowed in the work area
    v. Oxygen – although not flammable, oxygen can increase the chance of fire or explosion if present in higher concentrations. Because it has a higher boiling point than other materials such as nitrogen and helium, oxygen can condense in some closed systems, igniting normally non-combustible materials and increasing flammability limits of flammable gases and vapors. Oil and grease should not be used in areas where oxygen enrichment may occur, as they may spontaneously ignite.
    vi. Do not dispense cryogenic materials near smoke detectors.
    vii. Do NOT pour cryogenic liquids down the sink; that is not proper disposal, and will crack pipes
c. Personal Protective Equipment (PPE)

i. Safety glasses and a face shield should be worn to protect the eyes and face from splashing
ii. ALWAYS wear substantial, closed-toe shoes. Sandals provide no protection to the feet from cold temperatures (and can in fact as a reservoir to worsen any cryogen-spillage induced burn) breaking glass and heavy materials
iii. Gloves should be cold-impervious and should have long ribbed cuffs to prevent spillage into the glove, or be loose enough to be easily removed
iv. Wear a cold-impervious apron if splashing is a danger
v. Sleeves and pants should be worn outside of gloves and boots
vi. Metallic jewelry should not be worn around cryogenic materials, as it can transfer cold if contacted
vii. Use tongs to transfer objects to or from cryogenic liquids
viii. NOTE: PPE is not designed to withstand prolonged contact with or immersion into cryogenic liquids!

V. Safety and Emergency Procedures

a. If an alarm goes off, evacuate the area immediately. Turn off/secure equipment if possible
b. Do NOT attempt to rescue someone from a confined space who is unconscious and has been using cryogenic materials; call University Police at 645-2222, open the door and wait for help
c. If someone becomes dizzy or loses consciousness while you are with them and you are able to, both of you should move immediately to a well-ventilated area
d. Provide first aid
    i. Remove restrictive clothing, but do not remove anything frozen to tissue (clothing or equipment)
    ii. Flush area with tepid water
    iii. Do not rub or apply heat directly to area
    iv. Do not flex a frozen limb
    v. Cover with loose, sterile dressing and keep warm
    vi. Seek medical attention as soon as possible
e. CALL UNIVERSITY POLICE IMMEDIATELY AT 645-2222 IF THERE ARE INJURIES OR A RELEASE THAT CANNOT BE CONTROLLED