CRYOGENIC SAFETY

Department of Physics & Astronomy

COLLEGE OF SCIENCE | THE UNIVERSITY OF UTAH

INTRODUCTION

Cryogenics is the science of ultra low temperatures. These low temperatures are achieved by the liquefaction of gases.

The gases which are most widely used in industry and research are hydrogen, helium, nitrogen, fluorine, argon, oxygen and methane.

In our department, you'll most often be working with liquid **helium** and **nitrogen**. In teaching labs, **dry ice** is also used.

https://ehs.berkeley.edu/sites/default/files/publications/cryo-liquids-fact-sheet.pdf

PROPERTIES OF CRYOGENIC FLUIDS

- Extremely low temperatures
- Large ratio of expansion in volume from liquid to gas
- Most cryogenic liquids are odorless and colorless when vaporized to gas

PROPERTIES OF CRYOGENIC FLUIDS

- Boiling points of common cryogens
  - Helium -452.1 °F (-268.9 °C)
  - Nitrogen -320.4 °F (-195.8 °C)
  - Oxygen -297.3 °F (-182.9 °C)

- Liquid-to-gas expansion ratios of common cryogens
  - Helium 1 to 757
  - Nitrogen 1 to 696
  - Oxygen 1 to 860

STORAGE OF CRYOGENIC LIQUIDS

- Cryogenic fluids are stored in well insulated containers to minimize loss due to boil off
- The most commonly used container for handling cryogenic fluids is the **Dewar flask**
- Dewars are non pressurized, vacuum-jacketed vessels

CROSS-SECTION OF A CRYOGENIC DEWAR

Liquid Level Gauge

Not clearly shown – pressure relief valves

Pressure Regulators/Gauges

Vacuum Draw Port

Pressure Building Manifold

Outer Vessel

Superinsulation Layer

Inner Vessel

Liquid Draw/Fill Tube

PRECAUTIONS WHEN HANDLING CRYOGENS

- Cryogenic containers must not be dropped or tipped on their sides; this can cause a partial or complete loss of vacuum in the outer jacket.
- Frost spots may appear in case of loss of insulating vacuum. A vessel in this condition must be removed from service. Repairs must be handled by the manufacturer.
- **Never** use a hollow tube/rod as a dipstick. A warm tube will boil the cryogen and the change in pressure will cause the liquid to spout from the top.
- A hand cart or trolley must be used to transport large cryogenic dewars

Always push Dewars if they need to be moved. Never pull on Dewars - they are very heavy and can tip and crush you.

