

**Cryogenic Liquid / Solid Safety**

**General Introduction**

Cryogenic liquids and solids including liquid nitrogen, liquid helium and dry ice (solid carbon dioxide) are commonly used in laboratories and other areas across the university as preservatives, temperature controllers, sources of dry gases and in many other applications. Despite the common usage of cryogenic substances, the hazards associated with this substance are not always fully appreciated by everyone who might have cause to enter areas where they are in use. This guidance note is designed to help inform staff and students of the physical properties of cryogenic substances, the hazards associated with storage and use and the basic safety procedures which can be applied to reduce the risk. This note focuses on the hazards associated with liquid nitrogen as one of the most common (and hazardous) cryogenic materials used across the institution but the principles within can be applied to most other cryogens (where safety procedures may differ for certain substances these will be highlighted in the text).

**Characteristics of Liquid Nitrogen**

Nitrogen gas forms the bulk of the atmosphere around us, comprising almost 80% of the air we breathe. It is colourless, odourless and tasteless and therefore under normal circumstances cannot be detected by human senses. It is non-combustible, non-toxic and chemically under most conditions of use.

While nitrogen cannot be liquefied by compression alone at room temperature it can be condensed to a liquid if cooled below its normal boiling point of 196**°**C and will remain in the form of a colourless liquid so long as it is stored below this temperature. On rapid warming a white mist of water vapour may be seen before the gas disperses into the surrounding air. Although nitrogen gas is non-toxic it poses four main safety hazards to users:

* Liquid nitrogen evaporates rapidly and in doing so can expand to displace the oxygen from the surrounding air (particularly when it does so in small or poorly ventilated compartments). This can lead to a significant reduction in the oxygen concentration which in turn can introduce a risk of asphyxiation to anyone in the area.
* The extreme cold of liquid nitrogen (-196°C) is sufficient to cause damage to living tissue on direct contact. Cryogenic burns can be every bit as painful and damaging as scalds or high temperature burns and can lead to significant injury particularly in contact with the eyes where contact can result in sight loss.
* Liquid nitrogen expands rapidly on warming with an expansion ratio of approximately 700:1 at room temperature. This means that if stored in a sealed container it can expand on warming causing the container to rupture violently.
* Nitrogen has a lower boiling point than oxygen (-196°C vs -183°C) meaning that if air is passed through liquid nitrogen or containers of liquid nitrogen are left open to the air, liquid oxygen may form. Liquid oxygen is an extremely hazardous material which can react violently with organic materials such as oils or greases and significantly increases the likelihood of fire.

Other liquefied gases inert have similar properties including liquid helium and liquid argon both of which are also in use at the University. Liquid helium is even colder condensing at -270°C and has an expansion ratio of 1:757 whereas liquid argon condenses at -186°C and has an expansion ratio of 1:847. Both of these substances evaporate to form colourless, odourless gases and each pose a serious cryogenic risk as well as potentially displacing oxygen from the air in a compartment leading to a risk of asphyxiation.

**Asphyxiation (Oxygen Depletion)**

As liquid nitrogen evaporates it expands in a ratio of 1:694 (i.e. 1 litre of liquid nitrogen expands to form nearly 700 litres of nitrogen gas). If this occurs in an enclosed area which is poorly ventilated then oxygen will be displaced from the atmosphere leading to an overall reduction in the oxygen concentration from the usual 20.9%. If sufficient nitrogen evaporates into an enclosed area the oxygen level may fall to the point where the atmosphere can no longer support life causing rapid onset of unconsciousness and death by asphyxiation unless remedial measures are taken.

In the absence of specialist equipment, persons working in an atmosphere that is becoming oxygen deficient are unlikely to be aware of the increasing danger due to a lack of warning signs. Some physical symptoms may be observed including shortness of breath, increased respiration rate and raised pulse but these may not be obvious toy affected persons due to the impairment of judgement caused by oxygen depletion. Loss of consciousness (and subsequently death) due to a sudden reduction in the ambient oxygen concentration can occur rapidly and without any warning signs and it is imperative that precautions are taken to prevent this from occurring. A person entering a severely oxygen deficient atmosphere can become unconscious almost immediately and without warning and safe systems of work and early warning systems are used to prevent such an atmosphere from forming in the first place and warn staff and students in the event it does happen.

