



**Institute for Plasma Research**

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# **Cryogenic Safety**

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# Definition

## Cryogenics:

The branches of physics and engineering that involve the **study of very low temperatures** (below 120K or  $-153^{\circ}\text{C}$ ), how to produce them and how materials behave at those temperatures,

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# Cryogenics used at IPR

Presently, Liquid Nitrogen and Liquid Helium are handled at IPR.

We are discussing about the properties of both cryogenics in details,

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# Cryogenics used at IPR

Properties of Liquid Helium at 15°C & 1 bar pressure-

- Boiling Point : - 269°C (4.15K)
- He Gas/Air density ratio : 0.14
- Volumetric of Gas : 739 times
- Latent Heat of Vaporization : 20.7kJ/Kg.
- Flammability : Non flammable
- Odour of Gas : Odourless
- Colour of Gas : Colourless

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# Cryogenics used at IPR

Properties of Liquid Nitrogen at 15°C & 1 bar pressure-

- Boiling Point : - 196°C (77.15K)
- N<sub>2</sub> Gas/Air density ratio : 0.98
- Volumetric of Gas : 691 times
- Latent Heat of Vaporization : 199kJ/Kg.
- Flammability : Non flammable
- Odour of Gas : Odourless
- Colour of Gas : Colourless

# Hazards of Cryogenics

Hazards associated with handling of cryogen-

Hazards causing injury or illness,

1. Cold burn
2. Frost Bite,
3. Asphyxiation,



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# Hazards of Cryogenics

Hazards associated with handling of cryogen-

Hazards responsible for fire and equipment failure,

1. Frosting of moisture renders oxygen enrich environment and blockage of safety valves, vent etc.,
2. Equipment failure due to over pressurization,
3. Equipment failure due to embrittlement,

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# Hazards causing injury or illhealth

## 1. Cold Burn:

The danger of cold burns is most prominent when

1. **Handling open cryogen** containers, especially when cooling down warm vessels or objects,
2. **De-choking** vents/drains of cryogen handling system,
3. Doing connections/disconnections of piping/hoses,

**Eyes and Mucous membranes are most at risk.**

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# Hazards causing injury or illhealth

**2. Frostbite:** Frostbite have three stages as follows,

## I. Frostnip-

In this stage, the individual experiences a pins and needles sensation with the **skin turning very white and soft,**

No blistering occurs,

This stage produces no permanent damage and may be reversed by soaking in warm water or breathing warm breath on the affected area,

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# Hazards causing injury or illhealth

## II. Superficial Frostbite-

In this stage, **blistering** may occur. The skin feels numb, waxy and frozen. Ice crystals form in the skin cells and the rest of the skin remains flexible,

## III. Deep Frostbite-

In this stage, blood vessels, muscles, tendons, nerves and bone may be frozen. This stage can lead to **permanent damage**, blood clots and gangrene, in severe cases.

# Hazards causing injury or illhealth

## Means of Protection & Prevention Measures-

Safety Equipment for Eye Protection, Hand Protection, Leg Protection, Body Protection etc. to be used,



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# Hazards causing injury or illhealth

## First aid treatment-

Rinse affected area with **lukewarm water**. Do not rub the affected area. Do not apply powder or cream. Consult the medical professional.

