Safety Code of Practice 46, Part 5

2nd Edition, Sept 2023

THE SAFE USE OF LIQUID NITROGEN IN RESEARCH

Summary			
This Code of Practice establishes the minimum requirements for all Schools and Functions to ensure suitable control arrangements are in place for the safe use of liquid nitrogen within the University of Reading and undertaken by University Staff, Students and others as deemed appropriate by University of Reading Management.			
Document Control			
Document type (CoP / SN)		CoP	
Document owner		Scientific Safety Advisor	
Document status (Draft / Final)		FINAL	
Version		2	
Approved by		UHSWC	
Checked for accessibility	YES	Date	20/10/2023
Date of publication	14/11/2023	Next review date	14/11/2026
Date of original publication	Nov 2009	Revision frequency	
Superseded documents		Version 1	
Related documents		CoP46 pt 1, pt 2, pt 3, pt 4	

Contents

1 INTRODUCTION

This document establishes requirements for ensuring all work involving liquid nitrogen (LN2) is carried out by competent people working to a pre defined and agreed safe systems of work when using, storing or disposing of liquid nitrogen within the laboratory setting. It defines the training requirements and content of local rules that must be met and adhered to.

The purchase, use and maintenance of vessels, pressure equipment and gas alarm systems is covered in detail in Safety Guide 46 Part 1 Management and Safe Use of Work Equipment. This describes the management systems required to purchase, use and maintain all types of equipment used at work, including industrial gases. Part 2, Pressure Systems, deals with those aspects that relate to hazards from pressure (liquids and gases). Part 3 covers the safety of gas systems, including mains gas and industrial gases in cylinders. This Guide, Part 5, covers the safe use of liquid nitrogen in research.

2 SCOPE

This Code of Practice applies to all staff, students, contractors and visitors carrying out or planning to carry out work activities that involve liquid nitrogen. This CoP specifically covers safe work with liquid nitrogen and cryogenic storage in liquid nitrogen. Other cryogenic liquids, such as helium, oxygen (not permitted at UoR) and argon, are excluded from this code of practice

It does not cover use of liquid nitrogen for catering purposes, art installations, stage/theatre productions or special effects.

3 DEFINITIONS

Liquid nitrogen (LN2); nitrogen in a liquid state at low temperature. Liquid nitrogen has a boiling point of about −195.8 °C (−320 °F; 77 K).

Cryogen; a substance used to produce and maintain extremely low temperatures. Common cryogens include liquid nitrogen (most commonly used at UoR), liquid helium and dry ice (solid carbon dioxide).

Asphyxiation; A fatal condition caused by a lack of oxygen. It may be accompanied by an excess of carbon dioxide in the blood (hypercapnia). Produced by interference with respiration or insufficient oxygen in the air.

Oxygen depletion; a condition where the concentration of oxygen in the air drops below the normal level (21%). This can occur through displacement of the air by a gas or as a result of combustion or other chemical reaction.

Dewar; For the purposes of this Code of Practice the term Dewar shall mean a mobile thermally insulated receptacle for refrigerated liquefied gases that operates below 0.5 bar pressure.

Storage tank; The storage container from which the liquid nitrogen is transferred into the Dewar.

4 RESPONSIBILITIES

All staff and students are responsible for

- Ensuring they do not carry out any work with liquid nitrogen unless they
  - Are aware of the hazards and risk assessment findings related to the use of liquid nitrogen in the specific area in which they are working. For liquid nitrogen this MUST include a documented “worst case scenario” calculation (see appendix 2).
  - Are trained and authorised to move, use, dispense or dispose of liquid nitrogen.
  - Have carried out pre-use checks, as defined in the safe system of work or operating procedure.
- Reporting immediately any incidents, faults, damage or safety concerns regarding the equipment or facilities where work involving liquid nitrogen is carried out.
- Not attempting to dispense liquid nitrogen outside of normal working hours (see CoP 7 Outside Normal Working Hours).