The same is also true of both liquid helium and liquid argon. Liquid nitrogen and argon will tend to fill poorly ventilated compartments from the floor upwards as they evaporate. Argon is heavier than air and although nitrogen is a major component of air it tends to sink due to the low temperature at which the liquid evaporates. In contrast to this helium is very much lighter than air and will fill a compartment from the ceiling downwards (this can be very important when determining how to effectively ventilate an area where cryogenic liquids are in use and to correctly position oxygen depletion sensors).

**Note: Rescuers MUST NOT attempt to enter an oxygen deficient atmosphere without either wearing suitable compressed air breathing apparatus (and being trained in its use) or fully ventilating the area and confirming that the oxygen level has stabilised to the point where a safe entry may be made.**

**Note: In some cases multiple fatalities have occurred when individuals have tried to rescue an unconscious colleague from an oxygen deficient atmosphere and have themselves been overcome upon entering the area. Understandably the temptation to enter such an area can be very strong but due to the extremely high risk it is essential that any emergency response is carefully planned in advance and robust safety procedures are followed before any rescue attempt is made. If there is any doubt as to the nature of the atmosphere in an area staff and students should not enter.**

**Note: Filter based respiratory protection provides no protection from oxygen deficient atmospheres and MUST NOT be used under any circumstances to carry out rescues from oxygen deficient atmospheres.**

**Cryogenic (Cold) Burns**

Liquid nitrogen, helium and argon exist at very low (cryogenic) temperatures of -196°C, -270°C and -186°C respectively. Contact with any material at such a low temperature can cause severe tissue damage equivalent to a burn, delicate tissues such as skin and eyes are particularly vulnerable and appropriate protective equipment should always be used. Prolonged exposure to cryogenic materials can also lead to frostbite and hypothermia. Direct inhalation of the extremely cold vapour produced can cause damage to the lungs and in sensitive individuals can also trigger an asthma attack.

In addition to direct contact with cryogenic liquids, uninsulated pipework, valves or vessels containing cryogenic liquids can reach very low temperatures such that contact with unprotected skin could cause burns or frostbite very rapidly. In some cases this can lead to moisture on the body freezing in contact with the surface causing it to stick. Further damage can then be caused as flesh is torn away while trying to break free.

**Note: To minimise the risk of injury safe systems of work coupled with the use of appropriate personal protective equipment are necessary. As a minimum standard thermally protective clothing (e.g. labcoat),**

**insulated gloves and eye protection (preferably a face shield) should be used when handling liquid nitrogen.**

Cryogenic burns can be treated using similar techniques to high temperature burns although there are some key differences. The recommended technique is set out as follows:

1. Flush the affected area of skin with tepid water for approximately 20 minutes
2. Do not apply direct heat or hot water
3. Do not use a forceful flow of water as this may lead to further tissue damage.
4. The casualty should be moved to safe, warm area and medical attention sought
5. If the burn is large or severe an ambulance should be called
6. While waiting for medical attention to arrive the affected area should be flushed with tepid water and if safe to do so any tight jewellery removed. Any items that are stuck to the burn should be left in place to avoid causing further tissue damage.
7. The casualty should not be allowed to smoke and no hot beverages or food should be offered.

**Oxygen Enrichment (Liquid Oxygen)**

The extremely low temperature of liquid nitrogen can in some cases cause liquid oxygen to condense from the air and accumulate in containers. Liquid oxygen condenses at -183°C as a pale blue liquid which when absorbed onto combustible materials or present in large quantities can significantly increase the risk of fire and explosion. This is most likely to happen when a stream of air is passed through a container of liquid nitrogen or when Dewars or insulated flasks of liquid nitrogen are left open to the atmosphere due to missing or ill-fitting lids for an extended period of time (this is a particular problem when wide necked, shallow containers are used).

