



Working With Cryogenic Liquids



WARWICK

What are Cryogenic Liquids?

Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures.

Different cryogens become liquids under different conditions of temperature and pressure, but all have two properties in common:

- they are extremely cold:
- small amounts of liquid can expand into very large volumes of gas.

Background

Cryogenic liquids are extremely cold and can cause cold burns/frostbite if they are allowed contact with skin. In addition, vented gases can cause local oxygen depletion, which can rapidly lead to asphyxiation.

Like many other dangerous chemicals and gases, cryogenics are safe if properly stored and used.

However, if misused or used/stored improperly, cryogenics can seriously harm or even kill.

Dewars & Liquid Cylinders

Dewar is a generic name for containers of cryogenic liquids. Specifically there are two types:

Open non-pressurized



Pressurized (Liquid Cylinders)



Pressurized containers have valves for filling and dispensing cryogenic liquids and are fitted with Pressure Relief Valves.

Hazards



- Cold Burns & Frostbite
- Asphyxiation
- Explosions & Extreme Pressures
- Embrittlement
- Liquid Air Condensation



Cold Burns & Frostbite

- Liquid or cold vapour can cause damage to the skin similar to heat burns.
- Directly by touching the liquid or from splashes.
- Unprotected parts of the skin coming into contact with cold equipment may become stuck and tear on removal.
- Indirectly by exposure to the cold gas from pressure relief valves or transfer lines.



Asphyxiation (1)

- Vented gases or boil-off can cause local oxygen depletion
- 1 L of Liquid Nitrogen expands to 694 L gas
- 1 L of Liquid Helium expands to 754 L gas
- **DO NOT** travel in any lift with Cryogenic Liquids and **ONLY** transport in the goods lift.
- Store containers in well-ventilated space
- Department Health & Safety web pages have an Oxygen Depletion calculator

Asphyxiation (2)

Oxygen normally represents 21%

However, lower levels of Oxygen can produce the following symptoms:

1st Stage - Oxygen is reduced to 14% by vol.

Breathing increases, accelerated pulse rate and thinking clearly is diminished, (you may not be aware). Muscular co-ordination is somewhat disturbed.

2nd Stage - Oxygen reduced to range 14 – 10% by vol.

Consciousness continues but judgement becomes faulty.
Severe injuries may cause no pain.
Muscular efforts lead to rapid fatigue.
Emotions, particularly ill temper, are easily provoked.

Asphyxiation (3)

3rd Stage - Oxygen reduced to range 10 – 6%

Nausea and vomiting may occur.

Victim loses ability to perform any muscular movements or even move at all.

Up to or during this stage, the victim may be wholly unaware that anything is wrong. It is all quite painless.

Permanent damage to the brain may result.

4th Stage - Oxygen reduced to below 6%

Respiration consists of gasps, separated by periods of increased duration.

Convulsive movements may occur.

Breathing then stops but the heart may continue for a few minutes.

NB: The gas/vapour is heavier than air and is likely to accumulate in confined spaces, particularly at or below ground level.

An individual collapsing will therefore be at great personal risk.

Fatality at research facility in the UK in 1999

In 1999, a fatality involving use of liquid nitrogen occurred at the Western General Hospital in Edinburgh.

An **experienced** laboratory worker, who had worked with liquid nitrogen over a period of years, died whilst filling flasks with liquid nitrogen. Seven hundred litres leaked into the laboratory and evaporated, asphyxiating him. A colleague, who entered the room to investigate a hissing noise, which was due to liquid nitrogen streaming from a hose attached to the wall, was able to turn off the supply and summon help before she too was overcome.

Four other people were also injured during this incident.

The Oxygen monitor in the space was switched off.

A personal O₂ monitor



Explosions & Extreme Pressures



Caution:

Water in the air can freeze and form Ice plugs inside Dewars or Cryostats, allowing pressure to build to dangerous levels.

Embrittlement



Care must be taken when selecting materials for use at very low temperatures as they can become extremely brittle.

e.g. Vent tubing can crack or shatter.

Not only well-known materials such as rubber, but also certain carbon steels.

Inspect tubing before use and replace if damaged.



Liquid Air Condensation



Whilst nitrogen and helium appear to be safe from the risk of combustion because they are inert, these liquids are cold enough to condense air from the atmosphere.