Heads of Schools and Functions Heads of Schools and Heads of Function are responsible for establishing arrangements to ensure that where their School /Function is undertaking work with liquid nitrogen or where their School is facilitating a third party to use UoR facilities for this activity, that work complies with the requirements of this Code of Practice including:

- Identify any work with liquid nitrogen under the Schools or Function’s ownership or control.
- Define responsibilities for the laboratories and storage facilities where liquid nitrogen is in use by designating a named individual as laboratory manager and ensuring local rules are devised, implemented and enforced by the laboratory manager; guidance on these rules will be provided by local HSCs and the Scientific safety advisor
- Define responsibilities for assessing risk and identifying competence requirements related to the safe delivery, dispensing, storage and use of liquid nitrogen.
- Devise and, where necessary, document adequate safe systems of work.
- Provide suitable and sufficient induction and training and keep records of individual’s attendance and competency assessment and sign off following training.
- Ensure that where control measures, such as oxygen depletion or gas detection alarm system are in place, that these are maintained, calibrated and routinely tested.
- Develop, where necessary document, communicate, train and exercise emergency responses to foreseeable emergency situations arising from the use of liquid nitrogen, where determined as necessary by risk assessment Accidents and spillages are reported to H&S Services for investigation allocation
- out of hours working is prohibited

Scientific Safety Advisor is responsible for

- Developing, updating and reviewing policies, standards and providing advice on local rules and systems of work with liquid nitrogen

- Assist in the provision of suitable training for those involved in activities using liquid nitrogen
- Assessing the suitability and quality of training delivered
- Investigating accidents, incidents and near misses involving liquid nitrogen and the provision of advice on remedial actions

  Advising Schools and Estates & Facilities on the suitability of cryogenic storage facilities and equipment.

Supervisors

Supervisors are responsible for ensuring that all activities meet the requirements of this Code of Practice, including:

- a suitable and sufficient risk assessment is carried out for all activities involving liquid nitrogen
- that this assessment includes emergency arrangements and documents spills procedures, taking into account the volume, location and hazard(s) of the spillage.
- all persons working under their supervision have received appropriate training and information, including awareness of risks, appropriate control measures to apply, and emergency procedures;
- they provide or organise appropriate supervision to assess and monitor competence of persons under their control to work safely;
- all accidents and spillages are reported to H&S Services;

Full Time Health and Safety co-ordinators/Health and Safety managers are responsible for

- Including relevant safety information in the local induction of all staff and students into facilities where liquid nitrogen is used and/or stored. This is to include (but is not limited to);
  - Hazards associated with liquid nitrogen
  - Emergency response in the event of a spillage and/or an alarm condition
  - Ensuring that prohibition of out of hours liquid nitrogen use is communicated
- Provision of training for laboratory users of liquid nitrogen. This will cover category 1 and 2 outlined below. (category 3 will be provided by Gas Safe Ltd or the Scientific Safety Advisor).

  The three categories of user and required training are as follows, delivered in accordance with the individuals training need ;

  Category 1: Awareness training

  Category 2: Pouring from Dewars ("onions") and use of small quantities within the laboratory (<5L)

  Category 3: Decanting from pressure vessels.
- Reviewing the calculations provided on any risk assessment relating to the use of liquid nitrogen.

5 REQUIREMENTS

Before any work involving liquid nitrogen is conducted, a suitable and sufficient risk assessment must be carried out and recorded. The risk assessment must be conducted by a team or individual who has the sufficient knowledge and experience of working with liquid nitrogen to reliably assess the risks and put in place suitable control measures.

All risk assessments for liquid nitrogen work, including use of cryogenic storage Dewars, must include a calculation that takes into account the worst-case scenario in which the entire volume of the largest liquid cryogen vessel immediately and uncontrollably turns into gas and depletes the surrounding area of oxygen. See appendix 2.

The risk assessment and accompanying calculation should be submitted to the Health and Safety co-ordinator for review before commencing work.