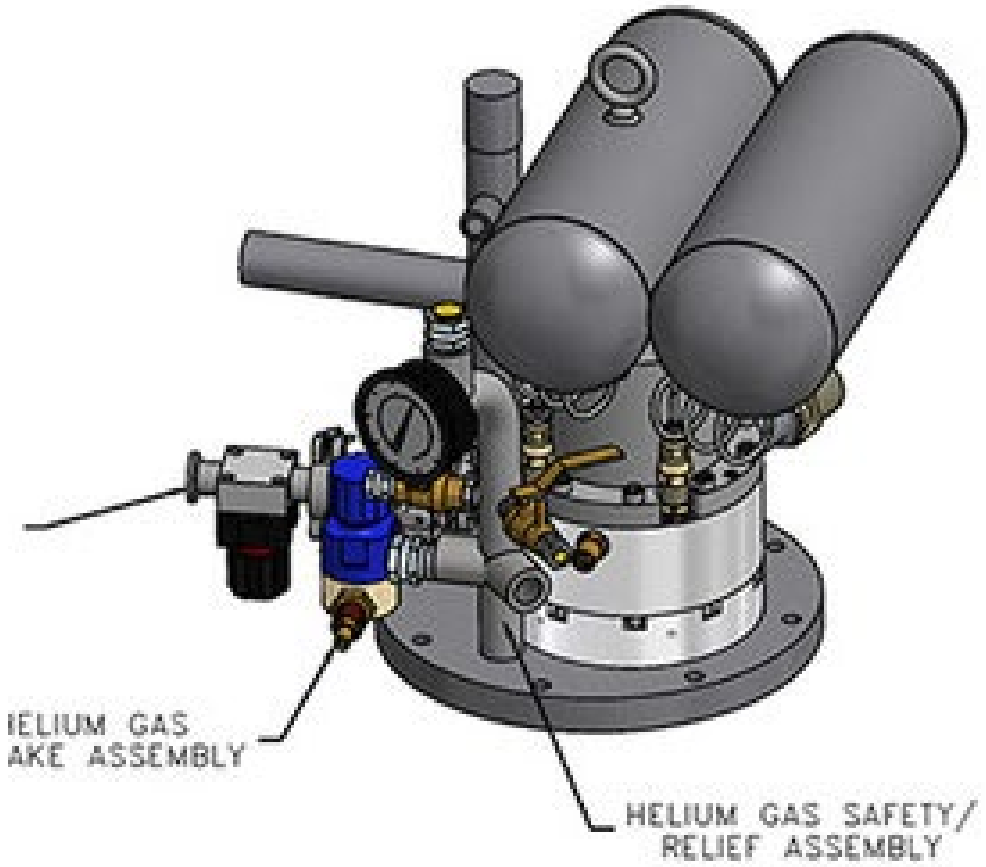
SPECIAL PRECAUTIONS WITH LIQUID HELIUM

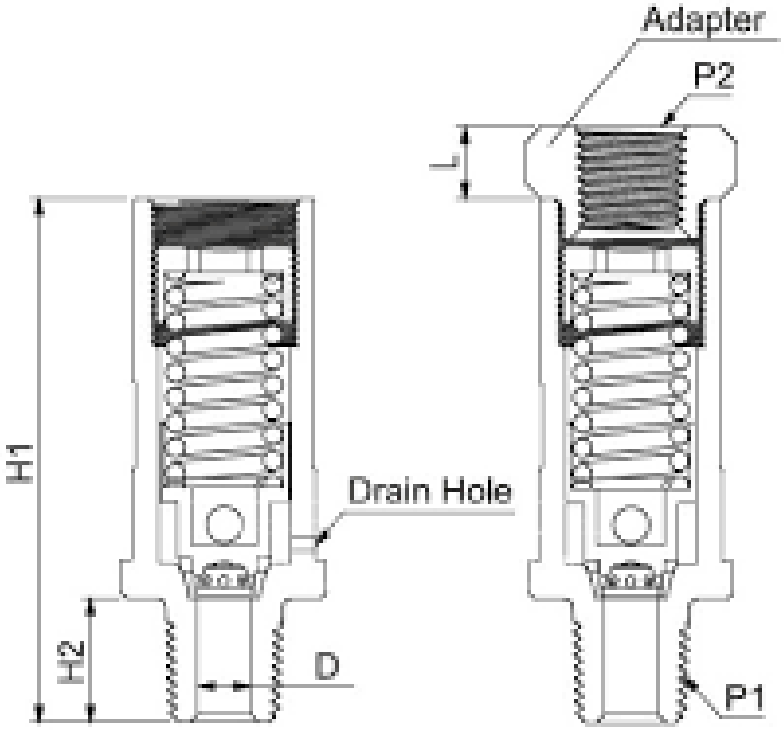
- Liquid helium is **extremely** cold and air readily liquifies and solidifies when exposed to the extremely low temperature
- Solidified gases may plug pressure relief passages and relief valves, creating a safety hazard
- The fill and vent ports of helium dewars must be kept closed at all times (except during filling) to prevent blockages from forming in the exit passage and a resultant pressure build up