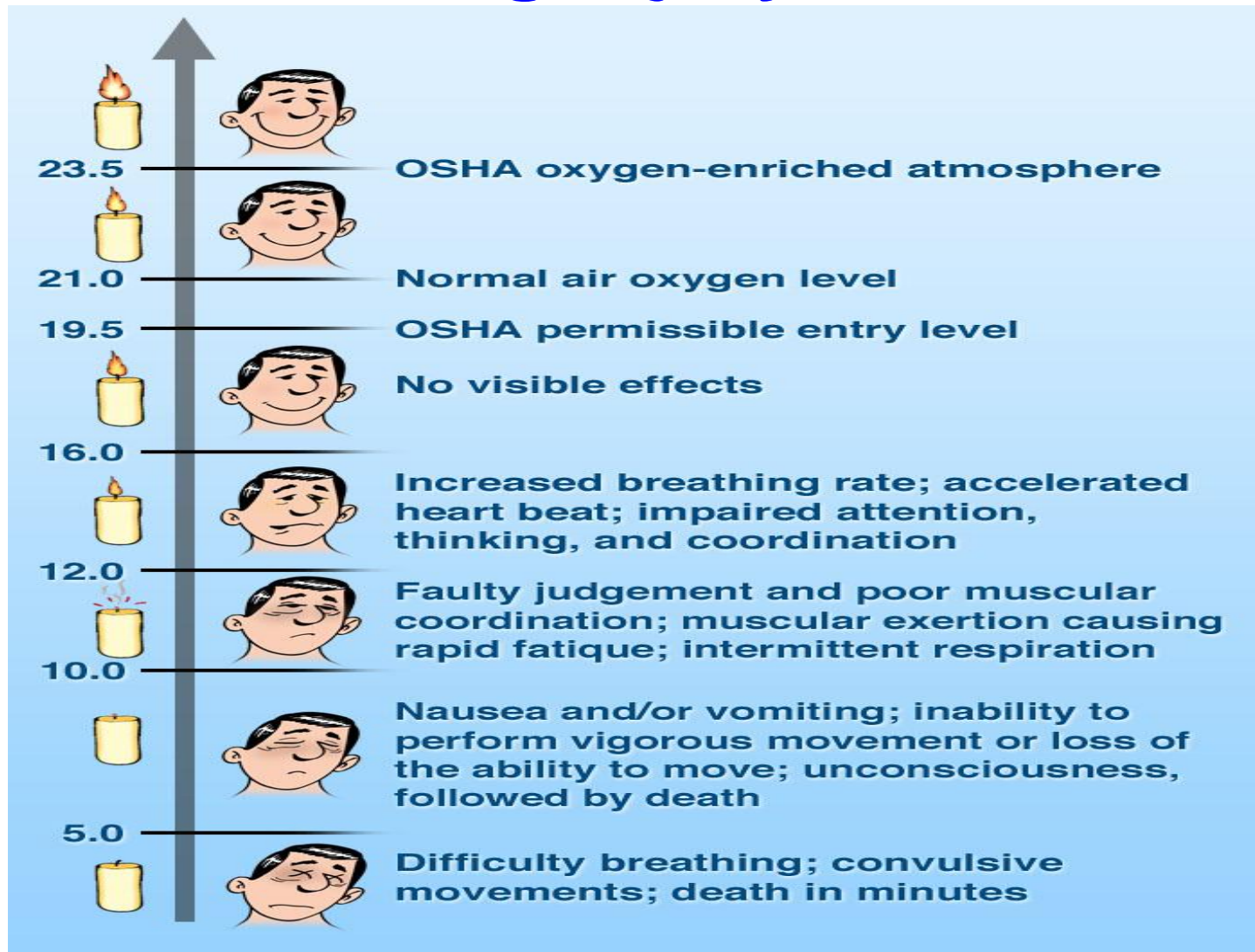
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# Hazards causing injury or illhealth

## 3. Asphyxiation:

- The evaporation/venting of cryogenic liquids in closed or badly ventilated rooms can lead to oxygen deficiency,
- Most of cryogen are odourless and colourless therefore they cannot be detected by smell but requires detector,
- Wet nitrogen is heavier than air and can therefore collect near the floor or in pits,

# Hazards causing injury or illhealth





# Hazards causing injury or illhealth

## 3. Asphyxiation:

Example for Helium discharge,

Formation of fog !!!



Beginning of the helium discharge  
(helium is mixing with the surrounding air)



Few seconds after the beginning of the  
helium discharge (just before full filling of  
the whole tunnel cross section)



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# Hazards causing injury or illhealth

## Means of Protection & Prevention Measures-

### Ventilation:

Sufficient ventilation of the working place,

Exhaust from transport Dewars/equipment should be taken out & vented at elevated level or feed it to gas recovery system - closed loop,

Do not drain liquid Cryogen in the closed room,



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# Hazards causing injury or illhealth

## Means of Protection & Prevention Measures-

### Monitoring:

Install **Oxygen monitors** with siren and display system in the working place to warn people working in the area.