The formation of liquid oxygen is a potential problem in closed systems such as a vacuum system containing liquid nitrogen (or where liquid nitrogen is used to condense moisture from a closed system). If air is present in the system (or enters via a leak) then liquid oxygen may condense and accumulate in traps or low points and can react in contact with other substances or equipment. This hazard should be considered when systems of this type are designed.

**Note: Liquid oxygen is extremely volatile and unsurprisingly is an extremely strong oxidising agent. If released into an existing fire the fire will become extremely intense. Should it come into contact with combustible materials such as oil, grease or even tarmac then an explosion can occur.**

**Note: In general, liquid oxygen should be allowed to evaporate in a safe area away from organic materials or ignition sources, in the event of a spillage the area should be evacuated, ignition sources removed and the spill allowed to evaporate for at least 30min or longer if required.**

**Overpressurisation of Storage Containers**

Cryogenic liquids expand rapidly on warming with expansion ratios from 1:694 and above at room temperature, meaning that if they are confined in a sealed container a build-up of pressure is likely as the liquid evaporates. If the gas formed is unable to escape then it can in turn lead to the sudden, violent failure of the container.

Ice plugs can form in the neck of Dewar flasks (and other narrow necked-containers) if they are left open to the atmosphere allowing moisture from the air to condense and freeze. These can block the outlet of the container effectively sealing and causing internal pressure to build up. This build-up of pressure could result in the ice plug being ejected with significant force or may lead to the vessel rupturing therefore caution should always be exercised if an ice plug is found to be present and the following actions taken:

1. The immediate area should be evacuated and only those who are dealing with the incident should be present (lone working should not be permitted when dealing with an ice plug).
2. All personnel involved in dealing with the ice plug should be suitably protected, a minimum standard would include closed to footwear, long trousers / sleeves, a fastened lab coat, full face shield and insulated gloves.
3. Pressure within the vessel should be relieved by piercing the ice plug using a thin, L-shaped heated wire. This should be applied to the plug from a distance where possible and care should be taken to not to lean over (or look into) the outlet of the vessel during or after this procedure.
4. Once the initial pressure has been released the plug may then be thawed and removed safely.

Sealed sample containers (e.g. Eppendorf Tubes) stored in liquid nitrogen may suffer a build-up of pressure when removed from cryogenic storage and allowed to warm up to room temperature. This occasionally causes one or more tubes to rupture explosively. To reduce the risk to users eye protection **MUST** be worn when removing samples from cryogenic storage.

The hazard from a bursting tube can be significantly reduced by enclosing samples in a protective secondary container (e.g. a plastic container) or by covering them immediately on their removal from the cryogenic storage vessel and leaving them enclosed (but not sealed) until they have reached the required temperature.

**Note: Due to the risk of overpressure containers used for the storage of cryogenic liquids must never be fully sealed. Improvised containers should also be avoided especially those with lids or screw tops.**

**Note: The formation of ice plugs can be prevented by diligent use of the correct Dewar stoppers which should be loose fitting to prevent pressure build-up.**

**Embrittlement of Materials**

Some materials (including plastics, rubbers, metals and organic materials) can become brittle and may fracture when cooled to extremely low temperatures especially if they remain cooled for an extended period of time. This clearly has implications for the design of storage vessels, equipment used to convey liquid nitrogen or any other equipment that may be in contact with a cryogenic liquid for a prolonged period of time. Stainless steel, nickel steel, copper and aluminium alloy have reasonably good low temperature characteristics with PTFE commonly used for sealing of liquid nitrogen systems. Carbon steel on the other hand becomes brittle and is prone to failure at low temperatures making it unsuitable for use in cryogenic applications.