The result of this calculation will determine what control measures are to be put in place. If you are unsure how to perform the calculation or need advice, please contact your local Health and Safety Coordinator or the Scientific Safety Advisor.

The use of oxygen deficiency monitors is a last resort; the primary goal is to remove the risk of an oxygen deficient atmosphere by good planning and design. Where the oxygen content may fall to a dangerous level, continuous monitoring methods must be used. Hand-held oxygen deficiency monitors are not suitable for permanent monitoring installations.

Where gas monitoring/alarm systems are installed, it is essential that all users of the area are familiar with the alarm sound and have received training on what to do (and what not to do) in the event of an alarm condition. This is to be included in the initial safety induction to the laboratory/facility.

Personal Protective Equipment (PPE)

The eyes are the most sensitive body part to the extreme cold of the liquid and vapours. The recommended PPE for handling cryogens includes:

• Face protection	• A full-face shield, or safety glasses with cheek and brow guards.
• Gloves	• Non-absorbent, insulated gloves with ribbed cuffs, made from a suitable material such as leather. The gloves should be loose fit for easy removal. Sleeves should cover the ends of the gloves. • NB Gauntlet gloves are not recommended because liquid can drip into them. Gloves are not made to permit the hands to be immersed in a cryogenic liquid. They will only provide short-term protection from accidental contact with the liquid.
• Body protection	• This is task dependant but a Howie style lab coat should be worn at all times. Legs should be covered with no exposed skin that could be burnt I the event of spillage.

• Shoes	• Closed toe shoes or boots (not Wellingtons) that will not allow liquefied gas to enter them in the event of a spill.
• General	• No metal jewellery, rings or watches should be worn on hands or wrists while transferring cryogenic liquids.

Table 1 Personal Protective Equipment for Cryogenic Gases and Liquids

5.1 Storage and use

There are 2 types of liquid nitrogen containers commonly used at the University of Reading. The terminology is not specifically defined and it is common to refer to any liquid nitrogen vessel as a Dewar (named after Sir James Dewar, the inventor of the vacuum flask). The distinction is to be made between non-pressurised vessels and pressurised vessels (covered by the PSSR 2000 regulations).

- Dewars **(Non-pressurised),** vacuum-walled containers which are equipped either with a loose-fitting cap or open top and are used for storage of liquid nitrogen itself or as cryogenic storage for biological materials. These can have either a narrow neck (intended for pouring from e.g "an onion") or a wide neck (intended to allow access to the stored contents e.g. cryovials)
- Dewars (**Pressurised),** Also known as storage tanks. Vacuum-walled insulated containers that are designed to withstand the build up of pressure within the vessel (up to the set points determined by the pressure relief valves and burst discs built into the vessel and pipe work). This pressure is then used to dispense the liquid contents via a suitable dispensing hose. The approximate working pressure for dispensing liquid nitrogen is in the range of 7-15psi or roughly 0.5 to 1 bar.

(Some larger vessels have a pressure building system of pipework to enable the user to draw off more liquid at one visit than the passive build up of pressure would otherwise allow). These can also be used to supply equipment with liquid nitrogen under pressure. If you are unsure which type of vessel you have or its functionality and features, please contact your local HSC or Scientific Safety Advisor. All users of these vessels are required to attend the Category 3 training provided.

Cryogenic liquids will vent (boil off) from their storage containers as part of normal operation. Generally 1% to 4% of the liquid content is converted to gas in 24 hours. As an example a 160-litre tank of nitrogen will vent the gas equivalent to two litres of liquid a day.

All cryogenic liquids must be stored and used in a well-ventilated area. Where possible, liquid cylinders and storage tanks should be located outside buildings in a secure area. Cryogenic liquids may only be stored in containers or systems designed in accordance with applicable standards.

5.2 Storage and use of Dewars in rooms

The suitability of a room for locating a cryogenic storage Dewar will be determined by the risk assessment, in particular the mandatory calculation regarding the "worst case scenario" release of the entire contents into the space.

