Health & Safety Services

University of Reading

Safety Code of Practice 46, Part 5

1st Edition, November 2009

MANAGEMENT AND SAFE USE OF WORK EQUIPMENT: CRYOGENIC GASES

Contents

1 SCOPE

Safety Guide 46 Part 1 Management and Safe Use of Work Equipment 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, deals with the cryogenic properties of liquids and gases.

2 GENERAL

A cryogenic liquid is defined as a liquid with a normal boiling point below -90°C. For the purposes of this Safety Guide, liquid propane is considered as an equivalent hazard, although its boiling point is considerably higher. The hazards associated with cryogenic gases include:

- extreme cold, resulting in frostbite for personnel who come into contact with the liquid.
- asphyxiation resulting from the release or inert gases and oxygen depletion.
- oxygen enrichment resulting from oxygen from the surrounding air condensing on a liquid nitrogen vessel that is left open to atmosphere.
- explosion due to rapid expansion of cryogenic gas and overpressure

Further information on the hazards is given in Appendix 1.

3 PLANNING AND ASSESSMENT

Before installing a cryogenic system a simple risk based assessment must be carried out. This can prevent wasted effort and cost. The following key points must be considered before authorising work or purchasing equipment:

1. Is the room big enough for the task i.e. sufficient room for the operators to pass round any surfaces and venting pipes without coming into contact with cold surfaces?
2. Does the room/location have adequate natural ventilation? Natural ventilation is always preferable to mechanical ventilation since mechanical systems can fail and create a hazard.
3. 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.
4. A calculation must be made of the maximum amount of gas that could be released into the room in all circumstances. Always try to keep the total amount of possible gas below 15% of the volume of the room, either by reducing the amount of cryogenic liquid or by increasing the natural ventilation. If this cannot be achieved, alternative locations and/or additional precautions must be implemented. NB 15% of volume takes into account the property of cryogenic gases to collect at low level due to the increased density of the cold vapour and its reduced dissipation rate due to temperature.
5. Check that there are no building heating thermostats in the room; the presence of cryogenic gases can have a detrimental effect on the heating for the rest of the building.

4 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	Normal clothing consisting of long sleeved shirts and trousers without cuffs or turn-ups, with a laboratory coat over. Lab coats must not have pockets. Trousers should be worn over the shoes/boots.
Shoes	Safety shoes or boots (not Wellingtons) that will not allow liquefied gas to enter them in the event of a spill i.e. no lace holes through to the inside of the shoe.
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 STORAGE AND USE

There are three types of storage for cryogenic liquids/gases:

- Dewars: Non-pressurised, vacuum-walled containers which are equipped either with a loose-fitting cap or open top and are used for storage of small amounts of liquid.
- Cryogenic Liquid Cylinders (pressurised vacuum-insulated vessels (PVIVs): These are sealed, vacuum-walled containers, which contain pressure up to 350 psig. Cryogenic liquids can also be extracted from these containers.
- Cryogenic Storage Tanks: These tanks range in size from 20,000 litres to 200,000 litres and are always pad mounted. Liquid and gas can be extracted from these containers.

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.

5.1 **Storage and use of Dewars in rooms**

There must be adequate ventilation in the room to cater for:

- The normal evaporation of all Dewars and liquid nitrogen containers within the room.
- The filling losses from filling the largest Dewar from a warm condition.

Neither of these conditions should cause the oxygen concentration to fall below 19.5%. For small numbers of Dewars (one or two), natural room ventilation will normally be adequate. Where larger numbers of Dewars are concentrated together or where storage is in pressurised containers, a more detailed assessment is necessary. See Annex 3 of Reference 1 for how to calculate ventilation requirements, and Annex 5 for how to calculate evaporation losses and losses due to filling.

Additionally, the complete spillage of the contents of the largest Dewar must not cause the oxygen concentration to fall below 18%.

Dewars must not be stored in sealed rooms (e.g. walk-in refrigerated rooms) because the reduced ventilation may be inadequate to mitigate against spillage and general evaporation.

5.2 **Labelling of Dewars and pressurised vacuum-insulated vessels (PVIVs)**

Liquid nitrogen dewars and liquid storage vessels must be clearly and adequately labelled. Reference 1 explains the legal requirements. As a minimum the label must include the statutory labelling requirements and basic safety information for users. Figure 1 shows a typical label. This includes:

- Product designation i.e. NITROGEN, REFRIGERATED LIQUID
- Product UN number i.e. UN 1977
- Product danger sign i.e. a green diamond with a cylinder symbol and the number 2 at the bottom