**Note: If you have any doubts on the suitability of a particular material for low temperature applications specialist advice should be sought.**

**Safe Use and Handling of Cryogenic Liquids**

**Managerial Controls**

As with all aspects of safety, an effective system of management is required to control the risks that may arise when work is undertaken. This will include preparing a suitable and sufficient risk assessment to identify and control potential hazards, these elements from the basic legal requirements of a safe system of work. The following features would be included in a suitable management system:

* Arrangements to check that locations where cryogenic liquids are stored, decanted or used are suitable for this purpose i.e. adequately ventilated whether by natural ventilation or through use of mechanical ventilation.
* A system to ensure that only the minimum volume of any cryogenic liquid consistent with the practical and technical requirements of the work is held in laboratories and storage facilities (other than bulk storage tanks).
* Arrangements to provide staff with adequate information, instruction and training in the hazards associated with cryogenic liquids and the safe working techniques required to reduce the risk to an acceptable level.
* Provision of appropriate protective equipment and supervisory arrangements to ensure that it is used correctly and stored appropriately.
* Arrangements for the periodic inspection and maintenance of cryogenic storage and decanting facilities, equipment and personal protective equipment. Systems should include procedures to be followed when defects are dentified.
* An effective emergency procedure that has been clearly communicated and is understood by all staff and students working with cryogenic liquids. It is recommended that emergency procedures are practised regularly by key users.

This list is not exhaustive and while some of these features are discussed further in this note, others that are not included may also be relevant depending on the nature of the work being undertaken locally.

**Training**

All people who work with cryogenic liquids (or enter areas where cryogenic liquids are stored, used or decanted) should be given adequate instruction covering the risks of asphyxiation, overpressure, cryogenic burns associated with cryogenic liquids. Instruction should also cover other key risks associated with specific substances e.g. the fire and explosion risk associated with liquid oxygen. Effective training should cover practical skills including the correct use of protective clothing and any equipment and methods used to handle cryogenic liquids during normal operational working. All relevant personnel must also be made aware of the correct actions to take in the event of an emergency. This type of training is often delivered as part of the unit induction program and should be compulsory for staff and students working with cryogenic materials.

**Note: Particular attention should be paid to the insidious nature of the asphyxiation risk associated with liquid nitrogen, argon and helium and to the emergency procedures that should be followed in the event of a spillage.**

**Note: Care should also be taken to ensure that anyone working with liquid oxygen (or likely to encounter it) is aware of the violent reaction that can occur when it comes into contact with organic materials in particular oils and greases.**

**Protective Clothing**

Eyes should be protected by safety goggles or for certain activities a face shield. Generally where there is a risk of splashing (e.g. during decanting) a face shield will be more appropriate to help protect the skin of the face and reduce the risk of cryogenic liquids entering the mouth and nose as well as protecting the eyes (which are especially sensitive to damage from cryogenic liquids.

Overalls or lab coats (preferably side fastening and without pockets) should be worn although non-absorbent insulated aprons may also be purchased. Sleeves and trousers should be worn outside gloves and boots ensuring that bare skin is covered. Closed toe footwear and insulated gloves should be worn when handling cryogenic liquids and metallic jewellery should be removed to reduce the risk of cryogenic burns.

**Note: If combustible clothing is splashed with liquid oxygen it may remain in a highly combustible state for a long period of time. Non-absorbent, fire resistant clothing will usually be more appropriate for operations involving liquid oxygen.**

**Handling Cryogenic Liquids**

Decanting cryogenic liquids or operations where items are immersed in a cryogenic liquid should always be performed slowly and with care to minimise the risk of thermal shock and the boiling and splashing which inevitably occurs. Wide necked or shallow containers should be covered to reduce splashing / loss of liquid (although care should be taken not to accidentally create a seal which could in turn lead to a build-up of pressure).

When inserting open ended pipes or tubes (including plastic and rubber tubing) into a cryogenic liquid the “warm” end should be blocked off until the “cold” end has cooled to the temperature of the liquid. If this is not done a stream of liquid and cold gas may issue from the tubing.

When cryogenic liquids evaporate rapidly they will often initially form a cloud of white vapour, for most cryogenic liquids (nitrogen, oxygen, argon) this vapour will tend to accumulate at low levels. Care should be taken to ensure when working with these substances close to manholes, trenches, basements or other low lying areas as the gas is likely to flow into these areas and accumulate.