Further consideration is to be given to the daily boil off rate and if there are other sources of gas or other cryogenic storage vessels in the same area. This will need to be assessed and re-assessed each time an additional vessel is added or moved from the area.

If you are considering storage of a Dewar(s) in any space, you must contact your local HSC before purchasing or locating the Dewar.

5.3 Labelling of Dewars

Liquid nitrogen Dewars must be clearly and adequately labelled, For "onions" and cell storage Dewars the following should be clearly visible from any angle;

- The liquid nitrogen hazard warning triangle
- The owner/responsible person's contact details

For pressurised dispensing Dewars the labelling should be in accordance with the system outlined in reference 1. The annual inspection of the vessels by the competent person will include a visual inspection of the labelling and the dates of expiry or recommissioning of the vessel. Failure to display the label will result in the vessel not being certified for use.

If you are unsure of the requirements you can contact the University Scientific Safety Advisor.

Label for nitrogen dewars

5.4 Area signage

Any room or area in which cryogenic liquids are stored, dispensed or used must display appropriate hazard warning signage – see below.

Liquid Nitrogen

The warning triangle (above left) must be used in all locations. Where the worst case scenario calculation result was below 19% the risk of asphyxiation sign (above middle) must be displayed. Where flammable gas may be present a prohibition notice (above right) must also be used.

Additional labelling for mandatory PPE requirements should be visible on the door to the area.

5.5 Safe working practices

General precautions

1. Liquid nitrogen must be handled, stored and used only in containers or systems designed in accordance with applicable standards, procedures or proven safe practices. **The use of domestic thermos-style vacuum flasks is not permitted.**
2. All use of liquid nitrogen, including open transfers and decanting, must take place in a well-ventilated area.
3. Suitable PPE should be used at all times. This includes a Howie style lab coat, thermally resistant gloves (which must be kept dry) with elasticated cuffs and eye protection (full face visor or safety specs depending on task based risk assessment. Closed toe non absorbent footwear should be worn and the legs should be covered with clothing.
4. All systems components piping, valves etc. must be of the appropriate materials to withstand the extreme temperatures.
5. Use tongs or other similar devices to immerse and remove objects from cryogenic liquids.
6. Where oxygen monitors are required, as determined by risk assessment, these must be checked for correct operation before use and maintained (See CoP 46 pt 1).
7. Hazard reviews are required on all newly purchased, built or modified tools using cryogenic materials. Contact Health and Safety Services for advice.
8. Do not use liquid nitrogen outside of working hours (18:00-08:00 Monday to Friday and Weekends).

5.6 Pressure systems

Pressure relief valves must be in place in systems and piping to prevent pressure build up, including where system sections could be valved off while containing cryogenic liquid. Pressure relief valve relief ports must be positioned to face toward a safe location.

5.7 Decanting from pressure vessels

Detailed procedures for safe decanting are given in BCGA Code of Practice CP30 (Ref. 1). The following is a summary of safety precautions:

- Care must be taken not to make contact with non-insulated pipes and system components.
- Wear all appropriate PPE.
- Only use containers designed for the specific cryogenic liquid being handled. Carry out pre-fill checks to ensure that the Dewar is clean and undamaged, and that the supply vessel pressure is not too high – if it is above 10 psig, vent the tank.
- Always follow the correct transfer procedure, including transfer equipment, coupling hoses etc.
- Do not hold the vessel or delivery pipe with unprotected hands while filling.
- Place the receptacle at a safe height, preferably close to the delivery pipe. Do not allow liquid nitrogen to fall through the air to reach the vessel being filled. The delivery pipe must be immediately in the mouth of the receiving vessel.
- Use a phase separator or to prevent splashing and spilling when transferring liquid nitrogen into or from a Dewar. Only funnels with vent pipes to release displaced gas/air can be used to aiding filling of smaller vessels, these must be capable of withstanding the extremely low temperatures.
- Insert pipes and funnels slowly to avoid splashing. Stand clear of boiling or splashing liquid and gas.
- Never overfill Dewars. Spillage damages flooring and could cause injury.
- Space must be left to replace lids/tops on Dewars, especially those that insert a considerable distance into the vessel.
- Do not move or bend the copper fill tube. This causes wear that will eventually cause the tube to break.
- Fill vessels slowly to minimise temperature-induced stresses.
- Ensure that the vessel stopper allows adequate venting of the evaporating gas to prevent pressure increases.