SPECIAL PRECAUTIONS WITH LIQUID HELIUM

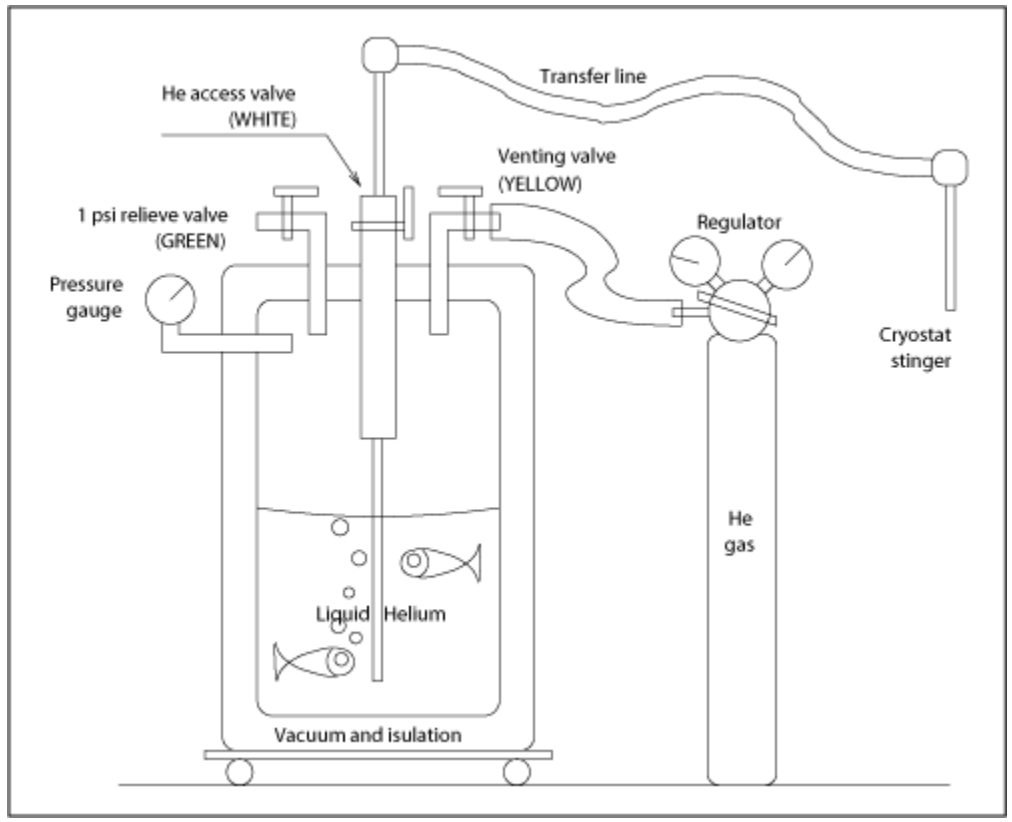
- Always store and handle liquid helium under positive pressure (if possible) or in a closed system to prevent the infiltration and solidification of air or other gases
- Storage dewars, whether full or empty, must be moved gently and carefully to avoid unsafe build-up of pressure
- In case of spill of large quantity of fluid, evacuate the area **immediately**
- When available, use service elevators for transferring unsealed containers of cryogens. Do not accompany any containers of cryogenic liquid in elevators

Pressure relief valves. If pressure in a Dewar is excessively high check the valve. Use it to relief pressure manually using a screw driver, gloves, safety glasses ….





Transfer Liquid He (or Nitrogen). This can also be a set up for flow cryostat.



GOOD

BAD

1) Start slow. Take time to cool equipment
2) The cylinder with the pressurizing gas must be secured to wall or other stationary object.

OXYGEN DEFICIENCY

- Cryogenic liquids must be handled in well-ventilated areas to prevent excessive concentrations of gas in enclosed spaces
- The gas vented/released from experimental equipment is also an asphyxiation hazard and should be well-vented
- Oxygen level detectors should be installed in spaces where there is chance of build up of gases causing oxygen deficiency
- **Remember:** nitrogen gas is heavy and will pool on the floor, but helium gas is light and will pool on the ceiling

FROST BURNS

- Contact with cryogens (both liquid and chilled vapor) can quickly cause burns similar to thermal burns caused by high temperature.
- Cryogens can cause embrittlement of the exposed body surface because of high water content of the human body
- Extreme blistering and tissue damage can result
- Splashing of cryogens can result in permanent eye damage

PRECAUTIONS WHEN HANDLING CRYOGENS

Rules 0: Clean up the space, no tripping hazards, empty the area around you. Inspect equipment and secure its position (against falling and …) Consider having a labmate accompanying you, inform your safety officer or supervisor. Wear long pants, closed-toe shoes, no sandals. During teaching demonstration/lab establish safety zone and rules to avoid crowding.