**Note: When nitrogen warms to room temperature it mixes freely with air and may affect the oxygen concentration throughout a poorly-ventilated compartment.**

**Note: Liquid helium will evaporate rapidly forming a white cloud of vapour. However as helium is very much lighter than air it will tend to accumulate at ceiling level first before filling a compartment. This is likely to affect the positioning of effective ventilation systems and oxygen depletion sensors.**

**Transport and Storage of Cryogenic Liquids**

**Storage of Cryogenic Liquids**

Cryogenic liquids may be stored in different containers depending on the quantity and application for which the liquid is being used. Large quantities of cryogenic liquids required for a stock supply are usually stored in large pressurised tanks which are located in well ventilated areas outside buildings. Bulk containers are generally filled directly by a supplier from a delivery tanker and may be used for dispensing into smaller containers for transport to an area where it is required or to provide a supply of cryogenic liquid for self-filling sample storage containers or piped supplies for dispensing. Bulk tanks require regular maintenance from a competent engineer to ensure they are working correctly and identify any components that may need to be repaired or replaced the responsibility for ensuring this takes place lies with the school or unit unless the tanks are owned and maintained by a third party (this is generally the preferred option).

**Note: Ice can build up on the outside pipework and valve groupings of bulk containers in particular those that are stored outside in all weathers. In severe cases could affect the operation of emergency equipment such as pressure relief valves etc. and should therefore be cleared regularly.** **Tank suppliers recommend the use of a hot kettle or low temperature heat gun / hair dryer to remove any ice on a weekly basis (blow lamps and other flaming heat sources must not be used for this purpose nor should the ice be removed by force or mechanical shock (e.g. use of a hammer). Before this is attempted a suitable risk assessment must be completed to ensure the safety of anyone involved.**

For general use liquid nitrogen is often stored in either pressurised dispensing vessels or large vacuum flasks known as Dewars. Pressurised dispensing vessels (also known as cryogenic liquid cylinders) are enclosed vessels with an integral pressure relief valve designed to prevent the vessel from failure. They are generally used to store smaller amounts of cryogenic liquids in a mobile container which can be used to dispense liquid when required from an integral pipe or hose. As with all pressure vessels they require regular inspection and maintenance. The safest containers are fitted with a “hold to fill” system so that in the event of a user collapsing during dispensing the flow of cryogenic liquid stops automatically.

For smaller applications unpressurised vacuum flasks ranging in size from 1l to 60l are in common use. These consist of an insulated double-skinned flask with a loose fitting stopper which reduces evaporation but does not entirely eliminate it (to prevent a build-up of pressure). These vessels can be used for transport or sample storage and are a common sight in laboratories and cryogenic stores.

For bulk sample storage large, self-filling tanks connected to a supply of cryogenic liquid are often used. These can hold many hundreds of samples and are generally fitted with a level gauge which allows the tank to self-fill from an external tank when the level of liquid in the tank falls or at a particular time each day. A stream of gas is often released during filling which can affect the local oxygen level and may set off low oxygen alarms if ventilation is insufficient. It is usually best practice to avoid working in storage areas during tank filling wherever possible. If this is inevitable then personal oxygen monitors should be used to supplement any fixed protection to ensure that any local reductions in air quality are identified. Care should be taken when adding or removing samples to do so gently to reduce the risk of splashing and to avoid leaning into the container.

All cryogenic liquid containers should be regularly inspected to ensure any damage or faults are highlighted as soon as possible. Corrosion and physical damage should be identified along with any patches of frost on the outside of Dewars and other containers which sometimes (but not always) indicates a failure in the vacuum insulation. If a valve grouping or dispenser is constantly releasing gas or liquid it could indicate contamination in the valve or that the valve is damaged and is not sealing correctly.

**Note: Cryogenic liquid containers no matter how small should only be stored in well ventilated areas of sufficient size to reduce the risk of asphyxiation in the event of a leak or failure. Large containers should never be stored in small unventilated areas.**

**Note: In rare cases the sensor associated with a self-filling tank can fail causing it to fill constantly until the cryogenic liquid supply is exhausted. In the event that this occurs the area should be evacuated and the supply isolated from a safe area if possible. Assistance should then be sought from a competent person.**

**Transport of Cryogenic Liquids**

Cryogenic liquids and solids are routinely transported from storage areas to laboratories and other locations where they are to be used. If the transfer cannot be achieved using a closed system such as pipework then it may be necessary to move a container of a cryogenic liquid from one area to another. Cryogenic liquids should only be transported in appropriate containers either Dewars or cryogenic liquid cylinders, other containers including improvised containers should not be used. Cryogenic solids may be moved in insulated boxes or other suitable containers.