5.8 Decanting from storage Dewars into smaller vessels

Do not try to lift, carry or pour from heavy containers. A 25 litre Dewar will weigh about 35kg when full. which is too heavy for one person to carry or pour safely. Use transportable tilting and pouring trolleys for pouring.

When pouring into narrow necked openings such as cryostats or cold traps, use a suitable funnel in the cold trap inlet to reduce spillage and start by pouring only a small amount into the funnel to let it cool down before filling properly – **pour slowly.**

5.9 Storage of samples in liquid nitrogen

When samples are removed from liquid nitrogen storage and warmed there is a possibility that the sample tube may explode. This may happen because tubes are not completely sealed and liquid nitrogen seeps into the tube and expands rapidly on warming. There is potential for significant injury and a possible associated infection risk to anyone nearby. The use of vapour phase storage and appropriate vials can reduce the likelihood of this occurring. If vials are stored in the liquid phase, on removal they should immediately be placed in secondary containment e.g. a plastic sandwich box, or behind a shield in a safety cabinet, until they reach room temperature or onto dry ice covered with a lid until any liquid nitrogen has dispersed to gaseous nitrogen. During removal, **the operator must wear a face shield** and bystanders should be wearing safety glasses.

5.10Transportation and manual handling

Lifting and carrying Dewars should be regarded as hazardous and will require a proper risk assessment and lifting procedure to be laid down.

The following precautions must be adopted:

- Only use closed "onion" (25 litre) Dewars and "transport" Dewars when moving liquid nitrogen.
- Moving large Dewars is always a two person operation.
- Keep unit upright at all times and handle it carefully. Tipping the container or laying it on its side can cause spillage of liquid nitrogen. Rough handling or tipping may also damage the container and any materials stored in it.
- Do not "walk", roll or drag Dewars across a floor. Large units are heavy enough to cause personal injury or damage to equipment if proper lifting and handling techniques are not used.
- Ensure that where wheeled Dewars are used, the route to be followed is even and does not have features such as gratings or cobbles that could cause the Dewar to tip over.
- Always ensure that the pressure inside the vessel is 50% or less of the relief valve level before moving a vessel.
- Have an inspection and maintenance regime to ensure that trolleys are maintained in good condition.

Vessels of less than 2 litre capacity

Temporary storage, sample transfer and working volumes on the bench e.g snap freezing, can be in small Dewar vessels with approximately 1 to 2 litres liquid volume and maximum capacity of no more than 5L. However, any lid must be vented to avoid the build-up of pressure which would happen in a sealed vessel. **Domestic thermos flasks must not be used** as they are not designed or manufactured to withstand the extreme cold and stresses liquid nitrogen will place on them, the lids are also unvented posing the risk of explosion due to pressure build up.

5.11 Use of lifts

Due to the confined nature of the enclosed space within a lift, the spillage of even a small volume of a liquid cryogen in a lift could result in an oxygen depleted atmosphere. **NEVER enter a lift with a liquid nitrogen.**

If it is unavoidable to transport a vessel in a lift, the following points should be incorporated into the documented safe system of work or SOP