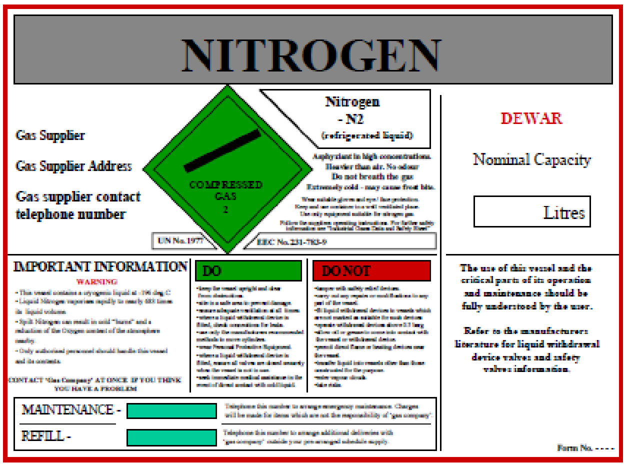

Figure 1 Liquid Nitrogen Dewar Label

5.3 **Area signage**

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

Risk of Asphyxiation

The warning triangle (above left) must be used in all locations. Where flammable gas may be present a prohibition notice (above right) must also be used.

5.4 Facilities using mixed cryogenic gases

The University does not permit the use or storage of liquid oxygen or hydrogen.

The boiling point of oxygen is above those of nitrogen and helium. In closed systems (such as cold traps cooled with liquid nitrogen) these liquids can cause oxygen to condense on their surface (resulting in a bluish liquid on the surface). This can lead to the ignition of normally non-combustible materials and the flammability limits of flammable gases and vapours are widened. Oil and grease may spontaneously ignite and as such should not be used where oxygen enrichment may occur.

Where large quantities of cryogenic gases are to be used (primarily liquid nitrogen and helium) and hence additional ventilation will be required in case of a major release, extraction should ideally be installed at low level.

6 SAFE WORKING PRACTICES

6.1 General precautions

1. Cryogenic liquids 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 cryogenic liquids, including open transfers and decanting, must take place in a well-ventilated area.
3. All systems components piping, valves etc. must be of the appropriate materials to withstand the extreme temperatures.
4. Use tongs or other similar devices to immerse and remove objects from cryogenic liquids.
5. Where oxygen monitors are required, these must be checked for correct operation before use.
6. Hazard reviews are required on all newly purchased, built or modified tools using cryogenic materials. Contact Health and Safety Services for advice.

6.2 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.

6.3 **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 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 special filling funnel to prevent splashing and spilling when transferring liquid nitrogen into or from a Dewar. Never use a funnel.
- 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.

6.4 **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.

6.5 **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 be placed in secondary containment e.g. a plastic sandwich box, or behind a shield in a safety cabinet, until they reach room temperature. During removal, the operator must wear a face shield.

6.6 Transportation 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.
- If using a vehicle, Dewars must be transported separately from the driver or passengers.
- 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.

6.6.1 Vessels of less than 2 litre capacity

Temporary storage can be in small Dewar vessels of 1 or 2 litre capacity. However, any lid must be vented to avoid the build-up of pressure which would happen in a sealed vessel.

6.7 Use of lifts

There is a small remote risk that a pressure vessel or Dewar may vent off or spill its contents whilst being transported in a lift and so place any accompanying handler at risk. Therefore when use of a lift to move liquid nitrogen within a building cannot be avoided you must produce a standard operating procedure following the guide lines below:

- Small volumes of liquid nitrogen (less than 500 ml) can be accompanied in a lift (based on worst case scenario calculation for a lift of 3 m^3).
- 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.

6.8 **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 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.

6.9 **Special precautions for working with liquid helium**

The most critical safety issue in dealing with liquid helium is its temperature. It is so cold that it will FREEZE ALL GASES AND LIQUIDS except helium itself. This includes not only water, but also nitrogen and oxygen. All of these can freeze inside a liquid helium Dewar or delivery lines, forming an "ice" plug which can potentially block the neck and create potential for an explosion. For this reason, it is imperative that procedures are followed to prevent air or other gases from entering the liquid delivery lines at any time. Should a blockage be suspected the Dewar must be moved to a safe location and the vendor must be contacted immediately.

Transferring liquid helium in non-vacuum jacketed piping can cause air surrounding the outside of the transfer pipe to condense and liquefy. The nitrogen in this liquid will evaporate first, leaving an enriched oxygen liquid behind. The area where this liquid collects should be insulated and oxygen-compatible.

7 **TRAINING**

All staff and students working with cryogenic liquids and gases must receive appropriate training, in accordance with written standard operating and emergency procedures for the facility. It is recommended that emergency procedures are rehearsed. All training must be recorded.

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

Schools that use cryogenic gases must ensure that first aiders are trained in how to deal with injuries from cryogenic liquid exposure.

FMD staff who may be required to work in areas where cryogenic liquids or gases are stored (e.g. cleaners, maintenance personnel) must receive basic hazard awareness training and instruction on what to do in an emergency.