Cryogenic liquids should not be moved in open containers to reduce the risk of splashing although containers must not be fully sealed and should always incorporate some form of pressure relief. Cryogenic liquid cylinders should be wheeled if they are to be moved whereas larger Dewars should be fitted to integral trolleys which should keep the container upright during transit. A manual handling risk assessment should be considered to avoid the risk of musculoskeletal disorders. Appropriate PPE should always be worn when handling or transporting cryogenic liquids.

Small quantities of cryogenic liquids (less than 2l) may be transported by hand in a suitable insulated container (again improvised containers should not be used). Where there is a need to transport cryogenic liquids or solids between floors small quantities should be transported by hand using the stairs. For larger quantities there is no option but to use an elevator due to the weight of the containers. It is of critical importance that no-one travels in the lift with cryogenic liquids or solids due to the risk of asphyxiation especially in the event of a fault or failure in the lift. Containers should be placed in the lift along with a suitable warning sign or preferably a barrier to prevent staff or students entering the lift. If it is possible to override the lift and take it out of service for other users then this should be done. It should then be sent to the desired floor and preferably met there by a second person.

**Note: Cryogenic liquids and solids should never be left unattended in public areas. The only time they may be left unattended is when being stored in an appropriate location or when being transported from one floor to another using the lift.**

**Note: Care should be taken to transport cryogenic materials at sensible times and via appropriate routes. While lone working should be avoided it is good practice to avoid transporting cryogenics during periods of high traffic (e.g. lecture changeover times). Service routes or other lower traffic routes may be appropriate if available.**

**Emergency Procedures**

When an accidental release or spillage of a cryogenic liquid occurs it can pose a very serious risk to both personnel and equipment in the area especially if it occurs inside a compartment. As a general rule when planning for an emergency the effect of a spillage involving the largest container present should be considered along with the combined volume of any containers connected to a supply manifold system (this may include an external bulk storage tank).

The first part of the process should be to determine the effect of such the spillage on the oxygen concentration in the area. Consider the following calculation which gives an estimate of the reduction in oxygen concentration caused by the spillage of an asphyxiants cryogenic liquid (e.g. liquid nitrogen).

**In simpler terms any spillage of a cryogenic liquid which produces an asphyxiant gas with a volume of 5% or greater of that of the compartment is likely to require evacuation and subsequent ventilation of the area.** However, it should not be assumed that smaller spillages will therefore be “safe” as the local circumstances such as temperature, ventilation, air changes and many other factors could still make it necessary to evacuate an area following a smaller spillage. Staff, students and visitors should be provided with training and instructions covering the actions to take in the event of a spillage and warned of the risks of remaining in the room or re-entering before the room has been fully ventilated.

1. Calculate the volume of gas produced by multiplying the expansion ratio of the gas by the quantity that may be spilled (answer in litres). Divide by 1000 to convert to cubic metres.
2. Calculate the approximate volume of the compartment in which the liquid may be spilled (in cubic metres).
3. Use the following equation to calculate the volume of oxygen displaced from the room and the concentration remaining:

V(ox) =0.21 x [V(Room) – (V(Dewar) x Expansion Ratio / 1000)]

C(ox) = 100 x V(ox) / V(Room)

V(ox) = Volume of oxygen remaining in room (cubic meters)

V(Dewar) = Volume of liquid nitrogen in Dewar (litres)

V(Room) = Volume of the room (cubic metres)

C(ox) = Concentration of oxygen in room (percent oxygen)