- A cryogenic pressure vessel should be vented off to atmosphere in a safe well ventilated area, until the pressure falls below 50% of the relief valve set pressure. Close all valves and check that the liquid has stabilised (monitor the pressure gauge) before placing in the lift.
- Dewars should only be filled to 90% of the net capacity to reduce the risk of spillage. Check open Dewars for excessive boil off. Allow to stand until there is no visible boil off. Then ensure that the correct neck plug is fitted.
- Always work in pairs
- Use a goods lift whenever possible.
- Use a key controlled lift where possible.
- If not key-controlled, use additional personnel, barriers and warning notices to prevent entry to the lift during the transfer.
- Place a personal oxygen monitor in the lift with the vessel/Dewar to alert the receiver of a dangerous condition in the lift if the vessel/Dewar leaks during transport.
- One person should send the lift and the second should be waiting to receive the vessel/Dewar at the floor destination.
- **No one should accompany the vessel/Dewar in the lift**.

5.12 Disposal of liquid nitrogen

Under no circumstances should liquid nitrogen be disposed of via the sink. This would give rise to a large volume of gaseous nitrogen through rapid boil off, damage the sink and pipework and pose serious risk of injury to the user.

The correct way to dispose of liquid nitrogen is through passive venting. For small transport Dewars containing up to 5L of LN2 this would be achieved by placing them in a fume cupboard with the lid ajar and allowing the liquid to boil off. For larger vessels they should be placed in a large, well ventilated space with a label affixed stating "controlled venting in progress, do not move".

If there is ever a need to rapidly dispose of a larger volume of liquid nitrogen this must only ever be done outside, under controlled conditions, wearing suitable PPE. It is best achieved by gradual pouring of the contents of the vessel onto a patch of clear ground well away from any persons not involved in the procedure. Any gradient/slope must be carefully considered and a safe distance between the location and any buildings or thoroughfares evaluated depending on the volume to be disposed of. Before this is caried out any personnel must contact their local HSC or the SSA for advice and approval.

5.13 Maintenance of Dewars

All large Dewars (25 litres or larger) should be subject to annual maintenance checks. Pressurised vessels must inspected by a competent person in accordance with a written scheme of examination (see Safety Guide 46 Part 2 Pressure Systems).

Dewars and their stoppers should be visually inspected by the user each time they are refilled.

Excessive venting and/or an isolated ice build-up on the vessel walls may indicate a fault in the vessel's integrity or a problem in the process line. If this is suspected, transfer the materials to another Dewar and contact the supplier.

6 EMERGENCY PROCEDURES AND ALARM SYSTEMS

Oxygen-deficient atmospheres are an invisible danger. They have no warning properties. Where oxygen depletion alarms have been installed as a control measure driven out of risk assessment, they must be serviced, maintained, calibrated and tested at a frequency specified by the manufacturer (minimum of an annual service and calibration). Training in what to do in the event of an alarm condition must be given to all users who have access to the area which is covered by the system.

- Schools must have written emergency procedures to deal with spillages, accidents and other unforeseen events. These must be displayed in the area and made known to all users.

- **Never enter an area suspected of being oxygen-deficient or where a low oxygen alarm is sounding.** Evacuate the area, deploy warning signs and restrict all access. Use monitoring devices to ensure oxygen levels are safe and **follow the approved written alarm procedure**. Doors to areas with oxygen depletion alarms should have clear signage to prevent entry in case of the alarm sounding. All users of an area with gas alarm systems should be aware of the alarm tone and what to do in the event of it sounding.

6.1 Dealing with spillages

A written emergency procedure to deal with spillages must be in place before commencing work with liquid nitrogen.

All users of the area that the spills procedure is applicable to need to be notified of the response **before a spillage occurs**. This should be covered in the laboratory induction.

7 TRAINING

All staff and students working with liquid nitrogen must receive appropriate training in accordance with written standard operating <u>and</u> emergency procedures for the facility. This training must be delivered by a competent person. This may be an approved external training provider or a competent designated individual. It is recommended that emergency procedures are rehearsed. All training must be recorded.

For liquid nitrogen the following three categories of user and required training are as follows, delivered in accordance with the individuals training need;

Category 1 : Awareness training

Category 2 : Pouring from dewars ("onions") and use of small quantities (<5L)

Category 3 : Decanting from pressure vessels.