Liquid nitrogen b.p. -196°C (77K)

Liquid oxygen b.p. -183°C (90K)

This condensed air contains higher oxygen content than normal air, increasing the risk of combustion.

Always replace lids on dewars.

The Other Hazard



Cryogenics look fun, hence the temptation to play!

Training

ALL users must be trained and shown the correct procedures

Trainers: Tom Orton (Physics)
 Steve York (MAS)
 Dr Andy Howes (Millburn House)

ALL users must be on the **Users Register**.

This is maintained by the Health & Safety Officer and posted on the wall near the workshop lobby filling station.

Filling Points

Workshop Lobby

Enclosed area hence the alarm system.
First fill of the day takes longer due to cooling
additional length of tubing.

In the Physics yard near the storage tank

Exposed to the weather.
Be aware of ground conditions when moving
containers (slippery, wet)

Millburn House

Adjacent to the storage tank

Materials and Analytical Sciences (MAS)

Outside, close to the goods lift

Safe Handling (Dispensing & Decanting)

Only into approved containers (such as official Thermos Flasks)

If filling at the lobby point ensure that you are familiar with what to do if the alarm sounds. Instructions are posted close by the filling point

Before filling, conduct a visual check to ensure all equipment & fittings are in good condition and delivery pipe-work is secure.

A cold outside jacket indicates a loss of vacuum

Ensure containers are not sited directly under the sensor and away from the main thoroughfare. (Lobby fill point)

Precautions

The decanting pressure is designed to be low (*less than 2 Barg*) to prevent splashing and too rapid transfer of the liquid, **however,**

TAKE CARE to OPEN VALVES SLOWLY,

in case the pressure is greater than it should be.

DO NOT leave containers unattended during the filling process.

Beware of spray (this can occur when dewar is close to full)

If you are unfamiliar with the type of dewar and it's controls - find someone to help you.

Never use valves and other devices unless you are sure how to operate them safely.

After Filling

Close valve (Do not over tighten)

Store transfer tube away securely after use.

Use the hot air gun to thaw screwed fittings if necessary.

Transporting Dewars & Liquid Cylinders

Large, full, containers are heavy, have a high C of G and a narrow wheelbase, so they are at risk of toppling over on slopes and whilst negotiating ridges and gaps in floors.

Move Liquid containers slowly and consider the floor surface in front while moving and avoid rough handling.

Be aware of people and obstacles while moving.

DO NOT use the passenger lift or travel in the goods lift with cryogenics (and ensure no one else does)

Lobby Alarm System

Level 1 alarm is set at **19%** Oxygen. This is a silent alarm and alerts you with a flashing Yellow LED below the Oxygen display

Level 2 alarm is set at **18%** Oxygen and is indicated by a Red strobe and siren acting as an early warning.
This level is not normally hazardous.

This cuts off the supply of Liquid Nitrogen making it impossible to transfer until the alarm is reset

To reset the alarm press the green button. This will silence the alarm but transfer will not re-initiate until Level 1 conditions have been met and the green button is pressed again.

Lobby Oxygen Monitor



Sensor position

Lobby Oxygen Monitor



PPE (Personal Protective Equipment)



Gloves - **Compulsory**

- Elasticated wrist cuffs preferred
- Disposable nitrile gloves as liner if required



Eye Protection - **Compulsory**

- Goggles or Face shield



Ear Defenders - **Optional**

- High pitch whistle occasionally during dispensing

PPE (Personal Protective Equipment)



These gloves are not for immersion but will prevent cold damage to skin from contact with hoses and cold machine parts.

PPE (Personal Protective Equipment)

It is important to highlight the difference between gloves provided for very low temperature situations and those for cryogen work.

The blue gauntlets pictured (right) are used mainly for accessing -80°C freezers and provide additional arm protection against cold contact with shelves or other cold surfaces.

Gloves without cuffs have the potential to trap liquid which can lead very quickly to cold burns and blistering and must not be used with liquid cryogenes.



PPE (Personal Protective Equipment)

Enclosed footwear, preferably safety shoes/boots, must be worn whilst handling cryogenic liquids.



Physics Yard Filling Point



Physics Yard Filling Point

Pressure Relief
Valve



Fill valve

Helium Filling Point



P2 Plant Room – pressurised dewar being filled from 1000 L tank

Summary