- Gloves must **always** be worn when working with cryogenic liquids. (possible exception – teaching lab, students use tongs)
- Safety glasses must be worn for eye protection. Face shields are recommended.
- Aprons are recommended to protect against splashing. .
- Watches, rings or similar items should not be worn as they can trap cryogenic liquid on the skin if spilled
- Ordinary carbon steels, most alloy steels, rubber, and plastic become brittle when subjected to the low temperatures of cryogens. These materials are unsuitable for use with cryogens. Metals which are suitable for cryogenic temperatures are copper, brass, bronze, aluminum. Teflon tubing can be used, but temporally and with extreme precaution.

Gloves for cryogenic liquids

Safety versus convenience trade off.
If gloves are not convenient, things can dropped, resulting in an accident.

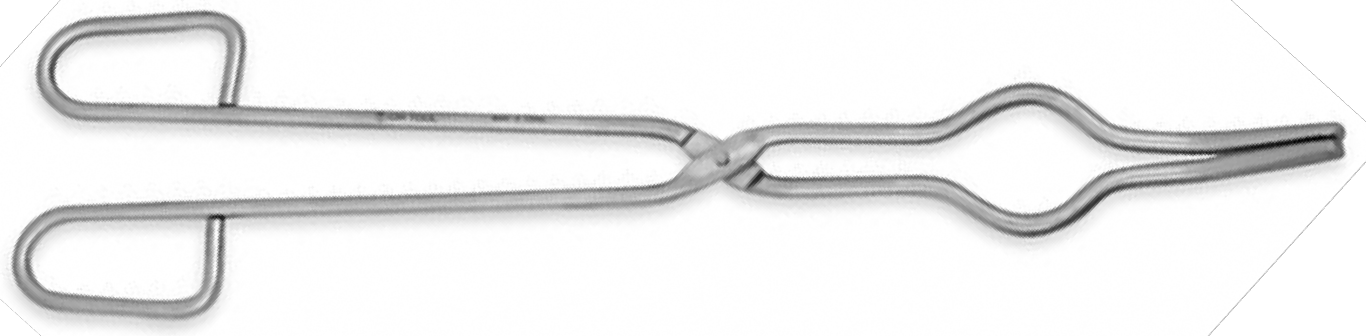
1) Get gloves of few sizes to match everybody in your group.

2) Leather ski gloves looks as a good compromise.

PRECAUTIONS WHEN HANDLING CRYOGENS

- Prevent the entry of liquid cryogen inside glass vials while inserting into a storage container; when removed, the liquid can expand causing the explosion of the vial.

- Tongs must always be used to withdraw objects immersed in liquid. Never use your hands, even if gloved



PRECAUTIONS WHEN HANDLING DRY ICE

Dry ice is the solid form of carbon dioxide. Dry ice sublimes at 194.7 K (−78.5 °C; −109.2 °F) at Earth atmospheric pressure. This extreme cold makes the solid dangerous to handle without protection from frostbite injury. While generally not very toxic, the outgassing from it can cause hypercapnia (abnormally elevated carbon dioxide levels in the blood) due to buildup in confined locations.

Dry ice bombs are commonly made from a container such as a plastic bottle, water and dry ice. The bottle is partly filled with water. Chunks of dry ice are added and the container is closed tightly. As the solid carbon dioxide warms, it sublimates to gas and the pressure in the bottle increases. Bombs typically rupture within 30 seconds to half an hour,

Wear a lab coat or a garment covering the ankles.

Wear appropriate eye protection, including goggles and/or a face shield.

Use tongs to handle Dry Ice when possible.

Use loose-fitting, thermally insulated gloves (e.g., leather or cloth) to manually handle Dry Ice.

Injuries

● If skin comes into contact with a cryogen, run the area under room temperature or warm water for fifteen minutes. Never use hot or cold water. The re-warming, or thawing, of affected area(s) should be done gradually. It may take up to 60 minutes to thaw the affected area(s) and bring back the natural color of the skin.

● If your finger is burned, do not put it in your mouth. This could burn your mouth or tongue.

● Do not rub a burned area: rubbing can cause further tissue damage.

● Always seek medical attention for frostbite injuries. You should obtain medical assistance as soon as possible when cryogens contact your skin. Immediately upon exposure, the frozen skin appears waxy and yellow and the burn usually is not painful. Then it painfully swells and blisters while the skin defrosts.