Users must demonstrate competency and be authorised before being allowed to use cryogenic gases.

All other staff who may be required to work in areas where cryogenic liquid nitrogen is stored (e.g. cleaners, maintenance personnel) must receive basic hazard awareness training and instruction on what to do in an emergency.

8 RELEVANT LEGISLATION

Health & Safety at Work Act 1974

- https://www.hse.gov.uk/legislation/hswa.htm

The Provision and Use of Work Equipment Regulation 1998

- https://www.hse.gov.uk/work-equipment-machinery/puwer.htm

9 REFERENCES

1. BCGA CODE OF PRACTICE CP30 The Safe Use of Liquid Nitrogen Dewars up to 50 Litre. Revision 3 : 2019.
2. Cryogenic Gases. Gas Safe Consultants Ltd.
3. Safe decanting of liquid nitrogen – workbook. BOC.
4. Care with cryogenics. BOC
5. Controlling the risks of inert gases. BOC.
6. British Standard BS 5429 : 1976. Code of practice for Safe operation of small-scale storage facilities for cryogenic liquids.

Appendix 1: Hazards of cryogenic gases

Extreme cold

By definition, all cryogenic liquids are extremely cold. Cryogenic liquids and their vapours can rapidly freeze human tissue. Brief exposures that would not affect skin on the face or hands can damage delicate tissues such as the eyes. Prolonged exposure of the skin or contact with cold surfaces can cause frostbite. Unprotected skin can stick to metal that is cooled by cryogenic liquids. Even non-metallic materials are dangerous to touch at low temperature. Prolonged breathing of extremely cold air may damage the lungs.

Cryogenic liquids can cause many common materials such as carbon steel, rubber and plastics to become brittle or break under stress.

Asphyxiation

All cryogenic liquids produce large volumes of gas when they vaporise. One volume of liquid nitrogen vaporises to 694 volumes of nitrogen gas at 20º C at 1 atm. Air is normally 21% oxygen by volume. When this is reduced to 15-16% oxygen, symptoms of asphyxia (see below) will be experienced.

When cryogenic liquids form a gas, that gas is very cold and usually heavier than air. This cold, heavy gas does not disperse well and can accumulate near the floor or in pits. Even if the gas is non-toxic, it displaces the air. Oxygen deficiency from the release of inert gases is a serious hazard in enclosed or confined spaces.

Symptoms of asphyxiation are giddiness, mental confusion, loss of judgment, loss of coordination, weakness, nausea, fainting, and death. If the oxygen content of air falls below 11%, an individual may lose consciousness without warning. Mental failure and coma follow within seconds. Warning symptoms are generally absent, but even if present, the loss of mental abilities, coordination and weakness may make it impossible for victims to help themselves or summon help from others.

Most cryogenic liquids are odourless, colourless and tasteless when vaporised into the gaseous state. Most liquids have no colour except liquid oxygen, which is light blue. However, when extremely cold liquids vaporise, the cold "boil-off" gases condense the moisture in the surrounding air, creating a highly visible fog. Fog clouds do not define the vapour cloud. They define the area where vapours are still cold enough to condense the moisture in the air. The vapour cloud may extend well beyond the fog cloud. Although fog clouds may be indicative of a release, they must never be used to define the leak area, which should not be entered by anyone.

Oxygen enrichment

Vaporisation of liquid oxygen in an enclosed area can cause oxygen enrichment, which could saturate combustibles in the area such as workers' clothing. This can cause a fire if an ignition source is present. Although oxygen is not flammable it will support and vigorously accelerate the combustion of other materials.

Leaving a liquid nitrogen Dewar open to atmosphere can cause oxygen from the air to condense in the container. This may lead to an undetected fire risk if organic materials are available to provide fuel.