Enter confined spaces, e.g. pits or tanks, only with portable oxygen monitor and ensure proper supervision,

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# Hazards causing injury or illhealth

## Rescue and First aid treatment-

### Symptoms :

If you feel dizzy, have an unexplained loss of co-ordination, or if your heart rate becomes unusually high, these may be signs of oxygen deficiency. Immediately go in fresh air and seek medical attention.

Victim of sudden asphyxia can not cry for help. He can not do anything by himself. Victim can be rescued only by other.

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# Hazards causing injury or illhealth

## Rescue and First aid treatment-

Rescue personnel should ensure that they are adequately **equipped with breathing apparatus** & air line respirators.

If somebody feels sick when working with cryogen he should be brought into a well ventilated room or open & clean atmosphere.

In case of unconsciousness give him Oxygen therapy and start artificial respiration immediately. Send victim to hospital immediately.

# Hazards causing injury or illhealth



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# Causes of Equipment Failure

## 1. Frosting-

The most imminent danger caused by condensation is the Freeze-up of exhaust pipes/vents of dewar/storage tanks by air and/or air moisture.

The plugging causes a pressure build-up which may lead to the bursting of the dewar. It may also render safety devices inoperative.

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# Causes of Equipment Failure

## Preventive Measures-

Do not leave dewars open to atmosphere. Purge and evacuate all equipment with dry gas thoroughly before charging Liq. Cryogen into any closed tanks / transfer lines,

Equip exhaust lines to atmosphere with non return valves.

Keep **slight higher pressure** than atmospheric pressure to prevent air ingress,

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# Causes of Equipment Failure

## 2. Pressurization-

### Stratification

If the cryogen in a large tank is not disturbed for some time, a temperature stratification may occur.

The stratification **causes a larger pressure rise** than expected due to the elevated temperature in the liquid surface layers.

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# Causes of Equipment Failure

## 2. Pressurization-

The release of cryo-pumped gas

Gas leaking into the insulation vacuum of a cryostat can be condensed by the cold surfaces and accumulate.

Upon eventual warm-up of the cryostat the desorbing gas can create a pressure in the inter-space which can both damage the internal and the external vessels.



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# Causes of Equipment Failure

## Preventive Measures against Pressurization

All transfer lines and containers/storage tanks in which cryogenic liquids can be confined must be **equipped with safety devices** like Safety Valve or Pressure Relief Valve.

The safety devices must be designed to work well in all possible operation conditions.

All safety devices should be **inspected and tested** periodically for its proper functioning.

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# Causes of Equipment Failure

## Preventive Measures against Pressurization

The following two principles should be applied:

1. **Redundancy** i.e. more safety devices than required respectively double safety devices and
2. **Diversity** i.e. safety devices based on different mechanisms,

Hence, there should always be at least two independent safety devices e.g. a safety valve and a bursting disk connected to separated pipes.

# Causes of Equipment Failure

## 3. Embrittlement-

Low temperature embrittlement does affect most materials more or less. It causes overloaded components to fracture spontaneously rather than accommodating the stress by plastic deformation.



# Safe Handling of DEWAR

Dewars is a double wall insulated vessel for storage of liquid Cryogen like liquid Helium and Liquid Nitrogen.



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# Safe Handling of DEWAR

1. Dewars' design is based on the density of cryogen and rate of evaporation / boiling point of the cryogen to be filled in.
2. Liquid Helium Dewar should not be used for Liquid Nitrogen.
3. Dewars should not be subjected to mechanical shock.
4. Leakage of liquid cryogen into vacuum space results over pressurisation due to evaporation so care should be taken and handle them in vertical position only.

# Safe Handling of DEWAR

5. Always **use standard trolley** for movement of Dewar & handle them as per manufacturer's operating instruction.



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# Safe Handling of DEWAR

6. If using a funnel, use caution not to overfill the container.
7. Wear appropriate Personal Protective Equipment during handling of Dewar.
8. Do not store in a confined space.

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# Safety Equipment

Even though all codes and standards have been meticulously followed, primary human safety protection devices have been placed at the prime locations of cryogenic equipments in the experimental buildings.



# Safety Equipment

Safety Shower



# Safety Equipment

Self-Contained  
Breathing  
Apparatus  
(SCBA) set



# Safety Equipment

Cryogenic  
Hand Gloves &  
Safety Goggles



# Safety Equipment

Cryogenic  
Apron



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# THANK YOU

