CRYOGENIC SAFETY

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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**.

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

TYPES OF CRYOGENIC DEWARS

CROSS-SECTION OF A CRYOGENIC DEWAR

POTENTIAL HAZARDS OF HANDLING CRYOGENS

- They displace oxygen in non-ventilated confined spaces creating an oxygen-deficient atmosphere and the risk of **asphyxiation**.
- Upon contact with skin, they can quickly cause **frost burn** due to extreme cold .
- Pressure build-up in a storage container can cause an **explosion**.
- Extreme temperature **alters properties** of materials
- **Oxygen enrichment** around valves and chilled surfaces

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

- Gloves must **always** be worn when working with cryogenic liquids
- Safety glasses or a face shield are recommended for eye and face protection
- Aprons should be worn to protect against splashing. At the very least, never wear shorts or open-toed shoes when working with cryogens.
- Watches, rings or similar items should not be worn as they can trap cryogenic liquid on the skin if spilled

PRECAUTIONS WHEN HANDLING CRYOGENS

- Keep a safe distance from boiling and splashing liquid and the cold gas it emits
- Boiling and splashing occur when transferring cryogenic liquid into a warm container or when inserting objects into the liquid
- These operations must be done slowly to minimize the hazard of splashing

PRECAUTIONS WHEN HANDLING CRYOGENS

- When transferring liquefied gases from one container to another, the receiving container must be cooled gradually to prevent thermal shock
- The liquid should be poured **slowly** to avoid spattering
- A discharge hose must be used when it is not safe or convenient to tilt the container or when removing liquid from large 50-or 100-L containers such as the XL-45 low pressure nitrogen dewar

PRECAUTIONS WHEN HANDLING CRYOGENS

- A hand cart or trolley must be used to transport large cryogenic dewars

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.

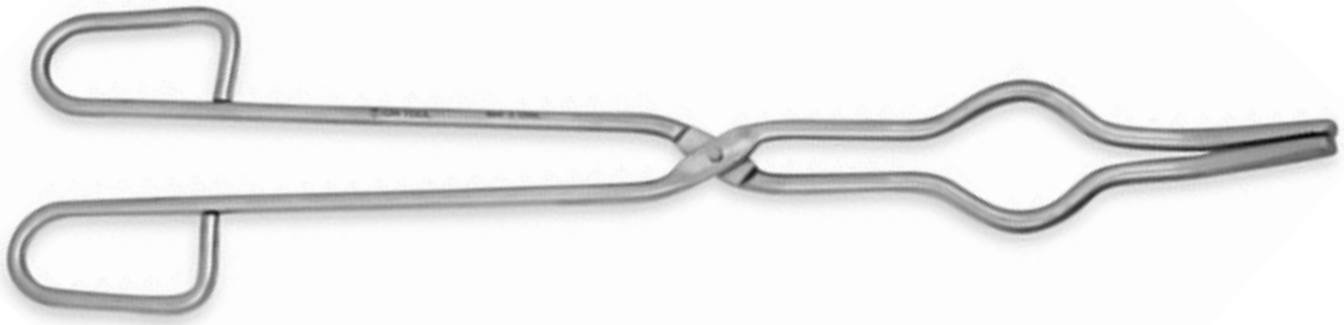
- Frost spots may appear in case of loss of insulating vacuum. A vessel in this condition must be removed from service. Repairs must be handled by the manufacturer.

- **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.

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



PRESSURE HAZARDS

- Usage of cryogens **always** present a high pressure hazard as the gases are stored at or near their boiling point
- Cryogenic liquid is constantly evaporating and there will always be gas present in the container
- The large liquid-to-gas expansion ratio provides the source of high pressure in storage dewars.

PRESSURE HAZARDS

- Dewars must be kept covered with a loose fitting cap to prevent air or moisture from entering the container, and to allow build up pressure to escape

- Make sure that no ice accumulates in the neck or on the cover and causes a blockage and subsequent pressure buildup

- Only containers specifically designed for holding cryogenic liquids must be used. **Never place cryogens in a sealed container**.

MATERIAL HAZARDS

- Ordinary carbon steels, most alloy steels, rubber, and plastic become brittle when subjected to the low temperatures of cryogens. These materials are considered unsuitable for use with cryogens

- Metals which are suitable for cryogenic temperatures are copper, brass, bronze, monel, and aluminium

OXYGEN ENRICHMENT

- When cryogenic liquid is transferred through uninsulated metal pipes, the surrounding air can condense on it
- An oxygen-enriched condensate can form (recall that liquid helium and nitrogen are below the boiling point of oxygen), increasing the flammability of materials near the system
- Combustible materials must be stored clear of equipment containing cryogenic fluids to reduce the risk of fire

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**