Explosion due to rapid expansion

Cryogenic liquids cannot be indefinitely maintained in the liquid state at room temperature and pressure. If they are vaporised in a sealed container the resulting increase in pressure can rupture the container. For this reason pressurised cryogenic containers are normally protected with multiple devices for over-pressure prevention. A pressure relief device must protect all equipment that may allow the liquid to become trapped.

Ice Plugs

Ice plugs may form in the neck of Dewar flasks that are left open or where the stopper plug is not periodically maintained. This effect is exacerbated by high humidity in the storage area. These can block the outlet and cause a build up of internal pressure which may result in either the plug being explosively ejected, or the rupture of the vessel. If an ice plug is found extreme caution is needed. The area should be vacated and the local HSC, H&SS and a senior member of technical staff contacted immediately. To prevent the formation of ice plugs a visual inspection of the stopper/bung/loose fitting lid should be carried out when the vessel is filed. If there is a build up of ice hindering the free movement of the stopper it should be removed by gently scrapping with a rounded blunt instrument or allowed to thaw, dry and then be reinserted. If the stopper is damaged it must be replaced or the Dewar decommissioned.

Appendix 2: Worst case scenario calculation

Worst case scenario - full contents of the largest vessel are released to atmosphere over a short period of time.

Step 1 Calculate volume of room (in cubic metres) (Vr)

Step 2 Calculate volume of cryogenic gas (Vg) at atmospheric pressure

Vg = volume of Dewar (litres) x expansion ratio for the liquid (for liquid nitrogen this is 682)

If the calculation suggests that the volume of gas released will be more than 15% of the room volume, additional precautions must be taken. This could be:

a) finding an alternative location
b) reducing the quantities of cryogenic liquid is use/storage
c) increasing the ventilation.

Note that pockets of higher concentrations of gas (i.e. lower oxygen concentration) will exist, particularly in the early stages after release, and particularly at low level.

Calculating oxygen levels

Volume of oxygen (Vo) in a room can be calculated using:

0.2095 x [Room volume (Vr) – Gas volume (Vg)]

Percentage of oxygen in a room can be calculated using

100 x [Volume of oxygen (Vo) % Room volume (Vr)]

The normal percentage of oxygen in a room is approximately 21.5%. Action should be taken if levels fall below 19% (working situations) and 18% (emergency situations).

Appendix 3: Cryogenic storage checklist

This checklist is an aid to monitoring by Schools responsible for the storage of bulk quantities of cryogenic materials. Should the answer to any of the questions be NO, an action plan is required. If in doubt, please contact Health & Safety Services on ext. 8888.

School	
Store Location	
Cryogenic Material	

	YES	NO
Does the room have mandatory safety warning signs on the door?	☐	☐
Is suitable PPE provided?	☐	☐
Are there maintenance records for the:		
a) storage equipment (cylinders, regulators)	☐	☐
b) ventilation equipment?	☐	☐
c) PPE?	☐	☐
Is there adequate ventilation?	☐	☐
State type of ventilation: e.g. mechanical, natural etc.		
Number of air changes per hour: a) normal cycle ____/hr b) emergency cycle ____/hr		
If necessary, is there a warning device in case of:		
a) oxygen enrichment/deficiency	☐	☐
b) failure of ventilation	☐	☐
Is there a written emergency procedure?	☐	☐
Are there written standard operating procedures in place for handling cryogenic materials?	☐	☐
Is the room restricted to trained users?	☐	☐
Have all users been given copies of the standard operating procedures and emergency procedures?	☐	☐
Has the atmospheric oxygen shift following maximum spillage been determined?	☐	☐
Is there a designated contact person in the case of emergencies?	☐	☐

School Area Health and Safety Co-ordinator (print):	
Signed:	
Date	

10 VERSION CONTROL LOG OF DOCUMENT CHANGES

Version	Changes	Author	Approved by	Approval date	Published date
1.0	Major Re-write	JR	UHSWC	20/10/23	14/11/23
2.0					
3.0					
4.0					
4.1					