Guidance:

Senior technical staff in Schools that use cryogenic gases must attend appropriate training, containing both theory and practical application. The current training provider is Gas Safe. Courses are organised through Health and Safety Services. All other users must receive training provided by senior technical staff, on the equipment/systems that they are authorised to use.

8 EMERGENCY PROCEDURES

Oxygen-deficient or enriched atmospheres are an invisible danger. They have no warning properties. Therefore:

- 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 enriched or where a low oxygen alarm is sounding. Use monitoring devices to ensure oxygen levels are adequate. Free entry is only permissible if the oxygen concentration is between 19.5% and 22%. Doors to areas with oxygen alarms should have clear signage to prevent entry in case of the alarm sounding.
- If there is any possibility of a change in the oxygen concentration, anyone entering must wear a personal continuous oxygen monitor which will give an audible alarm if the oxygen concentration varies outside safe limits.
- Should a Dewar of cryogenic liquid be venting continuously, remove it from service and if safe to do so transfer it to a safe, well ventilated area, then call the supplying vendor immediately. If it is not safe to move it, follow emergency procedure for dealing with spillages.

8.1 Dealing with spillages

In the event of a spillage:

- Evacuate all personnel from the area likely to be affected.
- If safe to do so, try to prevent gas flowing to pits, basements and stairwells, by closing doors to those areas.
- Take action to prevent any ventilation systems spreading the cryogenic gas to other areas.
- Open exterior doors and windows to encourage evaporation and safe dispersal.
- Allow the liquid to evaporate naturally.
- Prevent entry until all the gas has dispersed and the air is safe to breathe. Use an oxygen monitor to check oxygen levels. See Reference 1 for methods of calculating oxygen concentrations following a spill.

Guidance:

University staff must never be required to enter an oxygen-deficient or enriched atmosphere - the appropriate emergency response must always be to ventilate the area. If risk assessment identifies that this is insufficient and that breathing apparatus or a source of supplied air may be required in operational or emergency situations, you MUST consult Health and Safety Services so that an alternative, safer, system of work can be identified.

8.2 Ice plugs

Ice plugs may form in the neck of Dewar flasks that are left open. 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 those dealing with the incident equipped with appropriate protective clothing. This should include a full face-shield and appropriate gloves. Any pressure within the Dewar should be relieved by piercing a hole through the ice-plug with a thin, hot L-shaped wire. While doing so do not lean over the Dewar outlet. Having released any internal pressure, the plug may then be thawed and removed safely. The formation of ice plugs can be prevented by the correct use of the Dewar stoppers.

9 FIRST AID

Exposure to cryogenic liquids may result in cold burns/frostbite, hypothermia or asphyxiation. First Aiders must be made aware of the potential for incidents, be trained in appropriate first aid measures, and have plans of how to deal with an incident.

9.1.1 Frostbite

Frozen tissue is usually pain-free and appears waxy with a possible yellow colour. It will become swollen, painful and prone to infection when thawed.

- For skin contact, do not remove any clothing that is frozen. Wait until it is thoroughly thawed. Then remove any clothing that may restrict circulation to the frozen area.
- Do not rub frozen parts; tissue damage may result.
- As soon as practical, place the affected area in a tepid water bath. Never use hot water or dry heat.
- Once thawed, cover affected part with a bulky dry sterile dressing.
- In case of massive exposure, send for an ambulance immediately.
- Without incurring further injury, move the casualty from the source of the cold to a comfortable place.

If the body temperature is depressed (hypothermia), the casualty requires immediate medical attention. Do not apply direct heat or immerse in warm water as this may cause shock. Wrap the casualty in blankets or warm clothing; protect the head and torso as a priority. Move them to a warm place. Shock and cardiac dysrhythmia may be associated with severe hypothermia, so seek medical assistance immediately.

9.1.2 Asphyxiation

Anyone suffering from a lack of oxygen should be quickly moved to an area with a normal atmosphere - but do not enter the area if not safe to do so (oxygen levels below 11% can cause unconsciousness). If the casualty is not breathing, artificial respiration should be administered immediately. Give supplemental oxygen with respiration if oxygen is available and someone is trained to administer it. Immediately summon medical assistance and continue artificial respiration until the casualty revives or a doctor advises stopping.

10 REFERENCES

1. BCGA CODE OF PRACTICE CP30 The Safe Use of Liquid Nitrogen Dewars up to 50 Litre. Revision 1 : 2008.
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 20° 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.

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 19.5% (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	

Appendix 4: **Version control**

VERSION	KEEPER	REVIEWED	APPROVED BY	APPROVAL DATE
X.X	H&S	Every four years	XXXXX	XX/XX/XX
X.X	H&S	Annually	XXXXX	XX/XX/XX