Usually spillages will evaporate very quickly and disperse if the room is well ventilated, this process can be facilitated by opening windows and doors outside the area of immediate risk to promote an airflow (if safe to do so). Where large volumes of cryogenic liquids are stored consideration should be given to how effective ventilation can be achieved without putting staff at risk by entering the affected area. Heads of Unit are responsible for ensuring that these arrangements are incorporated into a formal emergency plan. Where it is necessary to leave a room unattended (e.g. overnight) it should be secured to prevent inadvertent access to what might be a hazardous area. Warning signs should be clearly posted at the point(s) of entry and any alarm systems should be clearly visible and audible from outside the area. Everyone who is likely to work in the area should be given clear instructions on their role in the event of an emergency as it cannot be assumed that supervisory staff will be on hand. Consideration should be given to carrying out emergency drills or exercises to help test emergency procedures.

**Alarm Systems**

Commercially available alarm systems capable of alerting anyone working in an area where cryogenic liquids are present to falling oxygen levels are easily available. While they cannot prevent the reduction from occurring they are nonetheless a useful warning system to help prevent asphyxiation and can in some cases be linked directly to emergency systems such as high throughput extraction fans. They should therefore be regarded as very much a second line of defence.

Two types of alarm system are in common usage; fixed alarm systems which continually monitor the oxygen level at fixed points in a compartment and personal alarms worn by an individual. Both systems will give an early warning if the local oxygen concentration falls below a pre-programmed threshold. Fixed alarm systems are unlikely to be considered reasonably practicable for most small-scale storage operations but are generally appropriate for larger facilities or for activities where cryogenic liquids undergo evaporation in an enclosed area. On the other hand personal alarm systems may not be appropriate for large facilities (although they can provide a useful back-up warning system) and are more likely to be used in smaller facilities.

When an alarm system is provided it is important that all staff are trained to recognise the alarm and respond appropriately, this will usually involve undertaking an evacuation of the area. Staff must be explicitly instructed not to enter an area when the alarm is sounding. Care should also be taken to ensure that staff can easily distinguish low oxygen level alarms with other building alarms such as the fire alarm to ensure appropriate actions are taken.

**Further Information**

Further information and guidance on any of the topics covered can be obtained by contacting the Safety and Environmental Protection Service using the detail below:

**General Office:** 0141 3305532

**Chemical Safety Adviser:**  0141 3302799

**Appendix 1: Recommendations for Signage**

The signage used to warn staff, students and visitors of the hazards associated with liquid nitrogen should be displayed at all possible entrances to storage facilities etc. In general it is better to have signage which is simple to understand and conveys the risks clearly without an overload of information. The most important information that should be conveyed to anyone entering the area is as follows:

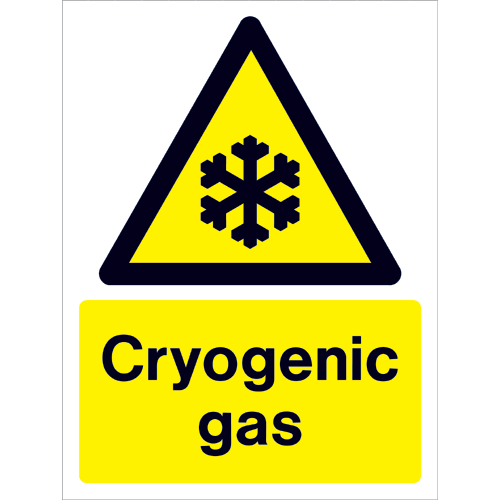
* Presence of cryogenic liquid
* Requirement for ventilation
* Prohibition of lone working

An ideal sign will cover some or all of these hazards with appropriate warning symbols used to provide emphasis, see below for an example of a suitable sign:



In some cases other information may also be included to help provide further guidance to anyone entering or working in the area, for example:

* Cryogenic hazard plus symbol (see below)
* Risk of asphyxiation
* List of emergency contacts / procedures to follow

The room should also be clearly marked with an identifiable room number and where possible a vision panel should be fitted in the door to allow a view into the area which could help identify a hazardous release or incident, this should not obscure other signage.

**Note: Signage should clearly communicate all of the relevant safety information but care should be taken to avoid “clutter”. Too much signage can be distracting and cause safety information to be ignored be users.**